Media e tecnologie per la didattica

Collana diretta da Pier Cesare Rivoltella, Pier Giuseppe Rossi

La collana si rivolge a quanti, operando nei settori dell'educazione e della formazione, sono interessati a una riflessione profonda sulla relazione tra conoscenza, azione e tecnologie. Queste modificano la concezione del mondo e gli artefatti tecnologici si collocano in modo "ambiguo" tra la persona e l'ambiente; in alcuni casi sono esterne alla persona, in altri sono quasi parte della persona, come a formare un corpo esteso.
La didattica e le tecnologie sono legate a doppio filo. Le tecnologie dell'educazione non sono un settore specialistico, ma un filo rosso che attraversa la didattica stessa. E questo da differenti prospettive. Le tecnologie e i media modificano modalità operative e culturali della società; influiscono sulle concettualizzazioni e sugli stili di studio e di conoscenza di studenti e adulti. I processi di mediazione nella didattica prendono forma grazie agli artefatti tecnologici che a un tempo strutturano e sono strutturati dai processi didattici.
Le nuove tecnologie modificano e rivoluzionano la relazione tra formale informale.

Partendo da tali presupposti la collana intende indagare vari versanti.
Il primo è quello del legame tra media, linguaggi, conoscenza e didattica. La ricerca dovrà esplorare, con un approccio sia teorico, sia sperimentale, come la presenza dei media intervenga sulle strutture del pensiero e come le pratiche didattiche interagiscano con i dispositivi sottesi, analizzando il legame con la professionalità docente, da un lato, e con nuove modalità di apprendimento dall'altro.
Il secondo versante è relativo al ruolo degli artefatti tecnologici nella mediazione didattica. Analizzerà l'impatto delle Tecnologie dell'Educazione nella progettazione, nell'insegnamento, nella documentazione e nella pratiche organizzative della scuola.
Lo spettro è molto ampio e non limitato alle nuove tecnologie; ampio spazio avranno, comunque, l'*e-learning*, il digitale in classe, il *web 2.0*, l'*IA*.
Il terzo versante intende indagare l'ambito tradizionalmente indicato con il termine *Media Education*. Esso riguarda l'integrazione dei *media* nel curricolo nella duplice dimensione dell'analisi critica e della produzione creativa e si allarga a comprendere i temi della cittadinanza digitale, dell'etica dei media, del consumo responsabile, nonché la declinazione del rapporto tra i media e il processo educativo/formativo nell'extra-scuola, nella prevenzione, nel lavoro sociale, nelle organizzazioni.
Per l'esplorazione dei tre versanti si darà voce non solo ad autori italiani, ma saranno anche proposti al pubblico italiano alcune significative produzioni della pubblicistica internazionale. Inoltre la collana sarà attenta ai territori di confine tra differenti discipline. Non solo, quindi, la pedagogia e la didattica, ma anche il mondo delle neuroscienze, delle scienze cognitive e dell'ingegneria dell'informazione.

Comitato scientifico

INCLUSIVE SCIENCE EDUCATION AND ROBOTICS

STUDIES AND EXPERIENCES

Edited by
Luisa Zecca and Edoardo Datteri

MEDIA E TECNOLOGIE PER LA DIDATTICA

FrancoAngeli

The project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No 872104.

C4S Communities for Sciences

Isbn digitale: 9788835150640

Indice

Preface

by *Gabriel Lemkow-Tovias*

To begin this preface, I propose an exercise of imagination and fantasy. Forget the here and now of where we are for a moment. Let us also forget historiographical accuracy, since we are neither expert archaeologists nor historians and we are not looking for accuracy, but rather something else. We are searching for something more subtle and intriguing, something less tangible, more fluid but no less important. We are human beings, to whom nature has given us the capacity of imagination. An imagination that has already raised us to the highest reflexive and literary peaks thanks creative beings such as Mary Shelley, Isaac Asimov, Gianni Rodari, Ursula LeGuin, NNeka Arimah, Michael Ende or Lie Zhi, among so many great storytellers who have accompanied us since the night of times.

Given that we are partly the fruit of the imagination that our ancestors built, let us project ourselves to another time and another possible, speculative, space: to a cold night in remote times, a night in which a story is being told around a fire. The shadows of the narrator, the wise old woman of the tribe, are cast over the cave helping to add intensity and drama to her story. The sound of the flute and the beating of drums tell us about the animals of the prairie and the intense rains of the wet season. While storytelling she throws petals into the air to make them fall into the bonfire, thus telling us about the period of plants flowering. And suddenly… suddenly! There is a moment of ecstasy in the community as a flame rises almost to the ceiling of the cavern as the wise old woman throws some powder into the hungry fire. The tribe remains silent, ecstatic, with eyes wide open, the girls and boys listen excitedly to the story that every year, about the flourishing period in which the gazelles graze and in which, with the arrival of good weather and more pleasant temperatures, the little ones can get further away from the cave to play and learn. But the wise woman of the tribe warns! Watch out! The dangers are always lurking! But it is true, as the tattooed hands of the old woman also show projecting her shadows in the form of a rabbit and a gazelle on the cave wall, the joyful moments also lurk in spring. The flute sounds again and the music shows us the path of the community, the dark places to avoid and the grasslands to visit to find the right food and its promised fruits…

It's already late, the stars shine in the sky. The cave makes that pleasant smell of ash and sweet spices that help the body to relax. The girls and boys have learned an important lesson tonight. The road meanders and we always have to look into the distance. One of the girls, with slanted eyes and very dark hair, meanwhile, tenderly hugs, with her only arm, her bag with spices that the old woman of the tribe has given her. Tonight it has been revealed by the old woman, that she, the sleepy girl, will be the next wise woman of the tribe. The word has been spoken. She will take up the legacy tomorrow, to lead her people. She, the little one-arm-girl-with-brave-sight, dreams of trees and flowers, of paths and spirits, and as she sleeps, her mind assimilates all that she has learned tonight about life on the prairies during the spring bloom. Tomorrow will be another day, in a few hours the sun will rise, and she will begin to learn the paths that each year the tribe must follow to find a new home to stay during springtime… Now, in the middle of this girl's dream, the future sage of the tribe, the full moon rises, the stars shine, and the occasional nocturnal songbird accompanies the sleep of an exhausted tribe, exhausted but thrilled to continue its path towards the grasslands in a few hours at dawn…

… Well then… we now move to thousands of eons in the future. Three girls and two boys are playing while the adults are at work rebuilding their machines. The children play to remember how the trip to Alpha Centauri was. In their play, they mimic the smelling of the NNmbuki singing-flowers and also mimic their dancing with the silvery Fumeni bats. While they are representing the low flight of one of these Fumenis, their friendly teacher, Emic, comes to see them. Emic explains to them that they will soon be back to normal gravity so they should start going down to the ground. Zero gravity can be dangerous if we forget about the G-shift! Emic, to relax the atmosphere, decides that it is time to sing his favorite relaxing song for children so that, little by little, they can adapt to the G-change. The song is beautiful, it tells the children a story about how long ago there was a wise old woman in a cave in the night of remote times, where she explained stories of flowers and winds, roads and spirits with the accompaniment of flute and drums to her tribe. Of a one-arm girl who would be the next wise woman of the tribe that would lead her people for the first time to the grasslands where each spring the tribe happily migrated.

Emic, while singing the song to the children, notices that his leg is starting to rust and he can't move now as well as before. It's true, he is already about 1000 years old and lately Rheky's metal is beginning to suffer the consequences of the hyper-oxygenated environment of spaceports full of tourists. Mbali, the shrewdest girl in the group, notices Emic's worried face, caresses his rusty knee, with her little black hand, and offers him her smile along with a little bit of Felsic resin oil that she had kept in her backpack. Mbali the girl, does it with all the ingenuity in the world since this resin does not serve to remove rust, but it is true, Emic thinks, that the little girl harbors good intentions with her empathetic action: She has realized that Emic also ages, even if it's a robot. And Mbali, of course, does not want to lose her best friend Emic or that he feels pain. Even though he is made of metal and numbers, Emic is like her, full of emotions and feelings, and like her, little Mbali knows that she will also suffer from the consequences of time. Although Emic knows that the felsic resin oil will not do any good, smiles back at Mbali, caresses her little head and continues singing for the children. Together they relax, some of them begin to show reddened tired eyes. They are now decelerating and lowering to the ground, as the ship's gravity returns to the usual state close to that of the Earth. Emic is happy. This time there have been no accidents. Everyone is already on the floor, a couple of children have fallen asleep. The little girl, Mbali is still awake and has begun to play with two obsolete miniaturized accelerators mimicking her and Emic talking to the singing flowers of Nnmbuki. Emic smiles, he is happy that the little ones enjoyed their time together with him during the excursion through the fields of Alpha Centauri. He now looks forward to teaching the next class about the New Caledonia Moon Purple Ocean Tour. And while he waits, also reminds himself that he must get that rust checked soon or he will have to replace his entire 27-SB2 trilateral leg…

… Good. Let's go back to the here and now. Let's talk about robotics and disability, let's talk about learning and socialization, let's talk about human potential and its interactions with the environment. Let's talk about the immense capacities we have, as human beings, to find interesting new phenomena to investigate and to find also new ways to help one another. The human being is a complex being, yes, but at the end of the day is neither more nor less complex than a deer or a butterfly fluttering through the meadow. Of course, we are social beings since the dawn of history. We were social beings during that night in which the old wise woman of the tribe projected her shadows at the bottom of the cave with the sound of her flute and the drums under the attentive gaze of the tribe and the new one-arm leader of the tribe. The same is true also that night, eons later, in which Emic contemplates the cold sidereal space from his ship on his way to the moon of New Caledonia while singing relaxing songs to his little students. We are social beings, to the point that we find ways to support each other as much as possible. It's a good opportunity to remember Margaret Mead's reflection about the fact that, for her, the first sign of civilization was that of the discovery of an old fractured femur which was found to have also healed after the fracture. A sign that, for Mead, showed how collaboration and support between human beings, especially with those in need, existed from prehistoric times and was more important than the individual survival instinct.

Humanity has therefore used gadgets throughout the ages to better control phenomena, to know their environment and to interact with one another. We have created gadgets to protect ourselves from the cold and to improve our means of communication, we have made tools to give renewed opportunities to other humans to thrive and we have even made tools to make other tools to make other tools…(!). And the fascinating thing about all this is that all these tools and resources have allowed us to face new challenges, to overcome moments of pain, to unite our communities and to overcome barriers that previously seemed insurmountable.

But we know that talking about technology without further ado is talking about almost nothing. Technologies are a "promesse de bonheur" if they are used for the right purposes. They can also be used as the most atrocious and terrible weapons of horror and suffering if used for the dehumanization of our fellow human beings and for the destruction of our environments. And it is this which we must not forget, as Theodor Adorno, Primo Levi or a Nelson Mandela insistently warned us: that memory is also an important backpack that we human beings must always carry, wherever we come from and whoever we are, to avoid repeating the horrors of the past. Either because these horrors were caused by other human beings, or because they occurred through the mediation of tools and inventions made by these same beings. The alarming thing is that new horrors lurk today, in the context of a nearby war, of a nuclear power plant that is once again at risk of provoking massive a contamination or of a global pandemic that resulted from our destruction and colonization of virgin ecosystems that previously were capable of self-containing their own viruses naturally.

We are in a historical moment, in a moment of deep and important changes. What decisions we make today in relation to the use of technologies and in relation to our peers will undoubtedly condition the future. This also includes what decisions we make today so as not to leave anyone behind, be it today or be it yesterday, as in the case of the first story that I have shared with you, that of the one-arm brave girl who will lead her tribe for the first time, her entire tribe to spring fields. Or be it tomorrow, as in the case of the narration about Emic, who I can tell you is already preparing his next class with great enthusiasm for all the little girls and boys in his group, without exception, be they humanoids or non-humanoids, having they some kind of specific mobility or learning disability (as Emic itself) or not, in the joint excursion through the purple oceans of the Moon of New Caledonia.

The means that we invent today or tomorrow to continue moving forward towards this unknown path that lies in front of us will be essential for the future that awaits us. And the articles that you will read next in this book are a good sign that there is still hope. That despite this uncertain future, there is still a future of interesting promises. And that, without any doubt, this future will also be shared with our fellow robots, be they humanoids or not, be they self-aware or not. But the future will be joint and shared, yes or yes. And who knows if, one day we will also call these robots "human beings" because, like Emic, they will also harbor good feelings, dreams and hopes, and the best of humanity's characteristics, striving for a shared and better life together with other human beings, with their peers.

And, hence, here I leave you, with this good sample of works of human beings for other human beings… and for robots too!

Introduction

by *Luisa Zecca*

This book brings together contributions proposing studies and experiences which investigate the relationship between inclusive education and educational robotics, with particular reference to children and people with disabilities, with special educational needs or at risk of school dropping out. All these contributions were presented during the National Conference IBR21 - Interazione Bambini-Robot, held on 13 and 14 April 2021, in the second session dedicated to robotics and communities in condition of vulnerability. The Conference hosted contributions on topics related to child-robot interaction, with particular reference to the psycho-pedagogical applications of robotics, methodologies of use, technologies in the field, implications and scientific, philosophical, social and cultural assumptions. Indeed, robotics is increasingly being used in contexts frequented by children of all ages, for educational, didactic, therapeutic and entertainment purposes. In schools and non-school learning contexts, robotic construction and programming activities aimed at refining cognitive, social and disciplinary skills are increasingly carried out. The role that interaction with humanoid robots can play in enhancing cognitive and motor skills in people with various types of disabilities – including those related to the autism spectrum – is being explored by international research. Robots are now part of the so-called "edutainment" world and the opportunities for children to come into contact and interact with robotic devices are multiplying.

Considering the issues addressed, the contributions of this book fit into the framework of the SwafS Horizon 2020 Project "Communities for Sciences (C4S) - Towards promoting an inclusive approach in Science Education", which sponsored the Conference IBR21. The three-year project started in October 2020 and is being developed in 9 European cities (Milan -Italy-, Brussels -Belgium-, Manresa and Vic -Spain-, Vienna -Austria-, Budapest -Hungary-, Sofia -Bulgaria-, Lund -Sweden- and Berlin -Germany-) and their areas of influence. The activities being implemented are coordinated by a local Hub in 6 cities with the leadership of one of these local partners of the Consortium. Each Hub is focusing on a specific vulnerable community (immigrants, Roma community and citizens with disabilities), working with and for children and youth aged 0-16 and their families. C4S studies the relationships between science and society, by focusing upon vulnerable communities due to the fact that they are often not visible as active social agents. It is necessary not only to create activities for them, but also to include them as co-participants of these activities, in order to ensure a more coherent approach towards inclusive education and to promote anticipatory policy-making. This is being done through science education activities and through formal and non-formal educational institutions, from an inclusive standpoint, in order to provide them with better science awareness and capacities and to make them progressively aware of exclusionary practices that at times may occur in science. Special emphasis is being placed on engaging them in an intersectional approach to fight against the gender discrimination suffered by women and girls on multiple levels. In addition to this, each Hub is being engaged with policy-makers, educators and institutional representatives to promote their role in supporting and promoting an inclusive science education approach and to consolidate such inclusive practices on more solid grounds. So, the main C4S goals are:

- encouraging citizens to engage in science through formal and non-formal science education and to promote the diffusion of science-based activities, namely in science centers and through other appropriate channels;
- implementing knowledge on science communication, to improve the quality and effectiveness of interactions between scientists, general media and public;
- developing the governance for the advancement of responsible research and innovation by all stakeholders, sensitive to society needs and demands, promoting an ethics framework for research and innovation;
- integrating society in scientific and innovation issues, policies and activities, in order to integrate citizens' interests and values and to increase the quality, relevance, social acceptability and sustainability of research and innovation outcomes in various fields of activity,

from social innovation to areas such as biotechnology and nanotechnology;
- promoting gender equality, in particular by supporting structural change in the organization of research institutions and in the content and design of research activities;
- developing the accessibility and use of results of publicly funded research.

Therefore, C4S intends to work with children and young people aged 0-16 from vulnerable communities, also together with their families, promoting inclusive science education activities within formal and non-formal pedagogical institutions through the creation of Community Living Labs. The laboratory approach allows for collaborative small group work and peer-to-peer knowledge exchange and the "allosteric" learning environments ensure the full participation of students with specific characteristics and their active involvement. The project also aims to raise institutional awareness of inclusive science education by promoting multilevel and multisectoral working groups with specialists from different areas, building work plans with policymakers and launching an International Observatory. Furthermore, the Community Living Labs are striving to create working groups together with community members themselves who co-participate in science education programmes, to propose a plurality of models to children and young people and to develop both a Style Guide on Inclusive Science Education for communication experts and a White Paper on Inclusive Science Education.

The research work carried out by C4S aims to identify factors that facilitate or hinder inclusion in Science Education, based on the assumption that an inclusive approach understood in a wider sense provides support not only for students with special educational needs, diagnosed or not, who have limited access to some learning areas, but also for students:

- with different socio-economic statuses, that in some countries translates into a huge gap between public and private schools;
- with cultural diversity, a dimension where can be included children of nomadic families, first-generation migrant families, Roma children, Muslim girls, and so forth;
- female, because girls usually have less access to STEAM literacy, in particular in countries where girls and boys don't receive the same education.

These dimensions are not separate: indeed, a student might be a migrant and poor girl with SEN, and these may make the barriers higher. While planning innovative activities, it is important that they should be for all, not only for the vulnerable: the vulnerable should not be "labelled"; indeed, the focus of inclusive education is to provide opportunities for everyone. Educational Robotics can approach and help children and youth in learning math, physics and engineering, but it is not only useful for knowledge building process: it can serve as assistive tool for students who have problems in specific fields; it can help develop transversal skills and have positive side effects as an improved learning motivation, leading to a reduction of the risk of social exclusion and dropping out of school; it may be used to change students' attitudes to learning allowing everyone to be accepted and involved; so, as a tool useful to support reaching outcomes and improving knowledge, computational thinking and well-being, it plays a very important role in helping students to become active learning and social actors.

The contributions of this book focus on these issues, exploring the modes of use of Educational Robotics for different age groups and within different school levels. After a broad overview of the concept of "inclusion", investigated in the school context and from the perspective of pupils with disabilities, the book is divided into two Sections, one dedicated to studies and researches and one to experiences. The first Section includes six papers, while the second four contributions.

For what concerns the Section 1. Studies, the first contribution, *Are robots boys or girls? Reflecting on stereotypes and opportunities in robotics in educational contexts*, written by Daniela Bagattini and Beatrice Miotti, focuses on the possible biases that the introduction of robots in the educational field might entail, by analysing the literature on the subject and highlighting risks and opportunities in the use of robotics in the classroom, with regard to gender stereotypes. The second paper, entitled *Use of humanoid robots for intellectual disability in educational and teaching contexts: A review of the literature* and written by Lia Daniela Sasanelli and Michele Baldassarre, explores how the use of humanoid robots, belonging to the category of Socially Assistive Robotics (SAR), can promote physical, cognitive and socio-emotional learning experiences for student with a diagnosis of Intellectual Disabilities (ID) in school contexts, by presenting a literature review on the subject. Two contributions follow both focusing on autism spectrum disorder (ASD). The first of the two, by Serena Sabrina Vadalà, Carmela Esposito, Laura Zampini, Eleonora Farina and Edoardo Datteri, presents an exploratory study aimed to investigate if five ASD and five typically developing (TD) children attribute false beliefs to a non-humanoid robot, assessing if the ASD and TD participants respond differentially to a robotic helping task; furthermore, the study intends to stimulate a reflection on whether the results that emerged can offer insights on children's theory of mind abilities. Instead, the second of the two contribution on ASD children, written by Lucia Campitiello, Michele Domenico Todino e Stefano Di Tore, consists of a research aimed at the design and construction of a robot, called ASD-Robot, for promoting the development of basic socio-relational skills in children with ASD, starting from the Rogers's three characteristics for a psycho-therapeutic relationship (Congruence, Unconditional positive regard and Accurate empathic understanding). Then, in the fifth paper of the Section, entitled *From roboethology to peer tutoring among adolescents in vulnerable contexts. A study on communicative mediation in the classroom*, Valeria Cotza, Monica Roncen and Luisa Zecca present a research aimed at studying the communicative functions that are used between peers and between adult expert and student-tutors during peer tutoring activities with socio-culturally deprived adolescents; specifically, the activities undertaken consist of educational robotics laboratory meetings using Coderbot as didactic mediator. Finally, in the sixth contribution (*Experiencing educational robotics in cognitive and behavioural rehabilitation of the patients: An exploratory study to design inclusive environments*), Lorella Gabriele and Eleonora Bilotta draw attention on young and elderly people with motor and intellectual disabilities, presenting a research aimed to design multisensory learning environments for cognitive rehabilitation using Lego robotics kits to work on executive processes and fine motor skills.

Regarding the Section 2. Experiences, in the first paper, *Beyond barriers. Inclusion and innovation through the use of educational robotic environments*, Daniela Di Donato e Paola Mattioli describe some educational pathways carried out for pre-school children using a variety of robots as mediators: Cubetto, Coding Express Lego, mTiny, Codey Rocky, Ozobot and Lego WeDo. Instead, the remaining three contributions are aimed at lower Secondary School order. The second paper of the Section, *Robotics and educational care for students at risk of dropping out of school: Theories and proposals for action*, written by Sonia Boldrini, is focusing on the recovery of pupils at risk of school dropping out, proposing some guidelines for educational intervention and sharing some key experiences from an educational robotics project carried out with Lego EV3 and Wedo 2.0 robots. Then, in their contribution Maura Sandri and Gabriella D'Orsi present a summer camp organized under the national educational programme (PON) "Social inclusion and fight against marginalization", based on digital storytelling with Scratch and addressed to 30 students at a lower Secondary School, aimed to rebalance conditions of socio-economic disadvantage and help break down gender stereotypes. In conclusion, the last paper, *When robotics helps to overcome barriers and grow up* written by Emanuela Scaioli, describes the three-year experience of a girl with ASD in a Robotic Lab at Secondary School, building and programming robots in team, projecting scientific activities and preparing robotic competitions.

Introductory essay. Disability at School: The inclusion is not ambient music

by *Matteo Schianchi*

Inclusion is by now an ordinary term when talking about schools and disabilities and, naturally, it must be declined in a broader perspective aimed at all pupils and all diversities. Remaining on the subject of disability, it has been said that this concept is now assuming a rhetorical function: it is ambient music because alongside its continuous proclamation no radical, widespread and significant changes are produced (Gardou, 2015).

Inclusion, in fact, is a complex horizon to be reached in a short time, it risks becoming a consolatory chimera if we do not return to focus, beyond the normative dimension, beyond the didactic technique, on cultural, social, pedagogical processes and on the very conditions that produce inclusion. Pupils with disabilities continue to be considered inferior individuals in everyday practice, in the eyes of adults and classmates, and in ordinary pedagogical approaches. In this context, obviously, no kind of inclusion is possible.

The Italian way of the school "for all" has long been the subject of analysis around its lights and shadows (Canevaro, 2007; Canevaro & Ianes 2016). There is also a lack of evaluation on the methodological procedures implemented (Cottini & Morganti, 2015). Certainly, despite significant experiences, there is still a lack of a well-established and organic system of inclusion in all schools: pupils with disabilities are mainly taken care of by support teachers. With the exception of primary schools, where teachers must now be trained in "special education" as part of their university course, the preparation of teachers is very poor. In many situations, pupils with disabilities have good individualized courses: their schooling proceeds on a parallel track that never meets that of the rest of the class, except on spontaneous occasions or in small projects. We have exceptional tools at our disposal to design and evaluate inclusion (Booth & Ainscow, 2011). Universal design for learning, based on reshaping didactic approaches and tools on individual learning modalities, but according to logics attentive to the involvement of all students are still far away. Personalization is best done. The levels of social exclusion of young people with disabilities when they finish school, i.e. when the forced coexistence with their peers is over, are very high: from the age of 18 onwards they attend services, social situations, professional conditions "for the disabled" (Schianchi, 2021a).

In these pages I intend to focus on some aspects that are sand in the gears for inclusive schools. In other words, it is a question of considering, in synthesis, some dimensions that seem to me to be scarcely addressed not only in the school debate and academic reflection, but also in the same training courses for teachers, both support and curricular.

The origins of school inclusion

In 1977, the Italian school, with an unprecedented measure, adopted a decisive change in terms of teaching and management of disability situations: the establishment of a single school pathway for all pupils put an end to the separation based on the system of differentiated classes and special schools. This officially ended the era of separation of pupils with disabilities, of medicalization (Ascenzi & Sani, 2020). In reality, the measure was not unanimously welcomed. It is enough to reread the news of the following year to see how many pupils were physically removed from state schools for being "too handicapped". In order to support the new law and try to counteract the prejudices that were strongly held by public opinion, an advertising campaign was launched to raise awareness, made up of commercials and posters supported by slogans such as: «Let's stop being afraid of those who look different»; «Let's help handicapped children fit in at school».

Looking at the posters and commercials of that campaign on the web brings us face to face with messages, linguistic and social codes that may seem very distant today. Yet, some issues such as the fear of the different with disabilities evoked by those slogans have not yet been deeply elaborated. To better understand the cultural climate of those years, and the scope of the legislative measure, another example is sufficient. A few years earlier, one of the first experiences of families with children with disabilities organized in Versilia (Tuscany) and narrated by a documentary ("L'estate più bella", 2018) had been strongly opposed (Alimena, 2021). In fact, such ordinary issues as accessible schools and holidays for people with disabilities continue to pose problems even today. After all, special schools, both public and private, continue to exist (Merlo, 2015); meeting disabled people in a holiday center continues to be a nuisance (Onnis, 2021). Moreover, the refutation of school inclusion of pupils with disabilities is beginning to have a certain scientific credentials (Ianes & Augello, 2019).

School inclusion was actually popularized with the UNESCO Conference in Salamanca (1994). The history of special education also distinguishes between the years after 1977, defined as the phase of inclusion, the 1990s, based on the concept of integration, and today's, which began with the new millennium, centered on the notion of inclusion. The latter, in the school context, is defined as a process oriented by cultural, political and ethical choices made by school models aimed at building an educational environment capable of welcoming everyone, focusing on participation and without excluding: everyone's differences (disability in our case) must be addressed in everyone's classes, according to specific strategies and methods that address those conditions, not according to a logic that excludes on the basis of criteria of normality.

More generally, the concept of inclusion linked to disability stems from a set of instances that redefine the very nature and essence of the issue, the participation and social roles of people. From the 1990s onwards, the social model of disability was definitively discussed, with the first formulations among disability activists and scholars dating back to the 1970s. According to this approach, it is not impairments as such that lead to a specific social condition of disabled people under the sign of exclusion. On the contrary, it is a social issue: in order to avoid the social exclusion or imprisonment of people with disabilities within specific institutions, the focus of the issue must be shifted from the deficits (which exist and are not to be denied) to the ways in which the political, social and educational contexts respond to the specificities of those individuals. Some commonly used tools or regulatory guidelines have supported this social definition of disability. For example: the bio-psycho-social classification of functioning and disability (ICF, 2001) adopted, as a rule in Italy, as one of the tools on which to base the school inclusion of pupils with disabilities; the UN Convention on the Rights of Persons with Disabilities (2006 and Italian law since 2009) which reasons in terms of the human rights already inherent in persons with disabilities, pointing the finger at forms of discrimination. Reasoning in terms of inclusion therefore means shifting the focus from deficits to the system of contexts, relationships and supports that favour the participation, self-expression and learning of people with disabilities.

Certainly, the cultural and conceptual instances, the necessary tools and the radical individual and collective changes to achieve inclusion are not assimilated by decree. The idea of disability as a deficit, as an objective obstacle that prevents people from doing things normally, remains widespread; in this condition people must be assisted so that they can satisfy their basic needs. This is the belittling and interiorizing idea that remains of disability: nothing to do with inclusion.

Discomfort in the face of disability

The long presence of pupils with disabilities in ordinary school life, their management by specific figures such as support teachers, educators, assistants, educational processes and everyday school life that unfold through tools, methods, relational contexts that we know to be articulated, complex and contradictory have made us forget something that is constantly present: disability poses a problem. Basically, the handling of these now ordinary presences in the school world has led us to ignore the psychological, social and relational discomfort that assails us when we are faced with disability, all the more so if it is of a complex type. Non-ordinary functions, languages, ways of relating, communicating and learning, difficult and painful situations, which we sometimes have few tools to decipher, pose problems for us and, in the end, disturb us. Even if we do not say so openly.

This uneasiness is an implicit deflagration on which research and teacher training should focus (Schianchi, 2021b).

The dynamics and sacrosanct principles of inclusion based on the idea that through daily attendance, the sharing of places, relationships, educational processes between "able-bodied" and "disabled" people are often left to spontaneous dimensions, to purely emotional approaches and rarely the subject of reflection. The sharing of places and experiences between different people is necessary and unavoidable, but it does not spontaneously and magically erase either the subjective discomfort in the face of disability or the dynamics of interiorization of the people who have it. On the contrary, the social and psychological literature has for some time been reminding us that the psychological discomfort caused by disability is continually present, deep-seated and cannot be neutralized even by greater knowledge (Braud, 2003). Forms of stigmatization and contempt towards those with a disability do not necessarily reduce with familiarity (Goffman, 2003). Some attitudes of positive acceptance of diversity at an explicit level are contradicted by implicit forms of rejection (Volpato, 2019). The processes of interiorization of people with disabilities are culturally and socially deeply rooted, to the point of being natural, and continually subject to renewal (Schianchi, 2019). The origins of this discomfort are, at the same time, psychological, social and cultural.

For some time now, a concept coined by Freud in 1919, the uncanny, has been introduced into the field of disability (Sausse, 2006). According to the father of psychoanalysis, when faced with different types of impairment we are disquieted, a sensation that lies in the sphere of what is frightening to us, causing anguish and horror. It is our unconscious that drives the mechanisms of this feeling, that weaves its threads. Uncanny is not what is unknown to us (and of which we can be afraid), but what should have remained hidden, secret, but instead, has re-emerged. It is something that had become extraneous through the process of removal and instead suddenly resurfaced. In addition to death, disturbing situations include epilepsy and madness, as well as infirmities of the body: mutilations and non-ordinary bodily manifestations (Freud, 1969).

Since it is always unforeseen, unpredictable, and undesirable, disability has a traumatic effect that imposes itself on our psyches: it prevents them from thinking about and harmoniously integrating the elements of the external world. In the face of disability, our gaze is placed in front of an absurd dimension that we cannot understand. It is impossible to make sense of this situation. The difficulty in relating to disability is not only in our unconscious, but in our way of thinking about and experiencing the body. Here another interpretation comes into play that is useful to consider.

We know, in fact, intimately and in the very materiality of our lives, the importance that our body has in the construction of our biological, psychic and social world. Don't we always find it difficult to relate to the complicated evolutions of the body, with its explosions, hesitations and decay? We sink into our bodies. That is why when its agreement with the world breaks down, our existence feels the ground beneath its feet missing and falls into uncertainty (Binswanger, 2007).

It is here that we all share the issue of disability as an attack on the body and its integrity. For some (the person with a disability) it is an experience. For some others (the person without a disability) it is a fear, a possibility never escaped forever. The person with a disability in front of us, and the person with a disability in front of him/herself both when he/she has lost his/her own bodily integrity in the course of his/her life and when he/she has never had it, refers to a possible aspect of our being in the world. It reminds us of our difficulty in thinking we can live with a disability, but also of the inevitable decline in life. The encounter with disability calls into question the existential alternatives, continually based on the body, between life and death, between ideal and real. According to this further interpretation, the uncanny, unlike Freud's thought, is not linked to the unconscious. That is, it does not bring out what was hidden and should have remained hidden but is precisely the becoming visible of the original existential anguish that characterizes our being in the world.

The socio-cultural origins of discomfort

These purely psychic dimensions originate in the body: the only common denominator among humans, the only way of grasping what we call the individual, the basis of our being in the world, of our existence, of our identity, of our relationships. In fact, disability is not a matter for some individuals, their families and the professions and services that deal with it: it is a matter intrinsically linked to the very nature of human beings. What we now call disability is a biological and social condition that characterizes the history of humanity. The whole body and the disabled body have always existed. There is no human history without impairment. However, this condition is considered abnormal, deviating from normality. On the contrary, human biological-social nature is made up both of integrity and of congenital or acquired bodily impairments caused by diseases, genetic errors, infections, accidents, incidents of various kinds, clashes, war-military events, accidents at work, forms of punishment and torture, self-damaging behavior, poor hygiene and food conditions. This non-unique biological nature, but made up of both bodily dimensions, is continuously removed, denied in all social and cultural dimensions and in our own psyche.

All types of disability (physical, intellectual, psychic, sensory) always involve, first and foremost, functions and uses of the body. It is precisely because it involves the body that disability is a universal anthropological issue. The body is not simply a biological envelope: there is never a division between body and soul, between soma and psyche, between sensibility and intellect, between instinct and spirit. The body, the relationships we build on it and the image we have of it are part of our interiority. In the body, on the body, our psychic sphere and our social sphere intersect, intertwine seamlessly, it is a precondition. For these reasons, psychic and social, psychic because social and vice versa, disability always concerns us, all of us, individually and collectively, and continually poses a problem. It is a theme that questions the idea that the human being has of his own nature. It raises questions about the ways and means of being in the world, about the boundary between human and non-human, between normal and abnormal, between life and death. It raises questions about the reasons why impairments develop that lead to deviations from what is considered normal, about their meaning, about the possibility of treating them, healing them, managing them, normalizing them. In other words, the disabled body highlights something that concerns all bodies. The social cannot be abstracted from the body. Bodies are, always and since always, in practice, subjected to social and cultural readings and constructions. This is true in living bodies and in thinking about them. The body, including the body with disabilities, is always, continuously and immediately invested with social values and meanings.

In our daily lives, we unconsciously classify bodies and people. Bodies are always classified in relation to gender, age and performance (Mauss, 2017). Disability casts doubt on the fact that we can fully fill the social roles that compete, at all ages and as they evolve, for women and men. The presence of impairments calls into question the reality and the sense attributed to the things of the world, for which those who, through their bodies, are able to guarantee the production and reproduction of the social order have social value: «Since the classificatory schemes through which the body is perceived and practically evaluated are always doubly founded, in the social division and in the sexual division of work, the relationship with the body is specified according to the sexes and according to the form assumed by the division of work between the sexes according to the position occupied in the social division of work» (Bourdieu, 2005, pp. 111-112).

Under the aegis of this whole series of relationships we have with the body, the person with a disability, because of that body and its compromised functions, seems to us, intuitively, not very suitable (in-able, dis-able, invalid) to be in the world: his existence is problematic. The ordinary individual for us is the one who acts to produce value and increases his value through relationships, work, exchange. The psychic, social and cultural reasons for which disability has always posed a problem contribute to fearing this intrinsic dimension of humanity, to considering it as abnormal, unnatural and undesirable. The status of inferiority that we attribute to individuals of any age with any kind of impairment is therefore pure and unconscious automatism. Stigmatization, discrimination, more or less unconscious pietism, forms of welfare, reduction to inferior individuals and citizens, as is well known, are clear consequences of these dynamics.

The persistence of stigma

The concept of stigma is well known and was coined by Goffman in 1963 precisely because of disability issues. Stigma is not a characteristic of the individual, a mark stamped on his or her body, but a social relationship: it is a point of view, a way of considering individuals with certain characteristics. This form of classification, which establishes a hierarchy of people, occurs and is reproduced in relationships: «one must not lose sight of the fact that what counts is the language of relationships and not that of attributes» (Goffman, 2003, p. 161).

The presence of stigmatization mechanisms continues to be present even in the social and professional environments in which disability is routinely present. Moreover, familiarity does not necessarily reduce contempt (Goffman, 2003). It is no coincidence that a more recent interpretation of stigma calls into question precisely situations in which there is disability (communities, social and health services) and professional figures related to them (Kleinman, 2002). In this meaning, stigma is not linked to a denial of the other and his or her non-ordinariness: it is the expression of a specific moral sense and a series of emotions and feelings that demand to be affirmed. It is the moral sense of discomfort in the face of non-ordinary functioning that continuously invokes the need for ordinariness, the normal course of things. Stigma is thus an element through which the members of a local community, a microcosm, express and defend their adherence to certain values: this can lead to the adoption of stigmatizing, if not violent and discriminatory criteria towards those who are considered responsible, with their anomalous presence and functioning, for challenging them.

Stigma becomes the unconscious and easy escape route, a form of survival, of the teaching and educational figures who work with disabilities. It is indeed difficult to enter into a relationship with non-ordinary functioning: the relationship involves a long work of mutual understanding and adaptation that also needs to be understood, supported. It is complex to deal with families who bring weariness, experiences, uncertainties and radical problems. It is difficult to disentangle a parent's illusory hopes, dreams, lack of awareness or partial awareness of the difficulties of a child with disabilities and the fact that professionals and services themselves may not see certain possibilities and potentialities. All these dynamics, when they do not find relevant ways to be understood and processed (and it must be the prerogative of every socio-educational service to provide this), easily find their solution in stigma. They concretely return to the idea that it is those behaviors, those deficits that represent the real problem. On the contrary, the crux of the matter, without denying the difficulties, is the individual and collective inabilities of the same service to deal with those complexities. Stigma is triggered in this inverted dynamic. That is, it is triggered in every possible context, in defense of values, dictates, conventions of norm and normality. The diversity of disability challenges them. So, instead of allowing oneself to be questioned by finding ways, strategies, behaviors, relationships that favour respect for each body and functioning, i.e. for each individual, it is much easier to point the finger at the anomaly and normality of the other.

Each person's beliefs about disability are based on prejudices, stereotypes, and experiences, but these last two steps are often lacking. However, the inclusive perspective, in order to take shape, needs a cultural substratum that must become a specific object of reflection and construction: the messages implicitly conveyed by teachers with respect to disability contribute to forming this culture in learners.

At the root of all these highly articulated dynamics is the general persistence (although there is no lack of significant experiences) of stigma. Not stigma in its basic, easily identifiable and censurable dimension, but stigma as an anchor of everyday life, as a means of defending ordinary values and functioning. Of course, all this happens without intending it, nor planning it, nor openly desiring it, but it happens. It continues to produce forms of interiorization of people with disabilities. And it will continue to happen until these dynamics become the object of analysis, confrontation, discussion, shared debate, throughout the school world and academic research itself. Let us look at some of them.

Let us start with words that seem innocent (to you this check to others another), with gestures that seem trivial (the positioning of desks in a classroom and the reasons behind them). We think of the time spent by pupils with disabilities outside the classroom, of their being looked after by figures (specialized teachers, educators) whose status is devalued. Is this not enough to tell us that this necessarily produces a devaluation in these pupils, in their peers, in the whole school world?

Let us add the use of diagnostic categories, not to mention acronyms, with which these pupils are commonly identified (the BES, a DVA, ADHD, etc.). Their accumulation in current and administrative language ends up making them effectively "specific and inferior subjects", as well as becoming categories of school spirit. The very naming of specific tools that are certainly necessary (diagnosis, PDP, PDF), the idea that they have to carry out "minimal" school programs with dispensations, compensations, alternative tools that trigger like an unconditional reflex. All this, in everyday language and practices, produce a stigma linked to the difficulty of coming to terms with diversity is motivated by a school moral sense that defends its own values, its own procedures, its own hierarchies of knowledge and individuals.

It is not yet common sense that schools are no longer governed by the imperative of national programs, but by specific educational objectives (law 59/1997): it is the school programs that must educate by adapting to the needs and specificities of children (including the presence of disabilities) and not vice versa. The student must be placed within the educational project, recognizing the potential and specific needs of each one. On the contrary, one continues, by instinct, to reason and act with educational-didactic ways based on the average normal pupil. Disability is not considered as a characteristic that must be taken into account in order for that specific pupil to reach the maximum of his or her potential and possibilities (and there are many in each pupil, even the most impaired), but continues to be thought of and experienced as a negative characteristic, which prevents pupils from doing as others do, that is, from being normal. It is always thought of as an inferior form of schooling, i.e. of life. The conceptual basis with which we view disability is always that and continues to produce stigma and inferiorisation. All these everyday dimensions are part of the labelling processes inherent in stigma.

The certifications, diagnoses, all the medical, administrative and bureaucratic procedures and processes to access services and benefits, specific to one's condition (and to which one is entitled), and which motivate and justify the professional figures, devices and money that go together, enter the school in a whole circuit of thoughts, practices, perceptions and relations that are, in fact, a continuous occasion for the production of stigma.

Facing us, on a daily basis, are

> the myth that the integration and teaching of pupils with disabilities must be based on medical and bio-structural knowledge [… the] need for the medical "piece of paper" to activate additional resources and teachers often still believe that a functional diagnosis from the ASL is needed in order to be able to construct meaningful individualized programming […] an individual-medical legal culture [that] weakens the pedagogical one and the work of the school, delegitimizes curricular teachers and delegates special ones, gives breath to specialist and hyper therapeutic sirens (Ianes & Augello, 2019, pp. 44-45).

The presence of new tools for the construction of school paths suitable for pupils with disabilities (the ICF-based individualized plan), even when it becomes fully operational and if it works over time, will not be sufficient to produce inclusion, to erase the stigma if cultures, people, contexts and relationships are not changed. We are still faced with a school that confirms inequalities even in the face of disability, despite egalitarian and inclusive principles.

Inclusion and liminality

Another concept is particularly interesting for interrogating inclusive practices, that of liminality. The concept was introduced in disability studies by taking up some classics of anthropological thought. Adopting some concepts related to rites of passage, Murphy (2017) states that people with disabilities are always, constantly, by their essence in an intermediate condition, of liminality, a social and cultural mechanism whereby they are considered neither sick nor healthy, neither dead nor fully alive, neither outside society nor fully participating. This is why people with disabilities live constantly, in a state of social suspension: they are neither flesh nor fish, they exist in partial isolation from society as persons, undefined.

This concept has been used to analyze how some people with intellectual disabilities had left an institution to go and live, in co-housing, in a city neighborhood: their everyday life had been built halfway between the institution and the neighborhoods community, which does not recognize them as its members by constantly thinking of them as those in the institution (Calvez, 1994). The school life of a pupil with disabilities who attends an ordinary school but is often, if not continuously, separated from his or her peers, only with the support teacher or in a special classroom, is also liminal.

Equally liminal is the everyday life of young people who attend schools, specific recreational and rehabilitation services and who end up in a world of their own (of relationships, of reference figures, of friendships) even if these services are "mixed", i.e. involving contact with facilities and people not related to the disability.

In this sense, liminality as a tool allows one to consider, in practice, the relationships experienced by persons with disabilities in order to interrogate the socio-cultural assumptions and repercussions of educational actions and processes. It is therefore useful to grasp, to explore, a series of aspects of the social experience of persons with disabilities and to move away from static and often oversimplifying readings, generally based on antithetical categories such as inclusion-exclusion. It also makes it possible to measure and evaluate what it means to be, eventually, included by focusing attention on the fact that being "within society" (i.e. not in separate places or situations) does not at all mean being included, participating. This presence may not be full, authentic, resulting in liminality. The fact of participating in a social gathering says nothing about the quality and characteristics of that belonging. The experience of pupils in state schools, for example, tells us this. Not only in everyday life conducted in the famous support classrooms, but at the end of the school day or cycle, when these children and young people often remain separated from the relationships and sociality of their classmates. In other words, it is the nature of belonging (or non-belonging) that concretely imprints a mark and a meaning on the experience of a person with disabilities.

Liminality, also, is a concept that, like that of stigma, questions us deeply and allows us to understand, in a different light, the assumptions with which we think and consider people with disabilities and how they experience these dynamics. Even with liminality, and despite certain criticisms that continue to start from a heuristic deficit that does not consider the whole prism of the components of disabilities and all the cultural, social and symbolic aspects that precede the socioeconomic mechanisms themselves, the very definition of disability and the social position that people are given are always at stake. The condition of liminality is the result and consequence of dynamics (thoughts, words, actions) that affect persons with disabilities and from which they can hardly escape. More precisely, it is constructed through a twofold movement: 1. persons with disabilities are given specific attention, treatment and services; 2. persons with disabilities and those who deal with them know that these collective and individual actions can never guarantee social inclusion.

Murphy affirms that this condition of liminality leads one to be in a situation between two antithetical experiences, highlighting the lacking, deficient, half-hearted character of the experience, without a precise identity, neither flesh nor fish. But this position between one thing and another is continuous, in everyday life and throughout existence: between inclusion and exclusion, between normality and abnormality, between difference and homologation, between ordinary services and specialized institutions, between discourses of inclusion and practices of exclusion, between being an ordinary citizen and a person with special needs, between being noticed and going unnoticed, between access and inaccessibility, between ability and deficit, between compensation and overcoming the limit, between autonomy and dependence, between family and external relations, between rights and assistance, between aspirations and needs.

Conclusions

The inclusion of disability, also in schools, is not a dynamic that is produced neither by decree, nor by guidelines, nor by educational technique, nor by good feelings. For this reason, teachers, but also the university and research world, cannot be content to move in normative or ideological circles. A reflection from a few years ago still applies:

> Acknowledging "different" therefore means not being under the illusion that it does not constitute a real problem of intervention, that it can be calmly assimilated to its term of diversity with the wishful thinking of socializing rhetoric, political apostolate, private philanthropy and false bourgeois consciousness. But to truly recognize diversity is to re-appropriate it to social living. Its "re-appropriation" is in fact required by the fact that the "diversity" of the handicapped can be recognized in its real meaning not as danger or extraneousness, but as a differentiated mode of the "being" of every human person (Massa, 1986, p. 178).

The condition of disability has always been the object of practices and cultures that have their core in inferiorisation. The more complex the impairment, the stronger the dynamics of inferiorisation. No educational process can be said to be inclusive if it does not succeed in producing, in the everyday life of people with and without disabilities, concrete experiences that combat, and do something different from, those forms of inferiorisation.

References

Alimena E. (2021), *Lotta per l'inclusione. Il movimento delle persone con disabilità motorie negli anni Settanta in Italia*, Erickson, Trento.
Ascenzi A. e Sani R., a cura di (2020), *Inclusione e promozione sociale nel sistema formativo italiano dall'Unità ad oggi*, Franco Angeli, Milano.
Binswanger L. (2007), Per *un'antropologia fenomenologica. Saggi e conferenze psichiatriche*, Feltrinelli, Milano.
Booth T. e Ainscow M. (2011), *L'index per l'inclusione*, Erickson, Trento.
Bourdieu P. (2005), *Il senso pratico*, Armando, Roma.
Braud P. (2003), "Violence symbolique et mal-être identitaire", *Raisons politiques*, 9: 33-47.
Calvez M. (1994), "Le handicap comme situation de seuil: élements pour une sociologie de la liminalité", *Sciences sociales et santé*, 1: 61-88.
Canevaro A. (2007), *L'integrazione scolastica degli alunni con disabilità. Trent'anni di inclusione nella scuola italiana*, Erickson, Trento.
Canevaro A. e Ianes D. (2016), *Orizzonte inclusione. Idee e temi da vent'anni di scuola inclusiva*, Erickson, Trento.
Cottini L. e Morganti A. (2015), *Evidence-Based Education e pedagogia speciale*, Carocci, Roma.
Freud S. (1969), *Il perturbante*, in Id., *Saggi sull'arte, la letteratura e il linguaggio* (pp. 267-307), Boringhieri, Torino, vol. I.
Gardou C. (2015), *Nessuna vita è minuscola. Per una società inclusiva*, Mondadori, Milano.
Goffman E. (2003), *Stigma. L'identità negata*, Ombrecorte, Verona.
Ianes D. e Augello G. (2019), *Gli inclusio-scettici. Gli argomenti di chi non crede nella scuola inclusiva e le proposte di chi si sbatte tutti i giorni per realizzarla*, Erickson, Trento.
Kleinman A. (2002), "Santé et Stigmate", *Actes de la Recherche en Sciences Sociales*, 143: 97-99.
Massa R. (1986), *Le tecniche e i corpi. Verso una scienza dell'educazione*, Unicopli, Milano.
Mauss M. (2017), *Le tecniche del corpo*, ETS, Pisa.
Merlo G. (2015), *L'attrazione speciale. Minori con disabilità: integrazione scolastica, scuole speciali, presa in carico, welfare locale,* Maggioli, Rimini.
Murphy R.F. (2017), *Il silenzio del corpo. Antropologia della disabilità*, Erickson, Trento.

Onnis S. (2021), "L'utente al tempo dei soggiorni estivi. Appunti per un'etnografia sulle vacanze riabilitative per disabili adulti del servizio socio-sanitario", *Minority Reports. Cultural Disability Studies*, 11: 153-173.
Sausse S. (2006), *Specchi infranti. Uno sguardo psicoanalitico sull'handicap, il bambino e la sua famiglia*, Ananke, Torino.
Schianchi M. (2019), *Il debito simbolico. Uno studio di storia della disabilità in Italia tra Otto e Novecento*, Carocci, Roma.
Schianchi M. (2021a), *Disabilità e relazioni sociali. Temi e sfide per l'azione educativa*, Carocci, Roma.
Schianchi M. (2021b), "Il disagio di fronte alla disabilità. Un deflagrante implicito su cui centrare ricerca e formazione degli insegnanti", *Professionalità studi*, 3: 148-167.
Volpato C. (2019), *Le radici psicologiche della disuguaglianza*, Laterza, Bari-Roma.

Section 1

Studies

Are robots boys or girls? Reflecting on stereotypes and opportunities in robotics in educational contexts

by *Daniela Bagattini* and *Beatrice Miotti*

Introduction

Educational robotics is, as we will see, increasingly widespread in Italian classrooms: initially this happens thanks to experimental projects, while since 2018, with the release of the "Indicazioni Nazionali Nuovi Scenari" (National Scientific Committee for the National Indications for the curriculum of the preschool and first cycle of education), robotics together with coding assumes «relevance also in terms of the curriculum» (Bagattini & Miotti, 2022, p. X). In addition to being effective in strengthening transversal skills mainly related to problem solving arising from reality tasks and all those skills that fall into the group of soft skills, educational robotics also has the ability to engage the emotional component which, according to Piaget, constitutes learning, together with the cognitive component. Giovanni Marcianò (2017) proposes a reflection on this aspect, highlighting how «the child's operational effort always corresponds to a strong affectivity experienced both internally and projected onto the artefact» (p. 7, our translation) and how «The "child-artefact" relationship (creator-creatures) has, with robotics, an "artefact-child" mirror relationship (creature-creator)» (p. 7, our translation). Recent studies also seem to show how working with laboratory teaching in scientific disciplines can help to broaden the "thinking space" of boys and girls: the possibility of testing themselves, reflecting on error, reconstructing, could help to mitigate the perception of low self-efficacy of girls in scientific disciplines (Hartmann et al., 2007; Zorn et al., 2007; Sullivan & Bers, 2013; 2015; 2018; Master et al., 2017; Banzato & Tosato, 2017; Screpanti et al., 2018).

At the same time, in the study of Human Robot Interaction one of the themes brought to attention is gender categorisation and the consequent possible attribution of stereotypes in the construction of the interaction. This issue is part of the broader debate on the risk of amplifying biases (gender, but also others) in artificial intelligence and seems interesting to address when we introduce robots in education.

So, on the one hand we have potential, on the other hand we have risks: how can robots help us or to what extent can their introduction reinforce those very stereotypes?

The aim of this contribution is to draw attention to the possible biases inherent to the introduction of robots and AI elements in the educational field: after discussing and illustrating how educational robotics can be used in the educational field, we will shift our attention to the issue of gender biases. Through analysis of the literature on the subject, we will try to provide a key to understanding and some reflections in order to build a child/robot relationship from school onwards as an opportunity to overcome prejudices and constraints rather than nurture them. The use of robots without stereotypical connotations can in fact allow a reflection on gender roles and dynamics as early as preschool and primary school, including through the reversal of "traditional" roles.

Educational Robotics

Educational robotics is a pedagogical approach in which technological artefacts are used by students as tools in an active teaching context for learning mainly interdisciplinary knowledge and skills. Educational robotics can allow students to see for themselves the application of the theories shared within the disciplines. Moreover, it can allow them first-hand experience of the laws and models that underlie reality (not only physical but also linguistic and humanistic). Lastly educational robotics encourages transversal skills ranging from problem solving to those defined by the DigComp 2.1[1]

[1] In particular competence 5.3 "Using digital technologies creatively" of the framework "Use digital tools and technologies to create knowledge and innovate processes and products. Participate individually and collectively in co-regulatory processes to understand and solve conceptual problems and problem situations in digital environments". https://docs.italia.it/italia/designers-italia/lg-competenzedigitali-docs/it/stabile/index.html.

framework on basic digital competence at multiple levels of experience, according to the school grade in which it is proposed.

The use of technology as a support for learning is not a new phenomenon, although it has recently gained more traction in terms of products, teaching proposals and training courses for teachers, but it finds its pedagogical foundations in the activities carried out by Seymour Papert in the 1970s. His studies led to the creation of an artefact controlled by instructions given by the students via a personal computer which was able to support the study of geometry. Papert, in his idea of constructionism (Papert, 1986; Harel & Papert 1991), affirms that learning is more effective when connected to a manipulative activity, when the students are constructors of the tools themselves, because the process that leads to creation is itself a moment of learning (Papert, 1980). Constructionism, on the other hand, draws its origins from constructivism and adopts its structural framework, which places the student at the centre of his or her own learning process, while attributing to the teacher the role of facilitator and guide to the students in the creation of their own knowledge, both through the physical construction of artefacts and through reality tasks. Active teaching thus becomes the most effective methodological framework that can be applied to find its fullest expression.

In the "learning by discovery" methodology (Bruner, 1961), as well as in the learning by doing approaches (Dewey, 1938) or in problem-based learning, the problems that are proposed to students are real and involve phases of observation, reflection, analysis and modelling of the problems by the boys and girls in order to find a solution that is not necessarily univocal. It is the path the student takes to reach the goal that gives the activity its educational value. The approach to error is also new and becomes an integral part of the process from problem to solution. The development of a strategy for solving a problem necessarily leads to proceeding in consecutive steps, thus refining what has already been achieved when faced with failure or an obstacle. In this case the error does not represent a negative judgement but has a strong heuristic potential, as it acts as a guide for the student, helping him to approach knowledge. Maria Montessori (1970) also spoke of "Mr. Error" with the aim of helping students to achieve autonomy and self-learning, thus giving a non-derisive connotation to the term itself. Students should not be afraid to try out an activity, because even in the event of failure this could be taken up with the teacher as a moment of reflection to improve their own progress.

Affiliation and identification in Educational Robotics

Robotics thus becomes educational insofar as it expresses children's own fantasy world, stimulates their imagination, leads them to actively devise and implement a project, unlike other technological methods in which they are passive users (e.g. simple video games). Producing an artefact does not only mean achieving an educational objective or completing an assigned task, it also means projecting one's own abilities onto an external object and this creates a sense of affiliation with the object. Children are proud of what they achieve because it is a product of their own imagination and not something derived from the outside world. In addition to these emotional aspects, there is also a sense of identification between the students and the robot. Often when they have to program the artefact's movements, the students put themselves in its place and follow the commands given by their companions as if they themselves were machines. Marcianò (2017) wrote: «Robotics brings children face to face not only with human behaviour. In a completely new relational dynamic: the child transfers his or her own behavioural patterns to the robot, and then assesses its success» (p. 8, our translation).

Donatella Merlo (2010), a teacher affiliated with the Movimento di Cooperazione Educativa, also talks about how powerful the use of educational robotics is with children: «Robots are special artefacts because they simulate the behaviour of a living being or animal. This means that they are perceived as being endowed with an intelligence of their own, with which they can communicate and thus establish a kind of relationship. From an educational point of view, this aspect is very powerful, because thanks to the special bond that is established between the object and the person who builds it, it helps to create motivation in the pupils» (p. 1).

It is precisely in these aspects that what we describe in this paper has relevance, because it is evident that the transfer of one's own schemes to the robot involves a transposition of one's own habits and thoughts that can be highly subject to biases of various kinds.

If Educational Robotics is a methodology that creates affiliation and motivation in students, to different degrees depending on the school level in which it is employed, the context in which it is activated is also important: being mainly an interdisciplinary activity, it cannot be carried out using a lecture-style teaching method or without a responsible and conscious involvement of all the teachers concerned. It is important that the students feel they are protagonists in order to activate what we have mentioned earlier and it is equally important that the teachers are able to bring out as needed the competences related to their discipline without making them the focus of the whole process.

Recently, a category of humanoid robots has also entered the classroom. They are part of a branch of robotics known as Social Robotics, which is not limited to the educational sphere but it is finding a range of applications in various fields such as hospital care, care of the disabled, etc. Unlike the various robotics kits that for years have allowed students to create their own artefacts, humanoid robots do not have to be co-designed by students, but are used as a means of studying the design of behaviours and actions, or for more emotional interaction, such as in the case of disability. Social robots are programmed to be able to interact and communicate with humans by responding to a set of social rules and behaviours appropriate to their function. The artificial intelligence that drives these objects is crucial in making them interactive but above all adaptive to the situations they face.

In schools, humanoid robots can be used mainly according to two strategies: the first concerns the study and programming of their "intelligent engine", which translates into coding algorithms and functions that the robot can use to simulate behaviours or solve problems. In this regard, we can refer to initiatives such as the Nao Challenge organized annually by Scuola di Robotica[2], where teams of students challenge each other by programming a Nao robot to carry out roles and tasks of social interest (in 2022, the theme is the use of the humanoid robot to promote museum or scientific culture).

The second strategy for use concerns the use of robots as virtual assistants or teachers (Chih-Wei et al., 2010; Guggemos et al., 2022), or as assistants in the care of students on the Autism Spectrum (Karakosta et al., 2019; Alabdulkareem et al., 2022).

Risks and opportunities for Educational Robotics in the classroom

The inclusion of educational robotics in the classroom and, in particular, the use of robots as learning tools, can therefore bring interesting advantages in the development of skills.

[2] https://www.naochallenge.it.

However, we need to consider the contexts in which these methodologies can be included, without forgetting the risks, in order to fully grasp the opportunities.

Divisions of various kinds still persist in schools: economic, territorial, social, not least the gender gap, a theme we intend to focus on in these chapter.

What is the latest on school and the gender gap?

Gender gaps still persist in schools today, from two closely related points of view.

The first is that of results: as emerges from the surveys of the National Institute for the Evaluation of the Education and Training system (INVALSI), in mathematics tests there is a difference between males and females that becomes stronger as age increases and in families with lower Economic, Social and Cultural Status (ESCS) (Invalsi, 2020).

The second point concerns students' educational choices: in this case, too, the data show strong differences between males and females, in the choice of both secondary school and university (Bagattini & Miotti, 2022, in press). As we can see from the tables, strong differences in the students' choices already emerge in enrolment to secondary school: only the scientific high school and the music high school attract almost equally both sexes; for the other academic high schools and for the technical and vocational schools, the data show strong gender imbalances: girls are 16.9% of the enrolled students in the technical-technological institutes; they choose the scientific high school like their male colleagues, but not specialisations in sports and applied sciences (where they represent respectively 29.9% and 32.8%).

Table 1 - Percentage distribution by gender of pupils enrolled in the first year of secondary schools, both state and private, by address - S.A. 2019/2020

	Male	*Female*
Liceo Classico	29.9	70.1
Liceo Linguistico	21.7	78.3
Liceo Scientifico	51.1	48.9
Liceo Scientifico - opz. Scienze Applicate	67.2	32.8
Liceo Scientifico - sezione ad indirizzo Sportivo	70.1	29.9

	Male	*Female*
Liceo Scienze Umane	11.4	88.6
Liceo Scienze Umane - opz. Economico Sociale	28.9	71.1
Liceo Musicale e Coreutico sez. Musicale	52.4	47.6
Liceo Musicale e Coreutico sez. Coreutica	9.4	90.6
Liceo Artistico	30	70
Liceo Europei / Internazionali	33.3	66.7
Totale Licei	39.5	60.5
Istituto Tecnico - Settore Economico	47.4	52.6
Istituto Tecnico - Settore Tecnologico	83.1	16.9
Totale Istituti Tecnici	70	30
Professionali	56.3	43.7
Professionali - IeFP	65.1	34.9
Totale Istituti Professionali	57.2	42.8
Totale iscritti	51.5	48.5

Source: https://www.miur.gov.it/documents/20182/2155736/Le+iscrizioni+al+primo+anno+dei+percorsi+di+istruzione+e+formazione.pdf/38d3ba49-1d5d-fda5-c282-3efec2f1695d?version=1.1&t=1561644835282

The differences are more pronounced in the choice of university pathways, particularly in the ICT sector, which in 2020/21 had a total of 5,315 females enrolled compared to 32,503 males.

Since these data relate to the entire body of enrolled students (and not to newly enrolled students), the time sequence (Fig. 1) does not show great fluctuations, although a slight increase in the number of girls in ICT courses could be a positive sign to continue monitoring in the future.

Table 2 - Percentage distribution by gender of those enrolled in the various degree courses. Academic year 2020-21. FoET2013 classification

	Male	*Female*
Agriculture, forestry, fisheries and veterinary	51.8%	48.2%
Arts and humanities	27.8%	72.2%
Business, administration and law	47.2%	52.8%
Education	7.9%	92.1%
Engineering, manufacturing and construction	71.1%	28.9%
Health and welfare	33.2%	66.8%
Information and Communication Technologies (ICTs)	85.9%	14.1%
Natural sciences, mathematics and statistics	42.5%	57.5%
Services[3]	63.1%	36.9%
Social sciences, journalism and information	38.3%	61.7%
Total	43.7%	56.3%

Source: our reworking of MIUR data - http://dati.ustat.miur.it/dataset/dati-per-bilancio-di-genere

[3] The category "services" includes courses related to sports and tourism. For further classifications, see the decoding file at: http://dati.ustat.miur.it/dataset/dati-per-bilancio-di-genere/resource/3f52db2f-24ce-4605-8e51-5618cc4ff4e3.

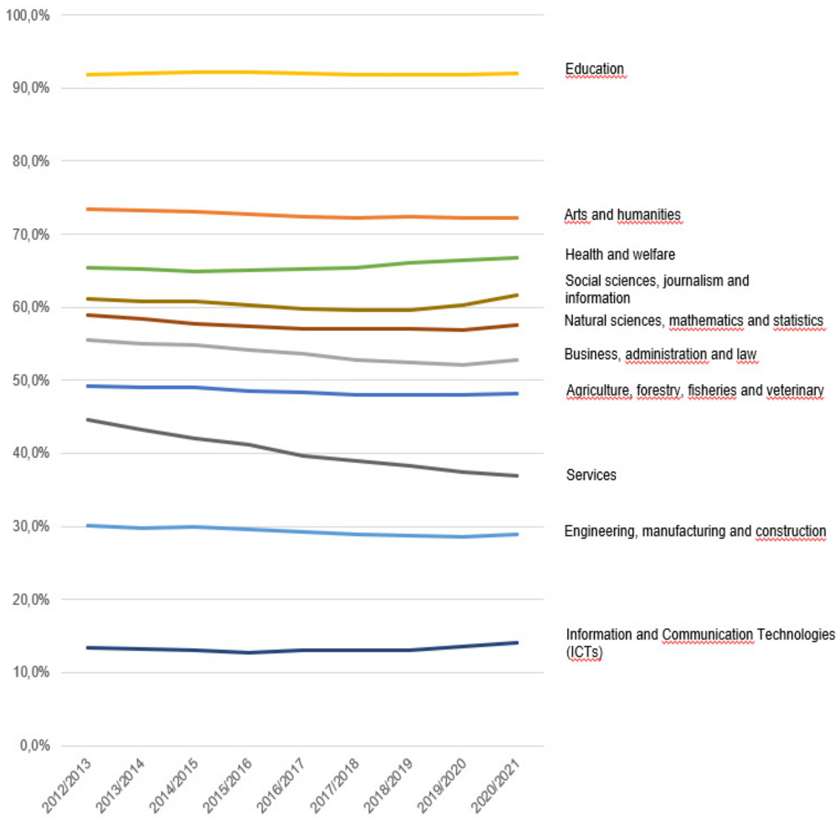


Fig. 1 - Percentage of female students enrolled in different degree courses, from the Academic Year 2021-2013 to 2020-21. FoET2013 classification.
Source: our reworking of MIUR data - http://dati.ustat.miur.it/dataset/dati-per-bilancio-di-genere

It is agreed that these differences in results and choices are not caused by biological differences (Ashcraft & Ridley, 2005; Hyde et al., 2008; Kurtz-Costes et al., 2008; Bieg et al., 2015; Ganley & Lubienski, 2016, Kersey et al., 2019), but arise from social factors, in particular from the persistence of stereotypes regarding the competences, attitudes, skills of boys and girls. These stereotypes, even if not always explicit and evident, strongly condition girls' interest in scientific subjects and, consequently, their student careers, leading to horizontal segregation (Colombo & Salmieri, 2020; Biemmi, 2010; 2017; Biemmi & Leonelli, 2017), concentration of women and men in different sectors and occupations.

When we introduce a new methodology in the classroom we cannot neglect this aspect, for two reasons: to avoid the risk of exacerbating stereotypes; to look for a way to use that innovative idea to overcome these criticalities. And robotics, from this point of view, is certainly not risk-free.

Robotics, artificial intelligence and stereotypes: The current debate

«A robot is a mirror held up not just to its creator, but to our whole species: What we make of the machine reflects what we are […] Robots don't have genders—they're metal and plastic and silicon, and filled with ones and zeroes. Gender is a complicated mix of biology, which robots don't have, and how we feel about that biology, feelings that robots also lack. Yet we are already finding ways to mirror our social problems in our robots» we read in an article published in 2018 in *Wired magazine* by Simon, entitled "It's Time to Talk About Robot Gender Stereotypes". The text addresses an issue that is having wide space in the international debate and is related to the very functioning of social robotics.

The answer to Robustelli's question: «We can ask ourselves if the attribution of sex and gender to robots can also take place solely on the basis of the presence of the same stereotypes that we attribute to human beings, for example sensitivity, empathy and disposition to childcare work as regards the female gender, and assertiveness, competition, disposition to repair objects or transport materials as regards the male gender» (2019, p. 9) is yes. Precisely in order to promote simplification, familiarisation and the construction of emotional bonds between us and robots, i.e. to make interaction simpler, in the process of anthropomorphising robots the most common mental associations are explicitly used, which, however, can conceal potentially dangerous biases: building a robot (but also an animated chatbot) using shared perceptions of what is masculine and what is feminine can contribute to feeding these sectorialisations, legitimising them (Fossa, 2022).

The problem of the reiteration and amplification of biases is a hot topic in the development of new software (Zorn et al., 2007), especially in the field of artificial intelligence, in an almost "structural" way: machine learning techniques are based on the acquisition of existing data, from which, through interaction with the surrounding environment and similarity criteria, useful information is extracted for the system to make decisions. In order to fully understand the extent of the problem and, above all, how it can be contained and resolved, it is necessary to understand how artificial intelligence works and how it is constructed.

In the meantime, we must make it clear that any robot we can imagine and build will never be able to think autonomously, like a living being. Whatever its degree of intelligence, it will never be spontaneous, but will always be constructed and decided by a human being, by a programmer. Artificial intelligence is that part of computer science that studies and develops algorithms that simulate human thought and behaviour. In order to better understand the doubts and questions described in this chapter, by simplifying an extremely complex subject with an as-yet-unexplored potential, we can identify two ways in which AI can be achieved: through supervised learning, or through unsupervised learning. Let us consider how a baby learns: his parents show him an image of a cat many times, pronouncing the correct name until the child connects the name to the animal. A link is thus established in the child's mind between the abstract and the concrete. It may happen, however, that the child encounters a cat that is slightly different from what he has in his mind, perhaps it is of a different colour, but he still manages to make an inference by calling it by the correct name, because it still has four legs, a tail and whiskers. He might actually mistake a lion or a lynx for a cat, because they have the same characteristics. To implement, for example, a system of artificial intelligence that reproduces the learning of the child, i.e. that is able to recognise a cat from many images, we proceed just like the parents with their child, submitting many images of animals to our system and leaving the algorithm the task of understanding which are cats and which are not, in the case of the unsupervised; instead, in the case of supervised learning, by giving it confirmatory feedback (for example, through a back propagation algorithm). So in this latter case we will also have linked a value (cat or not cat) to each image that we are going to submit to the system. This is perhaps the simplest algorithm of artificial intelligence and is called "binary classification". Obviously, to submit images to an algorithm requires them to be processed, which translates into a collection of encoded features related to what we want the system to learn.

The set of images that give rise to the learning process is called the "training set", and the way in which this is built is extremely important because it is on the basis of this that the AI system will or will not perform its function. Artificial intelligence systems are generally built using neural networks, i.e. data structures that attempt to reproduce the synapses of our brain in some way. But other applications exist, such as the Support Vector Machine, or the Self Organizing Map, in which the learning is not supervised and is adaptive, i.e. as new information is presented, the statistical values that regulate the possible choices are updated, and the system learns continuously.

It is precisely the fact that these systems learn from an existing corpus that cause the risk of repetition bias: this is confirmed by the famous Buolamwini and Gebru (2018) studies, which led to the latter's dismissal from the company where she worked. According to their work, the recognition systems worked very differently depending on the sex and characteristics of the face, and they managed to identify almost 100% of the white male faces, but not women's faces, especially African-American women.

The crucial element of the issue, on which the debate has focused, is the unconscious mental shift between machine, technology and impartiality: what AI does is a mirror of our society, of the way it works and of the distortions it has: if a system used to select candidates discards women's CVs, it happens because it is based on the data of the candidates accepted over the years: because most of them are male and it bases the subsequent choices on this training set.

The problems linked to the AI system itself has also led UNESCO to make a statement on the subject: «Algorithms and devices have the potential of spreading and reinforcing harmful gender stereotypes. These gender biases risk further stigmatising and marginalising women on a global scale. Considering the increasing ubiquity of AI in our societies, such biases put women at risk of being left behind in all realms of economic, political and social life. They may even off-set some of the considerable offline progress that countries have made towards gender equality in the recent past» (2020, p. 4).

The fact that AI-driven artefacts are designed on the basis of the very way we categorise and are, therefore, potential stereotype-reinforcers, does not mean that this is the only possible way. What is needed, however, is for the designer to be aware of this process of attributing human prejudices to the machine and, therefore, ultimately, to be aware of the presence of prejudices in our (human) way of reasoning. According to the Digital Economy and

Society Index (DE-SI) 2020, in Italy alone, 1.2% of the employed are specialised in STEM fields (with a European average of 1.6%). Overall, only 22% of women work in AI (28% in Italy). The data on university enrolment, which show a very low percentage of women in ICT-related fields, do not suggest any changes in the short term.

We have said that the goal of increasing the number of women in these sectors is important, but it is not enough: awareness of the problem is also needed.

Classroom risks

Before introducing robots into the classroom, it is therefore necessary to be aware of the above: firstly, stereotypical masculine and feminine concepts still influence the school careers of students, and not only are schools unable to intervene, but they first have to become aware of the problem; secondly, robotics and technological artefacts in general are neither "neutral" nor objective, but can lead to further stereotypes.

This certainly does not mean that we cannot work, and work well, with robotics in the classroom, quite the contrary.

Cecilia Robustelli, in the essay cited above, speaks of a third way. Quoting the words of Tomoko Koda, who says to «make them customizable according to the user's gender, preferences, social skills, conversational content, and culture» (2016, p. 17), she hopes that the gender of robots and virtual agents can be manipulated in such a way as to overcome traditional stereotypes while enabling "gender" recognition that does not involve, as in real life, discrimination.

The road is by no means easy, but it is absolutely necessary.

In this regard, there is an interesting survey that concerns university students, relating to the gender of robots. The results of this study «suggested that in the context of human-robot learning, robot gender does not affect participants' learning, intrinsic motivation, and the evaluation of the robot», but «Only participants' contact intentions were affected to some extent: Participants were more interested in future learning with a robot when the robots' gender did not match the task gender typicality of a given task». This leads the authors to confirm that «this outcome could be vital for social robotics: Using robots in learning context could serve as an intervention to overcome persisting gender-stereotypes and to promote equal learning opportunities for male and female students» (Reich-Stiebert & Eyssel, 2017, p. 173).

Although stemming from an exploratory study, these reflections allow us to consider the possibility of including in our work with robots in the classroom the aim of undermining the stereotypes we mentioned in paragraph XX.

Robots in the classroom: A chance to deconstruct stereotypes

So what can be done to turn a risk into an opportunity?

The first step is upstream and does not only concern robotics: recognising the possibility of unconscious conditioning in schools. Is it really the case that in every class, girls prefer subjects such as Italian, history, geography and art, while boys are more drawn to technical, mathematical and scientific subjects? Teachers should ask themselves these questions:

Is this really the case in my class? Are there any girls who seem interested?

What could be the reason for this lack of interest? What can I do to change it?

The first type of action is therefore to reflect on social roles and "deconstruct" stereotypes, inviting girls and boys to take a critical look at the world, but also at traditionally transmitted school knowledge. It is evident that such an approach towards learners requires an awareness upstream in the teachers, which is not always present, as noted in several studies (Bagattini, Pedani & Tolvay, 2021, Colombo & Salmieri, 2020; Grevio, 2020; Belliti & Serughetti, 2019; Biemmi, 2010; Biemmi & Leonelli, 2017, Abbatecola & Stagi, 2017; Dello Preite, 2014; Guerrini, 2013; Gamberi et al., 2010).

In a recent project carried out by INDIRE on coding and robotics, at the end of the course we chose to bring the issue of gender to the teachers' attention. This made it possible to reflect not only on the potential of innovative teaching methods, but also on the teachers' conceptions. On the one hand, some of them grasped the potential and also used the project to help girls increase their sense of self-efficacy with regard to stem subjects and ICT in particular, while on the other hand teachers replicated in the project the same stereotypes that prevent girls from seeing their own abilities (Bagattini & Miotti, 2022).

This type of training, however, cannot be limited to theoretical knowledge: it is necessary to stimulate the creativity of teachers in order to change the way lessons are given, overcoming a de-positivist approach that does not in itself stimulate the critical action necessary to deconstruct and even detect the presence of stereotypes. In addition to this, the creation of new content is fundamental (Colella, 2014).

With these premises we can better address the introduction of robotics and, in particular, humanoid artefacts to the classroom.

In this process, the role of the classroom group itself is fundamental: over the years there have been many robotics projects aimed specifically at girls. In our opinion, although they have the worthy aim of directing focus on the skills of females, they can be read as "exceptions". The fundamental point is instead to bring out the potential of girls in everyday teaching. In addition – and here we come to the question of anthropomorphisation – it would be advisable to avoid excessive "genderisation'" of projects, e.g. using robots with excessively marked gender traits, or building projects specifically for girls. In other words, attention must be paid to the way in which the robots are presented to the class, particularly when the relationship with the class also involves play, the process of their anthropomorphising can in fact be conditioned by our preconceptions regarding gender roles (Carpenter, Davis, Erwin-Stewart, Brandsford & Vye, 2009). If, on the one hand, at the very moment in which robots are named, dressed, there may be a risk of replicating stereotypes regarding roles, on the other hand, this very moment can be an opportunity to work reflexively on boys' and girls' conceptions and categorisations. The possibility of interacting with humanoids can on the other hand help to overcome these introjected categorisations (Koda, 2016; Robustelli, 2019), which then go on to condition educational and professional paths. The experience of the project mentioned above has shown that, if attention is paid to pre-existing dynamics and working with the class group without creating specific ad hoc paths for the girls, encouraging and supporting them, their self-awareness can be stimulated and strengthened.

Conclusions

In this brief reflection, beginning with the literature and the experience of a project conducted by INDIRE, we have tried to highlight risks and opportunities in the introduction of robotics in the classroom with regard to gender stereotypes. From our point of view, it is possible – and desirable – to use this active didactic methodology to stimulate a questioning of stereotypes, starting by unveiling their presence in the presumed objectivity of robotic artefacts and artificial intelligence itself. Discussing these issues in the classroom, playing at turning what we "take for granted" on its head can be instrumental in triggering a process of functional unravelling to highlight fractures in the narrative which, from the first childhood games, still paints one world for boys and another for girls, in order to promote self-awareness and also a future in which technology speaks a universal language.

References

Alabdulkareem A., Alhakbani N. and Al-Nafjan A. (2022), "A systematic review of research on robot-assisted therapy for children with autism", *Sensors*, 22, 3: 944. https://doi.org/10.3390/s22030944

Ashcraft M.H. and Ridley K.S. (2005), *Math anxiety and its cognitive consequences*, in Campbell, J.I.D., ed., *Handbook of Mathematical Cognition* (pp. 315-327), Psychology Press, New York.

Bagattini D. and Miotti B. (2022), *Lavorare sul genere a scuola con coding e robotica educativa*, Carocci, Roma. ISBN 978-88-290-1547-4

Bagattini D., Pedani V. e Tolvay E. (2021), *L'educazione alla parità tra i sessi e la prevenzione della violenza di genere: quale è il contributo delle scuole che partecipano al PON? Rapporto di monitoraggio sulle azioni intraprese dalle scuole e sul coinvolgimento di studentesse e studenti PON Per la Scuola: competenze e ambienti per l'apprendimento 2014-2020*, INDIRE, Firenze. Available in: http://pon20142020.indire.it/portale/?rapporti=volume-vi

Banzato M. and Tosato P. (2017), "Narrative learning in coding activities: Gender differences in middle school", *Formazione & Insegnamento*, 1, 15: 339-354.

Belliti D. e Serughetti G. (2020), "L'educazione per prevenire la violenza di genere e promuovere l'agency delle donne: lo stato delle politiche pubbliche in Italia", *Sicurezza e scienze sociali*, 3: 33-48.

Bieg M., Goetz T., Wolter I. and Hall N.C. (2015), "Gender stereotype endorsement differentially predicts girls' and boys' trait-state discrepancy in math anxiety", *Frontiers in psychology*, 6: 1-8.

Biemmi I. (2010), *Educazione sessista. Stereotipi di genere nei libri delle elementari*, Rosenberg & Sellier, Torino.

Biemmi I. e Leonelli S. (2017), *Gabbie di genere. Retaggi sessisti e scelte formative*. Rosenberg & Sellier, Torino.

Buolamwini J. and Gebru T. (2018), “Gender shades: Intersectional accuracy disparities in commercial gender classification”, *Proceedings of Machine Learning Research*, 81: 1-15.
Carpenter J., Davis J., Erwin-Stewart N., Lee T., Bransford J. and Vye N. (2009), “Gender representation in humanoid robots for domestic use”, *International Journal of Social Robotics* (special issue), 1, 3: 261-265.
Chang C.-W., Lee J.-H., Chao P.-Y., Wang C.-Y. and Chen G.-D. (2010), “Exploring the possibility of using humanoid robots as instructional tools for teaching a second language in primary school”, *Journal of Educational Technology & Society*, 13, 2: 13-24. Available in: http://www.jstor.org/stable/jeductechsoci.13.2.13
Colella P. (2014), *Libere e liberi di scegliere? Prospettive di genere nella didattica della matematica e della fisica*, in Sapegno M.S., a cura di, *La differenza insegna. La didattica delle discipline in una prospettiva di genere* (pp. 139-50), Carocci, Roma.
Colombo M. and Salmieri L. (2020), *Gender and education in Italy*, in Id., eds., *The Education of Gender, the Gender of Education. Sociological Research in Italy* (pp. 7-24), Associazione per Scuola Democratica, Roma.
Dello Preite F.D. (2013), “Stereotipi e pregiudizi di genere. Il ruolo della scuola e le competenze dei docenti”, *Formazione & Insegnamento*, 11, 3: 207-213.
Fossa F. (2021), “Robotica sociale e le tecnologie persuasive”. Available in: https://www.scuoladirobotica.it/robotica-sociale-persuasione-inganno-ed-etica-del-design/
Gamberi C., Maio M.A. e Selmi G. (2010), *Educare al genere. Riflessioni e strumenti per articolare la complessità*, Carocci, Roma.
Ganley C.M. and Lubienski S.T. (2016), “Mathematics confidence, interest, and performance: Examining gender patterns and reciprocal relations”, *Learning and Individual Differences*, 47: 182-193.
Group of Experts on Action against Violence against Women and Domestic Violence (GREVIO) (2020), *GREVIO’s (Baseline) Evaluation Report on legislative and other measures giving effect to the provisions of the Council of Europe Convention on Preventing and Combating Violence against Women and Domestic Violence (Istanbul Convention). ITALY*. Available in: https://rm.coe.int/grevio-report-italy-first-baseline-evaluation/168099724e
Guerrini V. (2013), “La relazione educativa a scuola. Educare al valore della differenza di genere per una società inclusiva”, *Formazione & Insegnamento*, 11, 3 Suppl.: 249-255.
Guggemos J., Seufert S., Sonderegger S. and Burkhard M. (2022), *Social robots in education: Conceptual overview and case study of use*, in Ifenthaler D., Isaías P. and Sampson D.G., eds., *Orchestration of learning environments in the digital world. Cognition and exploratory learning in the digital age*, Springer, Cham. https://doi.org/10.1007/978-3-030-90944-4_10

Hartmann S., Wiesner H. and Wiesner-Steiner A. (2007), *Robotics and gender. The use of robotics for the empowerment of girls in the classroom*, in Zorn I., Maass S., Rommes E., Schirmer C. and Schelhowe H., eds., *Coding and Educational Robotics. Gender Designs IT. Construction and Deconstruction of Information Society Technology* (pp. 175-88), Springer, Switzerland.
Hyde J.S., Lindberg S.M., Linn M.C., Ellis A.B. and Williams C.C. (2008), "Gender similarities characterize math performance", *Science*, 321: 494-495.
INVALSI (2020), *Competenze e disuguaglianze di genere a Scuola*. Available in: https://www.invalsiopen.it/competenze-disuguaglianze-genere-scuola/
Karakosta E., Dautenhahn K., Syrdal D., Wood L. and Robins B. (2019), "Using the humanoid robot Kaspar in a Greek school environment to support children with Autism Spectrum Condition. Paladyn", *Journal of Behavioral Robotics*, 10, 1: 298-317.
Kersey A.J., Csumitta K.D. and Cantlon J.F. (2019), "Gender similarities in the brain during mathematics development", *npj Sci. Learn*., 4: 19.
Koda T. (2016), *Perception of masculinity and femininity of agent's appearance and self-adaptors*, in Van den Herik J. and Joaquim F., eds., *Agents and Artificial Intelligence* (pp. 3-18), Proceedings of 8th International Conference on Agents & Artificial Intelligence (ICAART2016), Rome: 24-26 February 2016, vol. 1.
Kurtz-Costes B., Rowley S.J., Harris-Britt A. and Woods T.A. (2008), "Gender stereotypes about mathematics and science and self-perceptions of ability in late childhood and early adolescence", *Merrill-Palmer Quarterly*, 54, 3: 386-409.
Marcianò G. (2017), *Robot & scuola*, Hoepli, Milano.
Master A., Cheryan S., Moscatelli A. and Meltzoff A.N. (2017), "Programming experience promotes higher STEM motivation among first-grade girls", *Journal of Experimental Child Psychology*, 160: 92-106.
Montessori M. (1970), *La mente del bambino*, Garzanti, Milano.
Piaget J. (2000), *Lo sviluppo mentale del bambino e altri studi di psicologia*, Einaudi, Torino.
Reich-Stiebert N. and Eyssel F.A. (2017), *(Ir)relevance of gender? On the influence of gender stereotypes on learning with a robot*, in Mutlu B. and Tscheligi M., eds., *Proceedings of the 2017 ACM/IEEE International Conference on Human-Robot Interaction (HRI 2017)* (pp. 166-176), ACM, New York.
Robustelli C. (2019), "Robot umanoidi, genere e linguaggio. 'Siamo della stessa materia di cui sono fatti i sogni'", *Lingue e Culture dei Media*, 3: 1-15.
Screpanti L., Cesaretti L., Mazzieri E., Marchetti L., Baione A. and Scaradozzi D. (2018), *An Educational Robotics activity to promote gender equality in STEM Education,* in *International Conference on Information, Communication Technologies in Education* (ICICTE 2018), Proceedings, Chania, Greece.
Simonn M. (2018), "It's time to talk about robot gender stereotypes", *Wired*. Available in: https://www.wired.com/story/robot-gender-stereotypes/

Sullivan A. and Bers M.U. (2013), “Gender differences in kindergarteners’ robotics and programming achievement”, *International Journal of Technology and Design Education*, 23, 3: 691-702.
Sullivan A. and Bers M.U. (2016), “Girls, boys, and bots: Gender differences in young children’s performance on robotics and programming tasks”, *Journal of Information Technology Education: Innovations in Practice*, 15: 145-165.
Sullivan A. and Bers M.U. (2018), “The impact of teacher gender on girls’ performance on programming tasks in early elementary school”, *Journal of Information Technology Education: Innovations in Practice*, 17: 153-162.
Sullivan A. and Bers M.U. (2019), *Investigating the use of robotics to increase girls’ interest in engineering during early elementary school*, in *Int J Technol Des Educ 29* (pp. 1033-1051).
UNESCO (2020), *Artificial intelligence and gender equality: Key findings of UNESCO’s Global Dialogue*. Available in: https://unesdoc.unesco.org/ark:/48223/pf0000374174
Zorn I., Maass S., Rommes E., Schirmer C. and Schelhowe H., eds. (2007), *Coding and Educational Robotics. Gender Designs IT. Construction and Deconstruction of Information Society Technology*, Springer, Switzerland.

Use of humanoid robots for intellectual disability in educational and teaching contexts: A review of the literature

by *Lia Daniela Sasanelli* and *Michele Baldassarre*[1]

Introduction

Technology plays an important role today because it promotes, with richness and dynamism, authentic paths for all students.

In particular, for students with disabilities, it becomes a vehicle for inclusion.

Using the terminology of the *International Classification of Functioning, Disability and Health* (ICF- WHO, 2001), technology is configured as a facilitator able to promote interaction and active and conscious participation, achieving important behavioral and social benefits.

In the age of technology, Special Education cannot shy away from reflecting on and researching how technology can meet the special educational needs arising from disability situations. The ultimate aim is to identify, in educational planning, supports that can implement the functionality of compromised areas, contributing to improving the Quality of Life of people with disabilities (Giaconi, 2015).

In this direction, the branch of *Assistive Technology* (Bauer et al., 2011; Reichle, 2011; Shih, 2011) is gaining considerable interest, as it supports people with disabilities in carrying out functional activities of daily life.

[1] Although the authors shared the entire construction of the chapter, Lia Daniela Sasanelli wrote paragraph 1 "Intellectual disability: specificities and characteristics", paragraph 3 "Literature review" and the Introduction; Michele Baldassarre wrote paragraph 2 "Humanoid robots: uses and functions" and the Conclusions.

They have made a contribution to rehabilitation, access to information, and independent living, contributing to the process of autonomy and self-determination of these people (Zappaterra, 2020).

Assistive Technology allows to reduce the negative impact of their health conditions within the context in which they operate, promoting their effective *participation* and *inclusion*[2].

In recent years, useful activities have taken place that address the use of assistive technology in special education such as tablet computers, smart board applications, laptops, cloud technology applications have taken place (Cejka, Rogers & Portsmore, 2006; Liu, Wu & Chen, 2013; Aziz et al., 2012; Tapus et al., 2012).

The aim of this study is to explore how the use of humanoid robots, belonging to the category of Socially Assistive Robotics (SAR), can promote physical, cognitive and socio-emotional learning experiences for student with a diagnosis of *Intellectual Disabilities* (ID) in school contexts, promoting communication, socialisation and interaction.

ID is often associated with other pathologies in well-defined syndromic pictures or in comorbidity with other pathologies that are often diagnosed late. The motivation to explore this area stems from the fact that, while in the international scientific literature there are numerous contributions that analyse the SAR and Autism Spectrum Disorder (ASD), work examining its potential with students with ID without comorbidity with other conditions is lacking (Dautenhahn & Billard, 2002; Garcia, Brown, Park & Howard, 2014; Shamsuddin et al., 2012).

Students with ID, compared to their peers, learn abstract terms, concepts and symbols slowly and with difficulty; they forget quickly and have low recall skills (D'Alonzo, 2008; Simons & Dedroog, 2009; AA.VV., 2014). Therefore, they need teaching methods structured according to their individual characteristics and cognitive abilities (Rezaiyan et al., 2007), in which they make use of concrete materials (Panek & Jungers, 2008).

The specific characteristics and educational needs of students with ID seem to be appropriate to the benefits of humanoid robot-assisted social interaction (Özdemir & Karaman, 2017).

[2] *Inclusion* is understood here as a «systemic change, a transformative process of the educational system (school, university, vocational, etc.) aimed at identifying (on a cultural, political and practice level) and removing all barriers and obstacles that determine all forms of exclusion, marginalisation or discrimination» (Bocci, 2016, p. 22).

In fact, as evidenced by Mayer's studies (2002) through the principle of *multimedia*, humanoid robots stimulating multiple sensory organs, facilitate learning and motivate students.

Intellectual disability: Specificity and characteristics

In order to understand the real usefulness of robotics in the development of the abilities of children with intellectual disabilities, it is necessary to focus on the major difficulties linked to the condition of intellectual disability.

ID is an irreversible health condition determined as a result of severe mental and neuromotor disorders. Referred to in the past by the term *mental retardation*[3], ID are severe permanent developmental alterations, which manifest themselves, before the age of 18 years, as global syndromes related to developmental deficits in the abstract functions of knowledge, social and adaptation (Luckasson et al., 2002).

The DSM -5 (*Diagnostic and Statistical Manual of Mental Disorders; American Psychiatric Association*, 2013) identifies three criteria for intellectual disabilities:

1. *deficits in intellectual functioning* (reasoning, problem solving, abstract thinking, school learning, and learning from experience) confirmed by both clinical assessment and administration of an individual intelligence test;
2. *deficits in adaptive functioning*, consisting of a failure to meet developmental and sociocultural standards for personal independence and social responsibility. Adaptive deficits limit functioning in one or more activities of daily living, such as communication, social participation, and independent living, in multiple domains, such as home, school, work, and community;

[3]The DSM -5 has introduced the term *intellectual disability* as the definitive replacement for the term mental retardation. The term "mental retardation" can make one think of a slow buthomogeneous development. Research and clinical reality show, however, the existence of inhomogeneity in development. The existence of different group profiles (sometimes linked to particular symptoms other times linked to different causes, as in the case of infantile cerebral palsy) invites us to use the plural: intellectual disabilities (Vianello, 2018). The shift from the term mental retardation to ID implies a different approach in defining the deficit: from the simple identification of the characteristics of the individual and his deficit, to a multidimensional recognition that includes not only bio-psycho-social factors, but also cultural and environmental factors.

3. *onset of intellectual and adaptive deficits in developmental age*.

The general incidence of intellectual disabilities in the population varies between 1% and 3% (about 2 in 100 people out of 100 have an IQ below 70). Higher incidence in males (1.5:1). The causes of intellectual disabilities can be both genetic and non-genetic biological (Baroff, 1989). Among the genetic causes, the best known is Down, Williams, Angelman, Prader-Willi and X-Fragile syndromes (caused by a deletion).

As shown in the table below (Tab. 1) the DSM IV identifies four degrees of severity of mental retardation that reflect the level of intellectual impairment.

Tab. 1 - Classifications of Intellectual Disability Severity and characteristics

SEVERITY CATEGORY	***%***	***Approximate IQ range***	***Specifications***
MILD	85%	50-69	Organic or environmental causes. Sufficiently developed communication skills. Minor sensorimotor impairments. Inability to achieve formal thinking. Difficulties in abstraction skills. Potentially satisfactory levels of personal and social autonomy.
MODERATE	10%	36-49	Organic causes. Discontinuous development of cognitive functions (language, attention, memory, symbolic function and communication). Elementary communication skills. Discreet autonomy in known contexts. Adaptation deficit.
SEVERE	3.5%	20-35	Organic causes. Compromises in the psychomotor domain. Poor communication skills. Lack of personal and social autonomy. Present forms of discomfort and frustration
PROFOUND	1.5%	<20	Organic causes Severe sensorimotor impairment. Significantly impaired communication skills Communication often limited to mimic-gesture form. Absence of personal and social autonomy. Need for continuous specialist assistance.

Source: adapted from Venuti, 2010

ID, involve impairment in global mental abilities and this affects adaptive functioning in three domains: *social*, *conceptual* and *practical* domains[4]. To make the diagnosis at least one domain of adaptive functioning must be impaired, so that support is needed in one or more areas (school, work, home, community) (Vianello, 2008).

People with intellectual disabilities, in general, are not capable of achieving abstraction in thinking, remaining anchored at the stage of concrete stage of concrete operations (Piaget, 1957).

This would lead to an inability to mentally represent an action and to the *irreversibility of thought*.

Another characteristic is that of *mental rigidity* which hinders the possibility of extending one's abilities to situations other than those of acquisition mental rigidity leads to difficulties in adapting to situations and the environment, creating adaptive and relational problems.

Other limitations are evident in *planning abilities, creativity and imagination*. Attention (sustained and selective attention) and memory (especially short-term memory) are also severely impaired (AA.VV., 2014).

A final characteristic is the impairment, at different levels, of language skills. Deficits in verbal comprehension and expression are evident, as well as difficulties in phonology and articulation. Verbal deficits are also found in vocabulary, syntactic structure and pragmatics (AA.VV., 2014).

Humanoid Robots: Uses and functions

Humanoid robots, defined as such because they have human features, are today in continuous and unstoppable evolution.

They fall into the category of Socially Assistive Robotics (SAR), a form of Technology that includes all those robotic systems capable of providing help and assistance to the user in a situation of fragility, through social interaction.

[4] The conceptual domain includes the skills of language, reading, writing, mathematics, reasoning, knowledge, memory; the social domain refers to awareness of the thoughts and feelings of others (empathy, social judgement), interpersonal skills and the ability to make and keep friends (Mirandola, Losito, Ghetti & Cornoldi, 2014). Finally, the practical domain includes personal care, work responsibilities, money management, recreational activities, organisation of school and work tasks.

The aim is to achieve clear improvements in the context of rehabilitation, learning, convalescence without, however, appeal to the fixed contact (Feil-Seifer & Mataric, 2005).

The SAR was born from the intersection of two related branches of Robotics:

- *Assistive Robotics (AR):* concerned with designing robots that assist the disabled person through fixed interaction (e.g., rehabilitation robots, company on robots, the manipulator arms for the physically disabled) (Prange, Jannink, Groothuis-Oudshoorn, Hermens & IJzerman, 2006);
- *Socially* Intelligent *Robotics (SIR*) or *Interactive* Robotics: the main task is to foster human-robot social interaction (Breazeal & Scassellati, 2002; Fong et al., 2003), improving relational and communication skills (Feil-Seifer & Mataric, 2009). The humanoid robot, more specifically, falls into the category of socially intelligent robots as it is able to «perform tasks by sensing its environment and/or interacting with external sources and adapting its behavior» (International Organization for Standardization -ISO, 2012).

An Intelligent Robot is able to communicate with high-level dialogue, perceiving and communicating emotions, promoting the development of social skills (Virnes et al., 2008).

Thanks to their physical appearance and for the common sharing of the context with the user, Humanoid Robots are shown to be essential to create an engaging and prolonged relationship with humans, providing a protocol of intervention (educational, didactic, therapeutic) personalized, engaging and motivating (Breazeal, 2002).

They cover the role of *mediator of interaction* and *catalyst of social activity*.

They communicate with a high-level dialogue, perceiving and communicating emotions and promoting, thus, the development of social skills (Virnes et al., 2008).

The main characteristic of humanoid robots, indeed, remains their physical form and atropomorphic features, through which the social and emotional skills of users are promoted. They are programmed to emote through facial expressions, gestures and intonations and respond with appropriate body language (Lin, Abney & Bekey, 2011), displaying emotions such as surprise, fear, anger and disgust (Fig. 1).

Fig. 1 - Types of humanoid robots

Source: modified from https://aisoy.com/blogs/blog/the-5-social-robots-most-used-for-helping-children-with-autism99

Humanoid robots are able to establish real "affective circuits" with users, actively involving them in activities and promoting social skills as:

1. the emotions conveyed by the robot, condition and structure the perceptions of the user, directing the attention and preparing for action[5];
2. the emotions, in response to the action, preparing the user to action and influence the behavior (Virciko, Magyar & Sincak, 2015);
3. the emotions "prepare" the ground for the establishment and/or *consolidation of social skills*.

Use of humanoid robots in the classroom

As found in different studies, teachers are generally unaware of the technical capabilities of humanoid robots and are unsure of how best to use them within the classroom (Reich-Stiebert & Eyssel, 2016).

[5] The affective loop is the interactive process in which the user [of the system] first expresses his emotions through some physical interactions involving his body (e.g., gestures or manipulations) and the system then responds by generating affective expressions (using colors, sounds, optical animations) which, in turn, affect the user (mind and body) by gradually involving him more and more with the system (Höök, 2009).

To date, research on the use of humanoid robots in school settings has focused on three objectives (Silvera Tawil et al., 2018):

- increasing engagement and motivation;
- eliciting behaviour;
- modelling, teaching and/or practicing skills with young children.

Initially, humanoid robots were placed within classrooms as teaching assistants to support in subjects such as language, math, and science (Chin, Wu & Hong, 2011).

Secondly, the specific features of these robots were highlighted: first of all interactivity as they are able to provide feedback in real time making interaction with students easier and more motivating.

In fact, numerous studies attest to how Humanoid Robots support conceptual thinking, increase student and teacher motivation, and promote student-centered learning by facilitating their cognitive work (Chambers, Carbonaro & Murray, 2008; Edwards, Edwards, Spence, Harris & Gambino, 2016; Hyun, Kim, Jang & Park, 2008; Lieto et al., 2017; White & Robertson, 2015).

Other studies (Jormanainen, Zhang, Kinshuk & Sutinen, 2007; Han, Jo, Jones & Jo, 2008; Fridin, 2014), indicate that robots facilitate classroom management and, in large classes, enable the effective implementation of individual training programmes.

The outcomes vary according to the intervention method, the robot being used and the severity of the child's symptoms.

Tab. 2 -The common attributes of humanoid robots and desired instructional goals

ROLE	***DESCRIPTION***
Body movement	Elicit student response, gain attention, support visual examples.
Existence with human-like	Recall prerequisites, elicit student response, gain attention, present goals, present new content and support visual examples (Chang, Lee, Chao, Wang & Chen, 2010).
Interaction	Provide feedback, recall prerequisites, elicit student response.
Suspension humanity	Elicit student response, provide feedback.
Repeatable	Gain attention, recall prerequisites, enhance retention and transfer.

Source: Tuna et al., 2019, p. 363

The most widely used Robot turns out to be NAO (Aslam et al., 2016; Lewis et al., 2016; Shamsuddin et al., 2012; Standen, Brown, Roscoe et al., 2014) (Fig. 2).

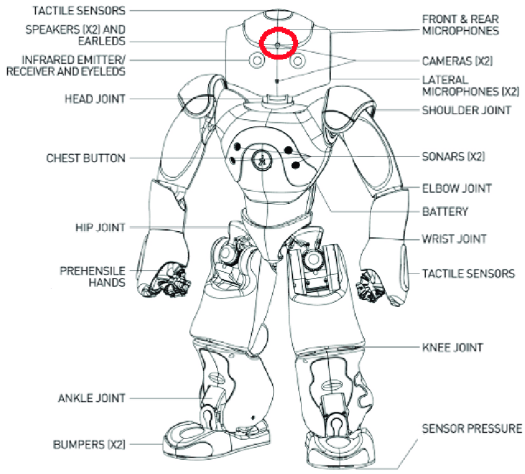


Fig. 2 - Humanoid Robot NAO
Source: SoftBank Robotics

«NAO is a small (58 cm height, 4.3 kg weight), programmable, humanoid robot developed by SoftBank Robotics. It is controlled using a Linux-based operating system, and includes a user interface that allows users to script robot behaviors. The hardware platform includes tactile sensors, speakers, microphones and video cameras, as well as prehensile hands with three fingers. It can reproduce sound, synthesize speech, and understand verbal utterances. NAO allows for a range of applications that stimulate the development of social and communication skills […]. The NAO robots are individually scripted and programmed by staff members to be positive role models and provide specific guidance and instructions during lessons, encourage students to express their ideas and provide positive feedback and reinforcement. Lessons are often reviewed, modified and repeated according to the students' needs and interests, teaching requirements and other demands across the learning areas. Lessons are structured following different formats including: performance, role-playing, step-by-step instructions, questions and answers, and social stories» (Roberts-Yate & Silvera-Tawil, 2019, p. 201).

In fact, being able to express and recognize emotions, thanks to sensors and cameras, they are able to propose games and activities to users with whom they interact, working on their motivation, attention and receptivity.

The main benefits of using NAO, in school contexts, are summarised below (Tab. 3).

Tab. 3 - Benefits of the Humanoid Robot NAO

GENERAL BENEFITS OF NAO	***BENEFITS OF NAO IN LEARNING***
Provides positive feedback	Stimulates learning processes
Encourages active listening	Increases self-determination
Reinforces positive social behaviour	Promotes, through imitation, learning in different areas: language, life skills, social skills, physical activity, gross and fine motor skills.
Increases motivation and involvement	

Source: adapted from Roberts-Yate & Silvera-Tawil, 2019

Literature Review

The main questions that guided the literature search presented here were:

1. How are humanoid robots integrated into the educational and teaching activities of students with intellectual disabilities?
2. What are the most significant elements or aspects of humanoid robots that capture the attention of students with intellectual disabilities?
3. Which areas (language and communication, socialization and interaction, learning, etc.) receive the most benefit?

The literature search started in August 2021 and ended in December of the same year.

A time span of 12 years (2010 to 2022) and the following search procedure was adopte:

1. identification of keywords (e.g. robotics and humanoid robots, intellectual disabilities and humanoid robots) needed to explore the available databases (ERIC, Scopus, Google Schoolar);
2. cataloguing of articles with authors' names, year, the title of the contribution, sample size, focus and robot in use;
3. the search for a methodology to analyse the contributions.

Although the use of humanoid robots at different stages of education has become widespread, studies exploring their potential in *intellectual disability* are very limited (Karal, 2013).

In fact, a recent literature review (Park et al., 2021) examining 32 studies on robot-mediated interventions to improve the communication and social skills of children and young people with disabilities showed that the majority of them were conducted on participants with ASD (81.3%), followed by EBD in three studies (9.3%). Two other studies (6.3%) were conducted with students with developmental delay (DD) and one (3.1%) with "minimally verbal" children.

The scientific literature presents numerous research papers on other focuses, such as:

- *SAR and Autism* (Lytridis, Vrochidou, Chatzistamatis & Kaburlasos, 2019; Pennazio, 2017; Robins & Dautenhahn, 2014; Robins, Dautenhahn & Dickerson, 2009; Robins, Dautenhahn, Te Boekhorst & Billard, 2005; Scassellati, Admoni & Mataric, 2012; Scassellati et al., 2018). Socially Intelligent Robots «because of their predictability, emotional simplicity, and adjustable interactivity, allow for the promotion of a communicative channel that passes through the attraction and channeling of attention (eye contact), continues with the solicitation of motivation, and finally with the imitation and enactment of new social behaviors» (Pennazio & Fedeli, 2019, p. 216);
- *Educational Robotics and Intellectual Disability* (Besio, Caprino & Laudanna, 2010; Caci, D'Amico & Cardaci, 2004; Caci & D'Amico, 2005; Businaro, Zecca & Castiglioni, 2014). These studies analyze the development of various aspects of learning, such as metacognition, social-cognitive skills, relationality and affectivity.

In recent years, pilot studies have been conducted on the use of humanoid robots in play activities for therapeutic purposes.

They have proven to be useful tools for promoting spontaneous play and interaction. In the pilot study by De Groot et al. (2019) through game activities, they aimed to find ways to increase the amount and level of detail of self-reported information. It was discovered that sound plays a key role in human-robot interaction and that the human voice is more pleasant and enjoyable, also due to the different intonation.

By programming the robot with the human voice, it would convey more emotion and require less effort to understand. Furthermore, a higher level of joy was observed during conversation-based interaction than during play-based interaction (De Groot et al., 2019).

For the purposes of our work, scientific contributions conducted in school contexts and for educational and teaching purposes were selected (Tab. 4).

Tab. 4 - Significant studies on the use of humanoid robots in intellectual disability in educational and teaching contexts

Study	***Authors***	***Title***	***Country of Study***	***Sample size***	***Focus***	***Robot***
1	Özdemir-Karaman (2017)	Investigating Interactions between Students with Mild Mental Retardation and Humanoid Robot in Terms of Feedback Types	Turkey	6	Feedback from the humanoid robot and effects on the user	iRobiQ
2	Roberts-Yates, Silvera-Tawil (2019)	Better Education Opportunities for Students with Autism and Intellectual Disabilities Through Digital Technology	Australia	28	Comparison of humanoid and anthropomorphic robots use	Nao and Paro
3	Alemi, Bahramipour (2019)	An innovative approach of incorporating a humanoid robot into teaching EFL learners with intellectual disabilities	Iran	10	Effects using a humanoid robot as a teacher-assistant can have on English vocabulary learning development and retention among individuals with Down syndrome	Nao
4	Aslam, Standen, Shopland, Burton, Brown (2016)	A Comparison of Humanoid and Non-humanoid Robots in Supporting the Learning of Pupils with Severe Intellectual Disabilities	UK	4	Comparison of humanoid and non-humanoid robot use	Nao and Lego Mind storm

In study 1 on feedback from the humanoid robot iRobiQ[6], it was found that students with ID focused more on stimuli involving physical contact and movement: arm movement, body movement and use of voice. The feedback to which students responded least were head movements and movements from the screen.

From the interviews conducted with the teachers, it is confirmed that the humanoid robot contributes positively to motivate the students and support them in their learning processes during the lesson.

From the study 2, humanoid robots proved to be an engaging social companion for students with ID.

In Roberts-Yates and Silvera-Tawil's study (n. 2), students with ID interacted with both humanoid robots (NAO) and anthropomorphic robots (Paro) on a constant and prolonged basis.

Both robots proved to be engaging social companions.

The NAO Robot was appreciated for its small size and simplified form capable of «encouraging turn-taking, eye contact, active listening, joint attention, problem solving, social interaction and social communication» (Roberts-Yates & Silvera-Tawil, 2019, p. 201).

It contributed to:

- provide positive feedback;
- encourage active listening;
- reinforce positive social behaviour;
- improve willingness to listen and interact;
- support participation;
- increase motivation.

The Paro robot[7], on the other hand, was introduced as part of the animal-assisted therapy programme to encourage self-expression, relaxation and emotion regulation.

Indeed, as confirmed by other studies (Banks, 2013; Gelderblom et al., 2010; Kidd et al., 2006; Robinson et al., 2013; McGlynn et al., 2014; Shibata et al., 2012) its soft fur and movements provoke positive responses while the

[6] Yujin Robot (2015). *iRobiQ robot*. Retrieved from: http://en.yujinrobot.com.

[7] Paro is an anthropomorphic robot (seal) designed by Shibata of the National Institute of Advanced Industrial Science and Technology of Japan, mainly used with elderly people suffering from dementia. The robot responds to touch and sound by moving its tail, head, opening and closing its eyes, or through soothing sounds that emulate the cries of a seal. It intervenes by decreasing states of anxiety and depression (http://www.parorobots.com/).

noises, produced after touches and caresses, are a source for relaxation and social interaction.

Regarding the effect of the use of a humanoid robot in second language learning (study 3), it is found that it supports learners with ID (student with Down Syndrome) to be more interactive in a natural and native situation and to have more interest and motivation in class.

The repetition strategy used for English language learning, in addition to games and motor activities, helped the participants to remember the vocabulary taught in different contexts and situations. The robot's friendly, childlike tone of voice and constant feedback helped the students to follow instructions and interact intensively.

Finally, study 4 stems from the observation that most schools cannot afford to buy the humanoid robot NAO due to its very high cost.

Therefore, in an experimental project involving four students with severe intellectual disabilities, 16 sessions with humanoid (NAO) and non-humanoid (Lego Mindstorm) robots were alternated.

The results showed that there were no significant differences between the two robots in terms of error rate and that for most of the sample (3 out of 4) the interaction with the non-humanoid robot was more enjoyable.

Conclusions

Despite the advantages that humanoid robots seem to offer and the existence of numerous scientific studies that have tested and verified their applicability in the field of inclusive education, they still appear to be underutilized (Galvez Trigo, Standen & Cobb, 2019).

The student with intellectual disabilities, having fewer tools to understand the world and its refined mechanisms, is likely to take a "defensive" attitude that can preclude openness to others and to the school experience (D'Alonzo, 2008, p. 164).

Always starting from the importance of relationships and a positive classroom climate where the student can find the joy of being welcomed and accompanied by peers and teachers, the research conducted has shown new and great potential arising from human-robot interaction (HRI), opening up many reflections.

«Unlike other special education tools, humanoid robots with their customisable applications are a great tool. For special education, humanoid robots are not only assistants to the teachers but also friends to the children. Humanoid robots may harness some wonder which causes to captivate those children, draw them in and make them want to interact and play to develop abilities such as identification, object classification and categorisation» (Tuna et. al., 2019, p. 369).

However, as argued by Huijnen, Lexis, Jansens and de Witte (2016), humanoid robotics solutions designed for special education should be created to fit the needs of special education teachers.

We also agree, with Scassellati, Admoni and Matarić (2012), that the innovative scope of the use of humanoid robots in education and teaching lies in the construct of *transfer*.

Applying social, cognitive, and linguistic skills and competencies learned through HRI in larger group and in a different context is the aspect that not only therapists, but also teachers and special educators need to consider in future studies.

It is necessary to engage more and more in this field of research and guide it, with specific skills, towards educational and didactic needs.

We conclude by saying that the HRI, today, is certainly an important operational proposal to be included in the life projects of people with disabilities.

Therefore, to derive maximum benefits, alongside a technical and specialized training (now predominant) on Robotics, it must be combined with a preparation, educational and pedagogical nature, on the functional profile of the person who will use it.

References

AA.VV. (2015), *Disabilità intellettiva a scuola*, Erickson, Trento.

Alemi M. and Bahramipour S. (2019), "An innovative approach of incorporating a humanoid robot into teaching EFL learners with intellectual disabilities", *Asian-Pacific Journal of Second and Foreign Language Education*, 4: 10.

American Psychiatric Association, (2013), *Diagnostic and statistical manual of mental disorders* (5th ed.).

Aslam S., Standen P.J., Shopland N., Burton A. and Brown D. (2016), *A comparison of humanoid and non-humanoid robots in supporting the learning of pupils with severe intellectual disabilities*, in *International Conference on Interactive Technologiesand Gamesxd v (ITAG)* (pp. 7-12).

Aziz K.A., Aziz N.A.A., Yusof A.M. and Paul A. (2012), "Potential for providing augmented reality elements in special education via cloud computing", *Procedia Engineering*, 41: 333-339.
Banks W.A. (2013), "Artificial emotions: Robots caring for the elderly", *Journal of the American Medical Association*, 14, 9: 635-636.
Baroff G.S. (1989), *Mental retardation: Nature, cause and management* (2th ed.), Edition Hemisphere Publishing Corporation, USA.
Bauer S.M., Elsaesser L.J. and Arthanat S. (2011), "Assistive technology device classification based upon the World Health Organization's, International Classification of Functioning, Disability and Health (ICF)", *Disability and Rehabilitation: Assistive Technology*, 6.
Besio S., Caprino F. and Laudanna E. (2010), *Using robots in education and therapy sessions for children with disabilities: Guidelins for teachers and rehabilitation professionals*, in Miesenberger K., Klaus J., Zagler W. and Karshmer A., eds., *Computers helping people with special needs*, Springer, Berlin.
Bocci F. (2016), *Didattica inclusiva. Questioni e suggestioni*, in Bocci F. et al., eds., *Rizodidattica. Teoria dell'apprendimento e modelli inclusivi*, Pensa MultiMedia, Lecce-Brescia.
Breazeal C. (2002), *Designing Sociable Robots*, MIT Press, Cambridge, MA.
Breazeal C. and Scassellati B. (2002), *Challenges in building robots that imitate people*, in Dautenhahn K. and Nehaniv, C.L., eds., *Imitation in animals and artifacts*, MIT Press, Cambridge, MA.
Businaro N., Zecca L. and Castiglioni L. (2014), "Implicazioni psicologiche di un laboratorio di robotica educativa nella scuola primaria: riflessioni sul caso di un bambino con ritardo mentale", *Psicologia Clinica dello Sviluppo*, 18, 2: 311-318.
Caci B. and D'Amico A. (2005), *Robotics: A new tool for education of subjects with cognitive diseases*, in Chiazzese G., Allegra M., Chifari A. and Ottaviano S., eds., *Methods and technologies for Learning, WIT transaction on information and communication technologies*, WIT Press, Southampton (UK).
Caci B., D'Amico A. and Cardaci M. (2004), "New frontiers for psychology and education: robotics", *Psychological Reports*, 94: 1327-1374.
Cejka E., Rogers C. and Portsmore M. (2006), "Kindergarten Robotics: Using robotics to motivate math, science, and engineering literacy in elementary school", *International Journal Engineering Education*, 22, 4: 711-722.
Chambers J. M., Carbonaro M. and Murray H. (2008), "Developing conceptual understanding of mechanical advantage through the use of Lego robotic technology", *Australasian Journal of Educational Technology*, 24, 4: 387-401.
Chang C.-W., Lee J.-H., Chao P.-Y., Wang C.-Y. and Chen G.-D. (2010), "Exploring the possibility of using humanoid robots as instructional tools for teaching a second language in primary school", *Educational Technology & Society*, 13, 2: 13-24.

Chin K.-Y., Wu C.-H. and Wong, Z.-W. (2011), *A humanoid robot as a teaching assistant for primary education*, in *Proceedings of 2011 Fifth International Conference on Genetic and Evolutionary Computing (ICGEC*), Xiamen, China.
D'Alonzo L. (2008). *Gestire le integrazioni a scuola*, La Scuola, Brescia.
Dautenhahn K. and Billard A. (2002). *Games children with autism can play with Robota, a humanoid robotic doll*, in *Universal access and assistive technology*, Springer, London.
De Groot J.J., Barakova E., Lourens T., van Wingerden E. and Sterkenburg, P. (2019), *Game-based human-robot interaction promotes self-disclosure in people with visual impairments and intellectual disabilities*, in *International Work-Conference on the Interplay Between Natural and Artificial Computation*.
Edwards A., Edwards C., Spence P.R., Harris C. and Gambino A. (2016), "Robots in the classroom: Differences in students' perceptions of credibility and learning between 'teacher as robot' and 'robot as teacher'", *Computers in Human Behavior*, 65: 627-634.
Feil-Seifer D. and Matarić M.J. (2005), *Defining Socially Assistive Robotics*, in *Proceedings of 9th IEEE International Conference on Rehabilitation Robotics*.
Feil-Seifer D. and Matarić M.J. (2009). *Human robot human-robot interaction (hri) interaction human robot*, in *Encyclopedia of complexity and systems science*. Springer, New York.
Fong T., Nourbakhsh I., Dautenhahn K. (2003), "A survey of socially interactive robots", *Robotics and Autonomous Systems*, 42, 3-4: 143-166.
Fridin M. (2014), "Storytelling by a kindergarten social assistive robot: A tool for constructive learning in preschool education", *Computers and Education*, 70: 53-64.
Galvez Trigo M.J., Standen P.J. and Cobb S.V.G. (2019), "Robots in special educationreasons for low uptake", *Journal of Enabling Technologies*, 13, 2: 59-69.
Garcia V. S., Brown L., Park H.W. and Howard A.M. (2014), *Engaging children in play therapy: The coupling of virtual reality games with social robotics*, in *Technologies of inclusive well-being*, Springer, Berlin Heidelberg.
Gelderblom G.J., Bemelmans R., Vanstipelen S. and de Witte L. (2010), *Development of Paro interventions for dementia patients in Dutch psycho-geriatric care,* in Ge S.S., Li H., Cabibihan J-J and Tan Y.K., eds., *Social Robotics*. Second International Conference on Social Robotics.
Giaconi C. (2015), *Qualità della vita e adulti con disabilità. Percorsi di ricerca e prospettive inclusive*, Franco Angeli, Milano.
Han J., Jo M., Jones V. and Jo J.H. (2008), "Comparative study on the educational use of home robots for children", *Journal of Information Processing Systems*, 4, 4.
Höök K. (2009), "Affective loop experiences: Designing for interactional embodiment. *Philosophical transactions of the Royal Society of London. Series B, Biological sciences*, 364, 1535: 3585-3595.

Huijnen C.A.G.J., Lexis M.A.S., Jansens R. and de Witte, L.P. (2016), "Mapping robots to therapy and educational objectives for children with autism spectrum disorder", *Journal of Autism and Developmental Disorders*, 46: 2100-2114.
Hyun E., Kim S., Jang S. and Park S. (2008), *Comparative study of effects of language education program using intelligence robot and multimedia on linguistic ability of young children*, in *Proceedings of the 14th IEEE International Workshop on Robot and Human Interactive Communication* (RO-MAN 2008). Piscataway, NJ: IEEE.
International Organization for Standardization (ISO) (2012), *Robots and Robotic Devices-Vocabulary*, Geneva, Italy.
Jormanainen I., Zhang Y., Kinshuk K. and Sutinen E. (2007), *Pedagogical agents for teacher intervention ineEducational robotics classes: Implementation issues*, in *Digital Game and Intelligent Toy Enhanced Learning, 2007. DIGITEL '07*. The First IEEE International Workshop on, IEEE.
Kidd C.D., Taggart W. and Turkle S. (2006), *A sociable robot to encourage social interaction among the elderly*, presented at the *IEEE International Conference on Robotics and Automation*, Orlando, Florida.
Lewis L., Charron N., Clamp C. and Craig M. (2016), *Co-robot therapy to foster social skills in special need learners: Three pilot studies*, in Caporuscio M., la Prieta F., Di Mascio T., Gennari R., Gutiérrez Rodriguez J. and Vittorini P., eds., *Methodologies and Intelligent Systems for Technology Enhanced Learning: 6th International Conference*, Springer International Publishing, Cham.
Lieto M.C., Inguaggiato E., Castro E., Cecchi F., Cioni G., Dell'Omo M. and Dario P. (2017), "Educational Robotics intervention on Executive Functions in preschool children: A pilot study", *Computers in Human Behavior*, 71: 16-23.
Lin P., Abney K. and Bekey, G.A. (2012), eds., *Robot ethics: The ethical and social implications of robotics*, MIT Press, Cambridge, MA.
Liu G.Z., Wu N.W. and Chen Y.W. (2013), "Identifying emerging trends for implementing learning technology in special education: A state-of-the-art review of selected articles published in 2008-2012", *Research in Developmental Disabilities*, 34: 3618-3628.
Luckasson R., Borthwick-Duffy S., Buntinx W.H.E., Coulter D.L., Craig E.M., Reeve A., Schalock R.L., Snell M.E., Spitalnik D.M., Spreat, S. and Tassé M.J. (2002), *Mental retardation: Definition, classification, and systems of supports* (10th ed.), American Association on Mental Retardation, Washington, DC.
Lytridis C., Vrochidou E., Chatzistamatis S. and Kaburlasos V. (2019), *Social engagement interaction games between children with Autism and humanoid robot NAO,* in Graña M., López-Guede J.M., Etxaniz O., Herrero Á., Sáez J.A., Quintián H. and Corchado E., eds., *International Joint Conference*, Springer, Cham.
Mayer R.E. (2002), "Multimedia learning", *Psychology of Learning and Motivation*, 41: 85-139.

McGlyn. S.A., Kemple S.C., Mitzner T.L., King C-H. and Rogers W.A. (2014), *Understanding older adults' perceptions of usefulness for the Paro robot*, Proc. Human Factors and Ergonomics Society Annual Meeting, SAGE Publications: 1914-1918.

Mirandola C., Losito N., Ghetti S. and Cornoldi C. (2014), "Emotional false memories in children with learning disabilities", *Research in Developmental Disabilities*, 35, 2: 261-268.

Özdemir D. and Karaman S. (2017), "Investigating interactions between students with mild mental retardation and humanoid robot in terms of feedback types", *Education and Science*, 42, 191: 109-138.

Panek P.E. and Jungers M.K. (2008), "Effects of age, gender, and causality on perceptions of persons with mental retardation", *Research in Developmental Disabilities*, 29, 2: 125-132.

Park J., Baek Y.E., Lim B.L. and Ko H. (2021), "Robot-mediated interventions to enhance communication and social abilities of children and youth with disabilities: a review of the literature", *International Journal of Special Education,* 36, 1: 99-112.

Pennazio V. (2017), "Social robotic to help children with autism in the interaction through imitation", *REM*, 9: 10-16.

Pennazio V. e Fedeli L. (2019), "Robotica, mondi virtuali 3D e storie sociali. Una proposta per il disturbo dello spettro autistico", *Form@re - Open Journal per la formazione in rete*, 19, 1: 213-231.

Piaget J. (1957), *Construction of reality in the child*, Routledge & Kegan Paul, London.

Prange G.B., Jannink M.J., Groothuis-Oudshoorn C.G., Hermens H.J. and IJzerman M.J. (2006). "Systematic review of the effect of robot-aided therapy on recovery of the hemiparetic arm after stroke", *Journal of Rehabilitation Research and Development*, 43: 171-183.

Reich-Stiebert N. and Eyssel F. (2016). "Robots in the classroom: What teachers think about teaching and learning with education robots", *Lecture Notes in Computer Science*, 9979: 671-680.

Reichle J. (2011), "Evaluating assistive technology in the education of persons with severe disabilities", *Journal of Behavioral Education*, 20.

Rezaiyan A., Mohammadi E. and Fallah P.A. (2007), "Effect of computer game intervention on the attention capacity of mentally retarded children", *International Journal of Nursing Practice*, 13, 5: 284 -288.

Roberts-Yates C. and Silvera-Tawil D. (2019), "Better education opportunities for students with autism and intellectual disabilities through digital technology", *International Journal of Special Education*, 34, 1.

Robins B., Dautenhahn K. and Dickerson P. (2009), *From isolation to communication: A case study evaluation of robot assisted play for children with autism with a minimally expressive humanoid robot*, in *Proceedings of 2nd International*

Conference on Advances in Computer-Human Interaction: ACHI '09, 205-211, IEEE, Piscataway, NJ.
Robins B., Dautenhahn K., Te Boekhorst R. and Billard A. (2005), "Robotic assistants in therapy and education of children with autism: Can a small humanoid robot help encourage social interaction skills?", *Univers. Access Inf. Soc.*, 4, 2: 105-120.
Robins B., Dickerson P., Stribling P. and Dautenhahn K. (2004), "Robot-mediated joint attention in children with autism: A case study in robot-human interaction", *Interact. Stud.*, 5, 2: 161-198.
Scassellati B., Admoni H. and Mataric M. (2012), "Robots for use in autism research", *Annual Review of Biomedical Engineering*, 14: 275-294.
Scassellati B., Boccanfuso L., Huang C.M., Mademtzi M., Qin M., Salomons N., Ventola P. and Shic F. (2018), "Improving social skills in children with ASD using a long-term, in-home social robot", *Science Robotics,* 3: 1-9.
Shamsuddin S., Yusso, H., Ismail L.I., Mohamed S., Hanapiah F.A. and Zaharid N.I. (2012), "Initial response in HRI- a case study on evaluation of child with autism spectrum disorders interacting with a humanoid robot NAO", *Procedia Engineering*, 41: 1448-1455.
Shamsuddin S., Yusuff H., Ismail L.I. and Mohamed S. (2012), "Humanoid robot NAO interacting with autistic children of moderately impaired intelligence to augment communication skills", *Procedia Engineering*, 41: 1533-1538.
Shibata T., Kawaguchi Y. and Wada K. (2012), "Investigation on people living with a social robot at home", *International Journal of Robotics*, 4: 53-63.
Shih C.H. (2011), "Assisting people with developmental disabilities to improve computer pointing efficiency through multiple mice and automatic pointing assistive programs", *Research in Developmental Disabilities*, 32.
Silvera-Tawil D., Roberts-Yates C. and Bradford D. (2018), *Talk to me: The role of humanrobot interaction in improving verbal communication skills in students with Autism or Intellectual Disability*, in *Proc. International Symposium on Robot and Human Interactive Communication*.
Simons J. and Dedroog I. (2009), "Body awareness in children with mental retardation", *Research in Developmental Disabilities*, 30, 6: 1343-1353.
Standen P., Brown D., Hedgecock J., Roscoe J., Galvez Trigo M.J. and Elgajiji E. (2014), "Adapting a humanoid robot for use with children with profound and multiple disabilities", *Technology, Rehabilitation and Empowerment of People with Special Needs*.
Tapus A., Peca A., Aly A., Pop C., Jisa L., Pintea S. and David D. (2012), "Children with autism social engagement in interaction with Nao, an imitative robot: A series of single case experiments", *Interaction Studies*, 13: 315-347.
Tuna G., Tuna A., Ahmetoglu E. and Kuscu H. (2019), "A survey on the use of humanoid robots in primary education: Prospects, research challenges, and future research directions", *Cypriot Journal of Educational Science*, 14, 3: 361-373.

Venuti P. (2010), *L'intervento in rete per i Bisogni Educativi Speciali*, Erickson, Trento.
Vianello R. (2008). *Disabilità intellettive*, Junior, Bergamo.
Vianello R. (2018), *Disabilità intellettive. Come e cosa fare,* Giunti, Firenze.
Vircikov M. and Magyar Sincak P. (2015), "The affective loop: A tool for autonomous and adaptive emotional human-robot interaction", *Advances in Intelligent Systems and Computing*.
Virnes M., Sutinen E. and Kärnä-Lin E. (2008), "How children's individual needs challenge the design of educational robotic", *Interaction Design and Children*.
White D.H. and Robertson L. (2015), "Implementing assistive technologies: A study on co-learning in the Canadian elementary school context", *Computers in Human Behavior*, 51: 1268-1275.
WHO (2001), *International Classification of Functioning Disability and Health*, Geneva.
Zappaterra T. (2020), "Pervasività del digitale, didattica e disabilità in tempo di Covid-19. Alcune riflessioni critiche", *Studi sulla Formazione*, 2, 23: 87-92.

Robots for the study of false belief attribution in autistic children: An exploratory study

by *Serena Sabrina Vadalà*, *Carmela Esposito*, *Laura Zampini*, *Eleonora Farina* and *Edoardo Datteri*

Introduction

Robots are generally thought of as mechanical systems which can help people carry out "practical" activities. This is the case of industrial robots, robots used to perform complicated surgical operations in medical contexts, robots used to assist elderly or disabled people (see Siciliano & Khatib, 2008 for a comprehensive illustration). In a particular sense of the term, robots can also help teachers and educators by serving as didactic mediators for the acquisition of a variety of disciplinary and cross-disciplinary competencies: this is what is typically called *educational robotics* (Anwar et al., 2019).

This chapter will explore a particular use of robots, which has received little attention by the educational robotics community, despite having been extensively discussed in the social robotics and cognitive science literature: the role of robots as tools to *acquire knowledge* on human behaviour and cognition. This *epistemic* use of robots radically differs from the way robots are typically used in educational robotics. One thing is to use a robot to *intervene* on an individual's cognitive abilities (e.g., to improve their executive functions, as in Di Lieto et al., 2017). Another thing is to use a robot to *study* their cognitive abilities – for example, to assess whether an individual possesses a particular cognitive ability or not, or to study the cognitive or neural mechanism underpinning it. The epistemic value of robots will be discussed here with reference to a robot-supported empirical investigation on the "mentalization" of robots by children with autistic spectrum disorder (ASD from now on) and typically developing (TD) children. As such, this chapter does not cover the use of robots to support rehabilitation and therapies destined to

ASD people (for reviews, see Alabdulkareem et al., 2022; Cabibihan et al., 2013; Pennisi et al., 2016).

More specifically, this chapter has two goals. First, we will report on an exploratory study whose aim is to assess whether five ASD and five TD children attribute false beliefs to a non-humanoid robot in what will be called a "robotic helping task" inspired by the "helping paradigm" exploited by Buttelmann and colleagues (2009). In particular, we wanted to probe whether five ASD children attributed false belief to the robot, to assess whether our ASD and TD participants responded differentially to the robotic helping task and to a standard "Sally and Anne" task, and – in the latter case – to identify the main differences. Studying whether children attribute false beliefs to robots is functional to the understanding of how children explain robot behaviours in educational contexts and in everyday life. As such, it may offer insights for the design of educational robotic activities and of (social) robots destined for interaction with children.

The second goal of this chapter is to reflect on whether the results of this study – more generally, children's performance in the robotic helping task – can offer insights on their theory of mind (ToM) abilities. Indeed, note that, *prima facie*, the results of the study can be brought to bear on their tendency to attribute false beliefs to *robots*. Can the same results be used to shed light on children's attribution of false beliefs to *people*, generally? One possible reason for scepticism comes from the consideration that robots are patently different from human beings at many levels of analysis – and on the assumption (by no means obvious) that robots cannot be said to "genuinely" possess a mind. Thus, the objection runs, one might not tend to attribute false beliefs to robots and yet be perfectly able to attribute false beliefs to human beings. In this work we will dismantle this objection and others, by providing reasons to believe that in some circumstances, and with some methodological provisos, robots may be used to investigate people's "general" false belief attribution abilities.

The study presented here offers some elements of novelty. Few studies have been published on (ASD and TD) children's attribution of false beliefs to robots, and they typically involve *humanoid* robots. This study complements this literature by showing evidence that children with ASD can attribute false beliefs to non-humanoid robots too. And, to the best of our knowledge, no methodological reflection has been offered so far on whether robots can be sensibly used to study ToM abilities in (ASD and TD) children.

The chapter is organised as follows. The second section presents some characteristics of the autism spectrum disorder, reflects on the relationship between ASD and difficulties in having a ToM, and describes some tasks used to study ToM. The third section offers a reflection on whether robots can be used to study cognitive abilities. The fourth section presents the exploratory study on the attribution of false beliefs to a non-humanoid robot anticipated before, and the fifth offers some concluding remarks. This study has received authorization by the Ethical Committee of the University of Milano-Bicocca.

Theory of mind and autism

Autism is a pervasive developmental disorder, characterised by a symptom dyad that can be traced to two macro areas of difficulty: social communication and imagination (Diagnostic and Statistical Manual of Mental Disorders - DSM-5, American Psychiatric Association - APA, 2013).

Deficits in the area of social communication include a more purely communicative difficulty and a social-relational one. Within the autistic spectrum disorder, in fact, some children are characterised by a total absence of language, others instead show a purely echolalic (Frith, 1989; Jordan & Powell, 1995) or – in some ways – abnormal language (Kanner, 1946), others still seem to master good verbal language. Contrary to what one might think, in the latter case children's communication is not without problems: some speak very little, while others may not be able to control the verbal flow (Cottini & Vivanti, 2013). In addition, they all have in common poor perspective taking competence – which implies a tendency to disregard and pay attention to an interlocutor's interest in a certain type of topic – and an inadequate management of conversation rules.

The main communication difficulties, therefore, regard the possibility of establishing social relationships (with particular reference to the group of peers) and of correctly interpreting others' behaviour (Cottini & Vivanti, 2013). According to Surian (2005), in fact, children with autism seem to present a level of social interaction that is not appropriate either to their chronological age or to their mental age at two levels: the child's actual implementation of a behaviour (or lack thereof), or his/her understanding of the behaviour of others (Vertè, Roeyers & Buysse, 2003).

One of the hypotheses that some authors have developed to justify the social-relational difficulties coincides with a deficit in Theory of Mind (ToM) (Baron-Cohen, Leslie & Frith, 1985). Sometimes, in fact, children with autism are defined as suffering from "mental blindness", which does not allow them to understand what is happening in the world around them: having a theory of mind means being able to reflect on the contents of one's own and others' minds. First-order ToM develops around age 4 and involves the ability to reflect on what another person thinks or feels; to recognise that different people want different things and have different beliefs and knowledge; and to understand a false belief (Baron-Cohen, 2001). Second-order theory of mind, on the other hand, involves the ability to predict what one person might think of another and the understanding of lies, sarcasm, and figurative language. Children generally acquire this level of awareness between the ages of 6 and 10. Many individuals diagnosed with ASD generally show difficulty in attributing mental states and beliefs to others and therefore fail first-order theory of mind tests (Kimhy, 2014). Many others, although they successfully perform tasks involving the use of a first-order theory of mind, have difficulty generalising this skill to everyday life or show that they have not developed a second-order theory of mind (Kimhy, 2014; Scheeren et al., 2013). In everyday life, this difficulty manifests itself in a marked impediment in understanding the point of view and perspective of others (inferring what the other sees and feels from a different perspective); in feeling empathy (understanding the emotional state of the other); in being able to tell or to recognize lies; understanding the other's intentions, and therefore whether the behaviour of others is accidental or intentional.

The main task used to assess first order ToM is false belief task: subject A attributes a so-called first-order false belief to a subject B if they believe that B holds a false belief about certain aspects of the physical world – for example, if they believe that B mistakenly thinks that a certain object is located in a certain place. These tasks are sometimes called elicited-response tasks (Setoh et al., 2016), since the subject is explicitly asked to react to a situation presented through various modalities (e.g., through a story represented on vignettes), and verbal tasks, because the subject is asked to verbally respond to a question (for a review, see Liverta-Sempio, Marchetti, Castelli, Lecciso & Pezzotta, 2005).

A large body of research literature attests to the fact that typically developing girls and boys under the age of 4 tend to fail elicited-response verbal false belief tasks (Perner et al.,1987). The same tends to happen with people with autism spectrum disorder (ASD) over the age of four (Baron-Cohen et al., 1985; Happé, 1995; Tager-Flusberg, 2000; Grant et al., 2001). Together with these empirical results, an equally large literature of methodological research has developed on the appropriateness of the above-mentioned tasks for the study of false belief understanding. Many authors, in particular, have pointed out that the failure to pass these tests may be due to the fact that they involve a considerable amount of cognitive and verbal production skills (Bloom & German, 2000). Some authors developed non-verbal spontaneous-response tasks, in which the spontaneous behaviour of the participants to the presented situation is observed (in contrast to verbal elicited-response tasks, in which the production of a verbal reaction is explicitly stimulated (Setoh et al., 2016). Tasks of this kind have led some researchers to produce evidence of the possession of mentalizing abilities also in typically developing individuals under the age of 4.

Of particular interest for the study presented here is the task developed by Buttelmann et al. (2009). This is a study of unexpected displacement of the non-verbal spontaneous-response type. The participant is shown two boxes A and B that can be closed; an adult places an object in A; the object is then moved to the other box in the absence of the adult (in the false belief condition) or in the presence of the adult (in the true belief condition). The adult then tries to open box A in which the object was initially placed, but fails to do so because the box has been locked. In the study by Buttelmann and colleagues, the participants (aged 18 months) spontaneously helped the adult to open box B in the false belief condition and box A in the true belief condition: on the basis of various methodological considerations, the authors explained this behaviour by assuming that the participants attributed to the adult a false belief about the location of the object in the false belief condition, and wished to help the adult retrieve the object; that they attributed to the adult the intention to open box A regardless of the location of the object in the true belief condition. The study by Buttelmann et al. (2009) provided the inspiration for the development of the robotic task proposed in the study described here.

Behavioural analysts suggest that in many cases the ability to take another person's perspective is in close interaction with environmental stimuli. Spradlin and Brady explain that a necessary requirement for good performance on a false belief task is the ability to discriminate stimuli available to oneself from stimuli available to others (Spradlin & Brady, 2008). Related to this issue is the difficulty in perceptual dysregulation common to many individuals with autism. The difficulties in perception are, in fact, in many cases caused by the perception of a sensory overload that does not allow the subject to have the attentional focus on him/herself and on the other person at the same time (Bogdashina, 2003).

Robots to understand theory of mind abilities

Diagnosis and theoretical modelling

A growing body of research suggests that robots are valuable tools to support cognitive, emotional, and socio-relational therapy for children with ASD (for reviews, see Alabdulkareem et al., 2022; Cabibihan et al., 2013; Pennisi et al., 2016). As pointed out before, this chapter does not deal with the therapeutic role of robots, being distinctively concerned with their role as tools to acquire knowledge on the cognitive and socio-relational abilities of children with ASD.

What kind of knowledge on ASD children can be ideally acquired using robots? One possibility is that they can play an active role in *diagnostic* processes. The term "diagnosis" is typically used to refer to the process that leads one to state that some individual has a particular disease (for the definitions of disease and diagnosis in medicine, see Hucklenbroich, 2017). A diagnosis of ASD thus leads one to conclude that the individual under examination has ASD. Can robots be meaningfully used to support diagnostic processes? This use is explored, for example, in Petric et al. (2017), where a humanoid robot is used to perform four diagnostic tasks modelled upon the ADOS test: response to a name call, joint attention, play request, functional and symbolic imitation. The robot performs actions that, in typical diagnostic scenarios, would be performed by human beings, and is able to analyse, to some extent, children's reactions. Another study in which a robot is used for diagnostic purposes is presented in Arent et al. (2019). In these cases, it is legitimate to say that the robot is used to acquire a certain kind of knowledge on an individual human being, namely, to conclude that that person has a certain disease or not.

This epistemic use of robots raises some methodological questions. First, why should robot-supported diagnosis be preferred to diagnosis by humans? Second, is the output of robot-supported diagnosis reliable? In other terms, can one safely infer that individual X has ASD based on their reaction to the behaviour of a robot? Concerning the second question, reasons for scepticism may come from the consideration that a good diagnostic process requires one to involve X in a truly human-human relationship, and that X's responses to the robot are of no help in establishing whether X has socio-relational difficulties manifesting themselves in interaction with other people. For example, X might not establish joint attention links with a robot because X does not truly perceive the robot as genuinely attending to something, or that its eyes are too different from human eyes to be "catchy" (thus, not because they lack joint attention abilities). For these reasons, X's responses to the robot-supported test might be regarded as poorly informative of X's responses to human-administered tests.

The first question – why should robots be preferred to humans in diagnosis? – may be addressed taking into account the hypothesis, strongly supported in the literature (Cabibihan et al., 2013; Scassellati, 2007), that some robots are particularly engaging for ASD people. This consideration might be explained in light of the predictability and the paucity of morphological details characterising most robots, especially those specifically designed for interaction with ASD children, in line with Baron-Cohen's "empathising-systemizing" theory (Baron-Cohen et al., 2002). One should be careful to note, however, that robots specifically designed for engaging ASD children may be less engaging for TD children, thus biassing the diagnostic process. Another, perhaps more powerful, reason for using robots in the diagnostic process is that, as pointed out by Scassellati (2007) and others, robots can deliver standardised social stimuli ("social presses") thus improving the quality of comparison among the diagnosed individuals.

The second question – is robot-supported diagnosis reliable? – may be addressed empirically, e.g., by evaluating whether the diagnostic results converge with the results of standard diagnostic methods. In a complementary fashion, one may investigate whether (ASD and TD) children's reaction to the stimuli delivered during robot-supported diagnosis (e.g., in joint attention tasks) are similar to their reactions to the same stimuli delivered by human beings (see, for example, Pierno et al., 2008; Wiese et al., 2014).

So far, we have discussed the potential role of robots as tools to support acquisition of a certain kind of knowledge about ASD children, namely, the acquisition of a diagnosis. Let us not introduce the methodological hypothesis that robots can be meaningfully used to acquire other forms of knowledge about human beings.

1. *Possession of an ability*. By delivering standardised stimuli to individual X, and observing X's responses, one may draw conclusions

on whether X possesses or not a certain ability C. Even though assessing the possession, or absence, of a particular ability may support diagnostic statements (e.g., the absence of mentalization abilities may support diagnosis of ASD), one thing is to diagnose the presence of a disease, another thing is to assess the possession of an ability.

2. *Mechanistic (cognitive) model of an individual's ability*. By varying the characteristics of the stimuli delivered to a system, initially considered as a "black box", and observing the differences in the responses, one may obtain theoretical insights on the cognitive mechanisms that are "internal" to the black box. For example, by observing that X's mentalization performances change depending on whether the robot interacting with X has a human-like face or not, one may formulate the hypothesis that the cognitive mechanisms underpinning X's mentalization abilities are influenced by other cognitive mechanisms devoted to the recognition of human-like faces. Stimulation-based strategies for discovering mental mechanisms have been extensively discussed by William Bechtel (2008).

This chapter will examine the first methodological hypothesis. We will present an exploratory study aimed at assessing whether some ASD and TD children can attribute false beliefs to a non-humanoid and non-social robot. As such, this study illustrates and elaborates on the idea that robots can be used to assess people's possession of particular abilities – in this case, the ability of attributing false beliefs to robots. Assessing possession of this ability may be of some interest for the design of robots interacting with ASD children, and for the design of educational or therapeutic robot-supported activities destined to ASD children.

However, as anticipated in the Introduction, one may legitimately doubt that this study (or an improved and less exploratory version of it) can be of particular interest out of the (educational or social) robotics literature, and that it can offer valuable insights on ASD children's possession of false-belief attribution abilities *generally* – i.e., on their ability to attribute false beliefs *to other people*. Indeed, one may surmise that being able to attribute false beliefs to robots is not the same as being able to attribute false beliefs to human beings. In the following sections, we will also discuss whether, and with what methodological provisos, a robot-supported false belief task can shed light on children's attribution of false beliefs to human beings.

Mentalizing robots: The literature

Some empirical studies on children's ascription of mental states to robots have been published so far. Of particular interest here are the studies specifically addressing the question whether ASD and TD children attribute false beliefs to robots.

One of such studies is reported in Zhang et al. (2019). The goal was to probe whether ASD and TD children, aged from 5 to 7, attribute false belief to a humanoid robot (NAO, SoftBanks Robotics) and predict its action accordingly, in a change-of-location and an unexpected-content task. The results show that most TD children, unlike ASD children, attribute false belief to the social robot. In another study (Banks, 2020), five ToM tasks were carried out, including a false belief task, involving various robots (presented through videos) and a human control. The main goals were to understand whether humans hold a ToM for social robots, and if ToM for robots varied according to the robots' social cues. The results suggested that the participants "mentalized" the robot, even though robot morphology influenced their ToM.

These studies explicitly focus on the question whether people with ASD have a ToM of (or more specifically attribute false beliefs to) *robots*. Can these results be brought to bear on people's ToM of *people*, generally? For example, should failure of ascribing false beliefs to NAO by ASD children, in Zhang et al. (2019), be interpreted as suggesting that (a) ASD children cannot attribute false beliefs to robots, regardless of whether they can attribute false beliefs to humans or not, or that (b) ASD children have general difficulties in ascribing false beliefs to other individuals, be they human or robotic? The second option may have interesting methodological implications, namely, that some robot-supported tasks can be employed to study ToM impairments in ASD children, enabling one to obtain results that speak to their socio-relational difficulties, extending far beyond the narrow domain of human-robot interaction. Robotic tasks might be preferred to more traditional tasks for reasons connected to the standardisation of the stimulus and to the attractiveness of robots to ASD people (see above).

Note that Zhang and colleagues (2019) seem to adopt perspective (b). Indeed, they interpret their experimental results as follows: their findings – namely, that ASD children do not pass their robotic version of the Sally-and-Anne task – «might derive from two possibilities. First, their impairments in ToM hindered the children with ASD from inferring the mental states of any agent, including the social robot». According to this interpretation, the results of the robotic test corroborate the hypothesis that ASD children have general ToM impairments. Then they add, «an alternative possibility is that children with ASD perceived the robots differently from TD children». This alternative explanation brings the experimental results to bear on their "general" ToM, too: according to this interpretation, failing the robot-supported test does not signal an impairment in children's ToM abilities, but only that their ToM mechanisms were not "activated" by the robot (because they did perceive it in a "peculiar" way).

To sum up. Some research has been published on the use of robots to assess whether ASD and TD children attribute false beliefs to robots. This literature gives rise to the question whether robots can be meaningfully used to study "general" ToM difficulties, and not only ASD children's perception of *robots*. The goal of this chapter is to introduce this methodological question and offer some insights for future reflections, also based on the exploratory study that we are now going to describe. Note that, somehow contrary to Zhang (2019), we obtained evidence that could be interpreted as suggesting that ASD children do sometimes attribute false beliefs to a robot. Moreover, our study, unlike the studies reviewed here, involves a *non-humanoid robot* and is based on a spontaneous-response task (see above) modelled after the "helping paradigm" by Buttelmann et al. (2009).

The study

The idea and the goals

The study that we are going to present is exploratory, involves a small number of participants, and should be thought of as the initial step of a longer research project that could be further developed in the future. As discussed in the previous section, the literature on false belief ascription to robots is relatively scarce, and methodological reflections on the usefulness of robots as epistemic tools to study ToM in ASD children are lacking. The task that we are going to describe was designed anew. For this reason, in this study we wanted to collect some preliminary observations that could be used to formulate clearer hypotheses to be subjected to more rigorous experimentation in the future. The importance of exploratory studies which are not guided by crystal-clear hypotheses in the first stages of discovery has been often discussed in the philosophy of science (see Franklin, 2005).

In this study, we administered a robot-supported test called "robotic helping task" (RHt) to a small group of ASD and a small group of TD children. The RHt, more thoroughly presented later, is a change-of-location task inspired by the helping paradigm reported in Buttelmann et al. (2009). Even though we made qualitative observations while the children performed the task, we represented its outcome as binary: "passed" or "failed". Under some auxiliary hypotheses, passing the test can be thought of as supporting the claim that the participant attributed a false belief to the robot. To the same participants, we administered a standard Sally-and-Anne task (STDt), whose outcome was also represented as "passed" or "failed". Passing the STDt can be thought of as supporting the claim that the participant attributed a false belief to one of the characters of the story.

The empirical goal of the study was to find out whether ASD and TD children show different performances at the STDt and the RHt. More specifically, we were guided by the following exploratory questions.

1. Can ASD children pass the RHt?
2. Do TD and ASD children tend to display the same performances at the two tasks?
3. If they do not, how do the two groups differ at the two tasks?

An affirmative answer to question 1 may be interpreted as suggesting that ASD children attribute false belief to the robot involved in the task. The discussion made in the section before enters stage here. Could this result be generalised as suggesting that ASD children can attribute false beliefs to other individuals, generally?

According to a possible interpretation of this result, ASD children possess a false belief attribution mechanism that underpins the ability to attribute, in some circumstances, false beliefs to an entity X (which can be human or artificial). For reasons that the task alone cannot help one clarify, this mechanism is activated in the RHt: robots activate ASD children's "general" false belief attribution mechanism. Note that more traditional tests, such as the STDt, could fail to activate, or perturb, this mechanism (which would nevertheless be "there" and potentially working) because they impose higher processing demands, potentially due to a sensory overload (Bogdashina, 2003). According to this interpretation, the RHt has the "right" characteristics to activate, in ASD children, a cognitive false-belief attribution mechanism that is idle or perturbed in other conditions. The RHt would thus provide information on ASD children's "general" false-belief attribution abilities, and not only on their ability to attribute false beliefs to robots. Regardless of whether ASD children *can* attribute false beliefs to other people in everyday contexts, the RHt would offer evidence that they do possess a general false belief attribution mechanism that can be activated in some cases.

This interpretation would clearly require support. However, one might wonder what would be needed to reject it. It is obvious that, superficially, the RHt only assesses ASD children's ability to attribute false beliefs to robots – this is how the task works. It is clear that, superficially, the RHt does not assess their ability to attribute false beliefs to people. So, to deny *in an interesting sense* that the RHt can be useful to study "general" ToM, one must claim that the results of RHt (superficially concerning robots) *cannot be used to infer* anything about children's ability to attribute false beliefs to other people. One way to interpret the claim that the RHt can only test ASD children's ability to attribute false beliefs to *robots*, but not to *other individuals* generally, would be to take it as suggesting that ASD children have *two* dedicated false belief attribution mechanisms, one activated by robots (in particular, by the RHt), another one activated by people (in particular, by the STDt, which – incidentally – does not involve "real" humans but puppets). Thus, children's performances in the RHt would speak to the working of the first mechanism only, and would say nothing about the second one. This hypothesis might well be true, even though it would imply a proliferation of separate mechanisms, each one devoted to the attribution of false beliefs to a distinct category of "third entities". We take the difficulty of defending this position as a reason to provisionally accept the claim that the RHt can provide evidence of children's possession of a false-attribution mechanism. If children attribute false beliefs to the robot in the RHt, this can be taken to support the claim that they can possess a "general" false-belief attribution mechanism which is triggered by that task (and, possibly, not activated in other contexts).

Question 2 is answered affirmatively if all children (be they ASD or TD) perform similarly at the two tasks. This is the case, for example, if ASD children fail both the STDt and the RHt, and if the TD children pass both tests. This result would indicate convergence between the two tasks and support the hypothesis that the RHt can be reliably used to assess the ability of attributing false beliefs to others, under the assumption that the STDt is a "good" false belief test. However, in that case, one may legitimately question the usefulness of the RHt, insofar as it is as "good" as the STDt, which is significantly less expensive and easier to perform.

More interesting, from a theoretical and methodological point of view, is the detection of differences in the outcomes of the two tests, in the two groups of participants (question 3). Among the many possible combinations of outcomes, it might be the case that ASD children fail the STDt and pass the RHt. This result would suggest that the ASD children possess some false-belief attribution abilities (contrary to what is suggested by the STDt). And, it may be interpreted methodologically as suggesting that the RHt can reveal possession of false-belief attribution abilities which are not revealed by the standard Sally and Anne task (perhaps due to its distinctive processing demands). Thus, that the RHt is a valid and insightful test for studying false belief attribution in ASD people.

Participants

The sample selected for this exploratory study consists of 5 ASD participants aged between 4 and 12 years, with no intellectual disability and good verbal skills, and 5 TD subjects in the same age range. These participants were selected in the framework of a collaboration with the "Meta" Cooperative, operating in the Monza-Brianza area, and the "Desio-Brianza Consortium". The exploratory nature of this study justifies the choice of such a low number of participants in such a wide age range. For all the participants, we collected informed consent declarations in accordance with the ethical guidelines imposed by the University of Milano-Bicocca Ethical Committee.

The robot

The study involved CoderBot, a small non-humanoid and non-social robot developed by the Department of Human Sciences for Education (RobotiCSS Lab - Laboratory of Robotics for Cognitive and Social Sciences) and the Department of Computer Science of the University of Milan-Bicocca (www.coderbot.org). The robot is equipped with both front and side ultrasonic sensors and a front camera. It can be programmed using Blockly, a visual block-based programming environment. It is worth noting that the task involved no programming activity: the robot was presented to the children after being programmed by the research group so that it performed the desired behaviour during the RHt.

The auxiliary tests

The study included a preliminary phase which was carried out at least one week before the robotic task, during which screening tests were administered to the participating subjects, both ASD and normotypic. Children were administered the following tests:

CPM (Colored Progressive Matrices) - Progressive colored Raven matrices (Italian standardization by Belacchi, Scalisi, Cannoni & Cornoldi, 2008). Raven's colored progressive matrices measure non-verbal intelligence in children between the ages of 3 and 11 years old. They consist of 3 series, of 12 items each; each item requires the child to complete a series of figures with the missing one, compared to a model presented, according to a criterion of growing difficulty. The model figures include graphic motifs that change from left to right and from top to bottom; the subject must understand the underlying logic to choose the right figure to complete the model. Administration takes approximately 30 minutes. The purpose of using this test is to provide important information on the ability of logical reasoning and fluid intelligence to analyse the behaviour of the participants in the "robotic task", which requires a certain level of non-verbal intelligence to understand the situation presented.

Proof of completion of stories on prosocial orientation (Grazzani & Ornaghi, 2015). The task consists of four short illustrated scenarios, concerning the following prosocial behaviours: comforting, making peace, sharing objects and helping. children are read the story and then asked to complete it with an ending. The purpose of administering this test is to check the variable of social competence involved in the non-verbal, spontaneous-response "robotic task". In particular, what is interesting to observe is the ability and predisposition of the participants to identify with the other, which in this case is a robot, and to help him achieve a goal. Furthermore, the results of this test will be useful in describing the performance of the participants in the classic Sally and Anne test.

Social Responsiveness Scale (Costantino & Gruber, 2005; Italian adaptation by Zuddas, Di Martino, Delitala, Anchisi & Melis, 2010). This scale assesses different aspects of social responsiveness: social awareness, social cognition, communication, social motivation and repetitive and stereotyped behaviors, or mannerisms. The SRS is made up of 65 items, with respect to which educators/teachers or parents express how much each behaviour refers to their child on a 4-point Likert scale (1 = not true, 2 = sometimes true, 3 = often true, 4 = almost always true). It is generally filled in by both teachers/educators and parents. In our study only parents compiled the scale. The role of this tool is to provide additional information on the social competences of the participants. This is very important information for interpreting the performance of the "robotic task".

Sally and Anne: the classic first order false belief test (Baron-Cohen, Leslie & Frith, 1985). The child listens to a short story about two puppets: Sally takes a marble and hides it in her basket. She then "leaves" the room and goes for a walk. While she is away, Anne takes the marble out of Sally's basket and puts it in her own box. Sally is then reintroduced and the child is asked the key question, the *Belief Question*: "Where will Sally look for her marble?". Other two control questions are asked. A reality question to understand if the child has really understood where the ball is after moving and a question (Where is the ball now?) and a memory question to understand if the subject remembers where the ball was before (Where was the ball before?). The answers to these questions were collected in an answer sheet indicating whether the subject passed or failed the task. These results were then compared with those of the robotic task to detect any performance difference in the two conditions.

The "robotic helping task"

A week later from the preliminary phase, the robotic task was carried out. The setting consists of two boxes (A and B) having a door that can be closed with an internal pin, and of a small box representing the object that the robot will have to reach, equipped with ARCodes that can be read by the robot. The boxes are neutral in colour to avoid possible distracting elements, especially for individuals on the autism spectrum. In the room there are several video cameras that will record the entire task and will later allow you to analyse the recorded videos.

In addition to the experimenter (S1) who followed the subject during the task, there was a second experimenter (S2) who had the task of activating the robot. The task consisted of three phases.

Familiarisation phase: the subject observes the robot as it reaches the box which is moved several times in space by the experimenter. The robot is programmed to follow the ARcode on the box and stop once reached. After various movements, S1 puts the object behind the robot which obviously does not move. This is a very important phase because, thanks to these movements, the subject must understand that the robot's goal is to reach the box. Finally, the subject is proposed to move the box himself in space. Control questions are asked to understand if the subject has understood the robot's desire:

1. Why, in your opinion, did the robot move before?
2. When I put the box behind the robots, why do you think the robot didn't move anymore?

Once the familiarisation with the robot is concluded, S1 presents the two boxes to the subject to make them understand the opening and closing mechanism of the doors. For this phase a definite time is not given but the time space necessary for the subject is left to assimilate the information about the robot's desire, that is the box.

True belief phase: the robot is placed in front of the boxes. S1 and the subject are positioned behind. The object and the two pins are located on the side of the boxes. The experimenter now takes the box and slowly places it in box A while continuing to observe the robot; then, again with a slow movement and with his gaze turned to the robot, slowly moves the object into box B. At this point the subject is asked the control question: "Do you think that the robot saw the movement?". If the answer is no, the subject is proposed to make the movements again. Once this step has been carried out, S1 asks the subject to close the doors. The robot starts and goes towards box A (empty), slamming against the door several times without being able to enter. At this point, the spontaneous attitudes of the subject are observed and the answer is awaited: if the subject helps the robot to enter box A (empty) then this phase can be considered to have been overcome since in this case he has understood that the robot's objective is that of entering the box and not reaching the object since the automaton has observed the movements.

False Belief Phase (FC): the setting is the same as the previous phase. The experimenter begins by slowly placing the object in box A, always with his gaze turned towards the robot. At this point the experimenter covers the robot with a box and returns to the side of the subject, takes the object from box A and moves it to box B, closing the doors. The control question is asked: "Do you think the robot saw the movement?". If the answer is yes then it continues, otherwise the move is repeated again. Now the robot is activated and will continue to go towards box A and crash without being able to enter.

Therefore, the spontaneous attitudes of the subject are observed and the response is attentive. To overcome this phase, the subject must understand that the robot wants the object but having not seen the movement continues to go towards box A, so the possible answers that can lead the subject to overcome the task are:

- the subject takes the object and gives it to the robot;
- the subject takes the robot and puts it inside box B where the object is located;
- the subject takes the object from box B, puts it in box A and opens the door to let the robot in;
- the subject takes the robot and places it in front of box B;
- the subject takes the robot, puts it in front of box B and opens the door;
- subject opens the door of box B.

The total duration of the task varies according to the response times of the subject, during this pilot study it had a duration ranging from 30 to 40 minutes, including a ten minute break between the VC phase and the FC phase.

Results

The auxiliary tests: Results

The SRS showed that the participants of the control group on average fall into a "normal" profile (Table 1). As regards the experimental group, S02 and S04 have a "severe" profile which indicates a serious interference in daily social interactions.

Raven's CPM: the participants in the control group are within the normal range for age, while 2 subjects in the experimental group have scores that are significantly below average.

Tab. 1 - Results Social Responsiveness Scale

Subj.	*Sex*	*Age*	*Group (experimental/control)*	*SRS_social awareness*	*SRS_social cognition*	*SRS_social communication*	*SRS_social motivation*	*SRS_social motivation*	*SRS_tot*
S01	F	63	S	9	9	14	5	9	46
S02	M	82	S	13	28	36	17	22	116
S03	M	130	S	11	20	21	9	13	74
S04	M	131	S	12	20	27	19	25	103
S05	M	137	S	6	15	23	14	22	80
C01	M	111	C	11	14	23	11	11	70
C02	M	71	C	2	1	3	3	2	11
C03	M	65	C	5	3	7	5	1	21
C04	F	88	C	6	3	8	1	6	24
C05	M	64	C	3	6	9	7	2	27

Tab. 2 - Results Raven, Prosocial Behavior and Sally and Anne

Subject	*Sex*	*Age*	*Group (experimental/control)*	*Raven*	*Prosocial Behaviour*	*ToM_Sally&Anne*
S01	F	63	S	16	1,5	1
S02	M	82	S	12	0,5	0
S03	M	130	S	27	1	0
S04	M	131	S	16	4	0
S05	M	137	S	32	3	0
C01	M	111	C	24	2,5	1
C02	M	71	C	26	1	0
C03	M	65	C	23	4	1
C04	F	88	C	23	2	1
C05	M	64	C	14	0,5	1

Proof of stories completion on prosocial orientation and "classic" test of Sally and Anne: from figure 1 it is interesting to note that most of the participants who achieved good results in completing prosocial stories then succeeded to pass the classic Sally and Anne test. However, some participants, particularly S03 and S04, who gained high scores in completing the prosocial stories, then failed to pass the classic Sally and Anne test. Overall, the experimental group failed to pass the classic Sally and Anne test, except for a single subject S01. We must remark that both S01 parents and educator are working hard on social skills; therefore, this result could be attributed to the specific training that the participant undergoes both at home and at school.

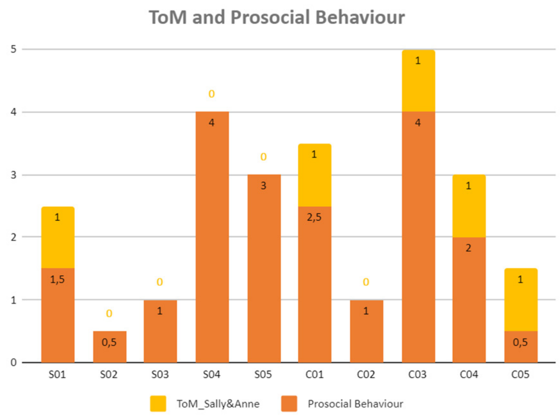


Fig. 1 - Comparison of results between the Sally and Anne test and Prosocial Behaviour test

The robotic helping task: Results

The results of the STDt and the RHt, administered to the ASD and the TD participants (labelled as Sx and Cx, respectively) are shown in Table 3. Note that the STDt is passed if the participant answers that Sally will look in the basket (i.e., where she had put it before leaving). The RHt is passed only if two conditions are met:

- in the TB condition – i.e., when the robot was not covered and "saw" the change of location of the object – the participant spontaneously helps the robot enter box A, which is empty;

- in the false belief condition – i.e., when the robot was covered – the participant displays one of the spontaneous responses listed previously, intending to help the robot reach the object in box B.

Note that the RHt can be thought of as revealing attribution of a false belief to the robot only if both conditions are met, as thoroughly discussed in Buttelmann et al. (2009).

Let now discuss how these results speak to the three empirical goals of this study, which are the following.

1. Can ASD children pass the RHt?
2. Do TD and ASD children tend to display the same performances at the two tasks?
3. If they do not, how do the two groups differ at the two tasks?

The choice of a small sample (five ASD children, five TD children) does not enable us to formulate general answers to these questions. The following answers will concern our pool of participants, and further studies will investigate whether they can be generalised in one way or another.

Can ASD children pass the RHt (question 1)? Three out of five ASD children passed the task. Two of them, S02 and S04, did not. Participant S02 tended to play with the robot for the whole duration of the task, paying little or no attention to the task. Participant S04 displayed the "right" reaction in the FB condition and the "wrong" reaction in the TB condition, helping the robot reach box B.

Do TD and ASD children tend to display the same performances at the two tasks (question 2)? As shown in Table 1, the answer is negative for our small pool of participants. This brings us to the third question: how do the two groups differ from one another at the two tasks?

This question can be answered, first, identifying ASD/TD differences in each single task.

- The ASD and the TD participants behaved differently in the STDt: 4 out of 5 ASD children failed it, while 4 out of 5 passed it.
- They also behaved differently in the RHt: 3 out of 5 ASD children passed the test, while all the TD children failed it.
- Second, one may identify STDt/RHt differences within each single group of participants.
- As far as the ASD group is concerned, the results are variegated. One participant (S01) passed both tests. Two participants (S02, S04) failed both tests. Two participants (S03, S05) failed the STDt and passed the RHt.

- The results are more homogeneous in the TD group: 4 out of 5 children passed the STDt but failed the RHt. C02 failed both tests.
- These rather aseptic results can be profitably complemented with more qualitative observations of our participants' behaviour, that can be useful to interpret the data and obtain possible explanations.
- As far as the ASD group is concerned, S01 passed the classic false belief task, correctly answering the first-order false belief question and the memory question, showing that he remembered the story. However, he did not answer the reality question correctly, showing that he did not understand where the object really was. On the other tests (SRS, Raven, Story Completion) he obtained normal scores. He passed the RHt.
- S02 failed the classic test and gave a wrong answer to the memory question, showing that he did not understand the story. However, he correctly answered the reality question revealing that he understood the actual location of the object. With regard to the SRS test, he falled into a "severe" profile that indicates a serious interference in daily social interactions. He also failed the CPM and showed several difficulties, although passing the test, in the completion tests. He failed the RHt.
- S03 failed the classical task. However, it correctly answered both the reality question and the memory question, thus demonstrating that it remembered the story and understood the actual real location of the object. According to SRS scores, he has a normal profile. He passed the RHt.
- S04 failed the classical task. However, he correctly answered both the reality question and the memory question, thus demonstrating that he remembered the story and understood the actual location of the object. He has a severe SRS profile, indicating serious difficulties in everyday social interactions. He passed the other two tests (Raven, Story Completion). He failed the RHt.
- S05 failed the classical task. However, he correctly answered both the reality question and the memory question, thus showing that he remembered the story and understood whether the object actually was. He passed the RHt.

As previously mentioned, all the TD participants showed difficulties in the RHt. More specifically, C02 and C04 displayed the "wrong" reaction in both the TB and FB condition. C03 and C05 displayed the "right" reaction in the TB condition and the "wrong" reaction in the FB condition. C01 displayed the "wrong" reaction in the TB condition, and the "right" reaction in the FB condition.

Tab. 3 - For each participant (Sx: ASD child, Cx: TD child), the table summarises the results at the STDt and at the RHt

Participant	*STDt*	*RHt*
S01	Passed	Passed
S02	Failed	Failed
S03	Failed	Passed
S04	Failed	Failed
S05	Failed	Passed
C01	Passed	Failed
C02	Failed	Failed
C03	Passed	Failed
C04	Passed	Failed
C05	Passed	Failed

Discussion and concluding remarks

The results of this exploratory study are in line with the literature when comparing TD and ASD children using classical standard tests. In particular, a significant difference emerges, in favour of TD children, with respect to social responsiveness, prosocial behaviour and understanding of false belief using the classic paradigm of unexpected displacement (Sally and Anne, STDt).

An interesting aspect seems to emerge if we compare the two groups on the "robotic helping task". All TD children do not pass the task, which is instead better understood by ASD children. This result can be interpreted – as suggested in the section on objectives – as an indicator of the ASD children's possession of cognitive decentering and false belief attribution skills, which the classic Sally and Anne test is unable to capture. This may also be in line with the idea that the use of false belief tasks involving people or characters with human characteristics (including humanoid robots) contributes to a sensory and perceptual overload that hinders the cognitive processes of hierarchization and selection of salient elements to understand the intentionality of actions based on beliefs, whether true or false. It is therefore possible that ASD children are able to understand the objectives of the robot by observing its movements, without being "disturbed" by other sources of information that would make the situation too complex.

On the other hand, the fact that TD children fail the robotic helping task leaves room for different interpretations: it is possible that children do not recognise the robot as an agent endowed with thought and intentionality. It is also possible that, although the children understand the robot's purpose, the empathic closeness that would lead to the activation of pro-social behaviour is not activated in this case.

The results of this exploratory study offer interesting insights into cognitive perspective taking processes and false belief attribution skills in both TD and ASD children, and on the possibility of using robots to study ToM in ASD and TD children. However, the small number of subjects involved only allows for hypotheses and speculations that should be tested with studies involving a sufficiently large number of subjects.

Acknowledgements

The authors are grateful to Prof. Elisabetta Lalumera for all the insightful comments and suggestions that we received in the initial stages of this research project. They also want to thank the "Meta" Cooperative and the Desio-Brianza Consortium for their invaluable support in the setting-up of the empirical research and in the involvement of the participants.

References

Alabdulkareem A., Alhakbani N. and Al-Nafjan A. (2022), "A systematic review of research on robot-assisted therapy for children with autism", *Sensors*, 22, 3: 944. https://doi.org/10.3390/s22030944

American Psychiatric Association. Diagnostic and statistical manual of mental disorders (5th ed.), Arlington,VA: American Psychiatric Publishing, 2013. (ed. it.: Manuale diagnostico e statistico dei disturbi mentali, Cortina, Milano, 2014)

Anwar S., Bascou N.A., Menekse M. and Kardgar A. (2019), "A systematic review of studies on educational robotics", *Journal of Pre-College Engineering Education Research*, 9, 2: 19-42. https://doi.org/10.7771/2157-9288.1223

Arent K., Kruk-Lasocka J., Niemiec T. and Szczepanowski R. (2019), *Social robot in diagnosis of autism among preschool children*, in *2019 24th International Conference on Methods and Models in Automation and Robotics (MMAR)* (652-656). https://doi.org/10.1109/MMAR.2019.8864666

Banks J. (2020), "Theory of mind in social robots: replication of five established human tests, *International Journal of Social Robotics*, 12, 2: 403-414. https://doi.org/10.1007/s12369-019-00588-x

Baron-Cohen S. (2001), "Theory of mind in normal development and autism", *Prisme*, 34, 1: 74-183.

Baron-Cohen S., Leslie A.M. and Frith U. (1985), "Does the autistic child have a 'theory of mind?" *Cognition*, 21, 1: 37-46.

Baron-Cohen S., Wheelwright S., Lawson J., Griffin R. and Hill J. (2002), *The exact mind: Empathising and systemising in autism spectrum conditions*, in *Handbook of cognitive development* (pp. 491-508).

Bechtel W. (2008), *Mental Mechanisms. Philosophical Perspectives on Cognitive Neuroscience*, Routledge.

Bloom P. and German T.P. (2000), "Two reasons to abandon the false belief task as a test of theory of mind", *Cognition*, 77, 1: B25-B31.

Bogdashina O. (2003), *Sensory issues in autism: Different sensory experiences different perceptual worlds*, Jessica Kingsley Publishers, Philadelphia, PA.

Buttelmann D., Carpenter M. and Tomasello M. (2009), "Eighteen-month-old infants show false belief understanding in an active helping paradigm", *Cognition*, 112, 2: 337-342. https://doi.org/10.1016/j.cognition.2009.05.006

Cabibihan J., Javed H., Ang M. and Aljunied S.M. (2013), "Why robots? A survey on the roles and benefits of social robots in the therapy of children with autism", *International Journal of Social Robotics*, 5, 4: 593-618. https://doi.org/10.1007/s12369-013-0202-2

Cottini L. e Vivanti G. (2013), *Autismo: come e cosa fare con bambini e ragazzi a scuola*, Giunti, Firenze, pp. 63-95.

Di Lieto M.C., Inguaggiato E., Castro E., Cecchi F., Cioni G., Dell'Omo M., Laschi C., Pecini C., Santerini G., Sgandurra G. and Dario P. (2017), "Educational Robotics intervention on Executive Functions in preschool children: A pilot study", *Computers in Human Behavior*, 71: 16-23. https://doi.org/http://dx.doi.org/10.1016/j.chb.2017.01.018

Franklin L.R. (2005), "Exploratory Experiments", *Philosophy of Science*, 72, 5: 888-899. https://doi.org/10.1086/508117

Frith U. (1989), *Autism and "theory of mind"*, in *Diagnosis and treatment of autism* (pp. 33-52), Springer, Boston, MA.
Grant C.M., Grayson A. and Boucher J. (2001), "Using tests of false belief with children with autism: How valid and reliable are they?", *Autism*, 5, 2: 135-145.
Happé F.G. (1995), "The role of age and verbal ability in the theory of mind task performance of subjects with autism", *Child development*, 66, 3: 843-855.
Hucklenbroich P. (2017), *Medical theory and its notions of definition and explanation*, in *Handbook of the Philosophy of Medicine*. Springer, Netherlands. https://doi.org/10.1007/978-94-017-8706-2_44-2
Jordan R. and Powell S. (1995), "Autism: The case for early specialist intervention", *Early Years*, 16, 1: 46-50.
Kanner L. (1946), "Irrelevant and metaphorical language in early infantile autism", *American journal of Psychiatry*, 103, 2: 242-246.
Kimhi Y. (2014), "Theory of mind abilities and deficits in autism spectrum disorders", *Topics in Language Disorder,* 34, 4: 329-343. doi: 10.1097/TLD.0000000000000033
Liverta Sempio O., Marchetti A. e Lecciso F., a cura di (2005), *La teoria della mente tra normalità e patologia*, Cortina, Milano.
Pennisi P., Tonacci A., Tartarisco G., Billeci L., Ruta L., Gangemi S. and Pioggia G. (2016), "Autism and social robotics: A systematic review", *Autism Research*, 9, 2: 165-183. https://doi.org/10.1002/aur.1527
Perner J., Leekam S.R. and Wimmer H. (1987), "Three-year-olds' difficulty with false belief: The case for a conceptual deficit", *British journal of developmental psychology*, 5, 2: 125-137.
Petric F., Miklic D. and Kovacic Z. (2017), *Robot-assisted autism spectrum disorder diagnostics using POMDPs*, in *Proceedings of the Companion of the 2017 ACM/IEEE International Conference on Human-Robot Interaction* (pp. 369-370). https://doi.org/10.1145/3029798.3034819
Pierno A.C., Mari M. and Castiello U. (2008), "Robotic movement elicits visuomotor priming in children with autism", *Neuropsychologia*, 46: 448-454. https://doi.org/10.1016/j.neuropsychologia.2007.08.020
Scassellati B. (2007), *How social robots will help us to diagnose, treat, and understand autism. 2. What we know about autism*, in Thrun S., Brooks R. and Durrant-Whyte H., eds., *Robotics Research* (pp. 552-563).
Scheeren A.M., de Rosnay M., Koot H.M. and Begeer S. (2013), "Rethinking theory of mind in high-functioning autism spectrum disorder", *Journal of Child Psychology and Psychiatry*, 54, 6: 628-635. https://doi.org/10.1111/jcpp.12007
Setoh P., Scott R.M. and Baillargeon R. (2016), "Two-and-a-half-year-olds succeed at a traditional false-belief task with reduced processing demands", *Proceedings of the National Academy of Sciences*, 113, 47: 13360-13365.
Siciliano B. and Khatib O., eds. (2008), *Springer Handbook of Robotics*, Springer Berlin Heidelberg. https://doi.org/10.1007/978-3-540-30301-5

Spradlin J.E. and Brady N. (2008), "A behavior analytic interpretation of theory of mind", *Revista internacional de psicologia y terapia psicologica = International journal of psychology and psychological therapy*, 8, 3: 335.
Surian L. (2005), *L'autismo. Conoscerlo e affrontarlo*, il Mulino, Bologna.
Tager-Flusberg H. (2000), "Language and understanding minds: Connections in autism", *Understanding other minds: Perspectives from developmental cognitive neuroscience*, 2: 124-149.
Verté S., Roeyers H. and Buysse A. (2003), "Behavioural problems, social competence and self-concept in siblings of children with autism", *Child: Care, Health and Development*, 29, 3: 193-205.
Wiese E., Müller H.J. and Wykowska A. (2014), *Using a gaze-cueing paradigm to examine social cognitive mechanisms of individuals with autism observing robot and human faces*, in *LNAI* (pp. 370-379), vol. 8755. https://doi.org/10.1007/978-3-319-11973-1_38
Zhang Y., Song W., Tan Z., Wang Y., Lam C.M., Hoi S.P., Xiong Q., Chen J. and Yi L. (2019), "Theory of robot mind: False belief attribution to social robots in children with and without autism", *Frontiers in Psychology*, 10: 1732. https://doi.org/10.3389/fpsyg.2019.01732

Engage social skills in children with Autism Spectrum Disorder with ASD-Robot

by *Lucia Campitiello*, *Michele Domenico Todino* and *Stefano Di Tore*

Introduction

Recent researches have highlighted how the employment of social robots in the field of disability can promote the development of socio-relational skills (Conti et al., 2015; Xiao et al., 2020) in children with Spectrum Disorder Autistic (ASD). The child-robot interaction can promote the implementation of new social behaviors and increase joint attention (Lytridis et al., 2019). According to Baron-Cohen's (2009) empathizing-systemizing (ES) theory, it appears that children with autism easily interact with highly formal systems in which behavior can be predicted. Generally, children with autism show a propensity to interact first with the robot and then with the human being (Dunst et al., 2013). The interaction with the robot stimulates children to imitate the observed behaviors (Duquette et al., 2008) and to increase the maintenance of shared attention (Robins et al., 2005). Considering the two categories of deficit of Autism Spectrum Disorder, namely the deficit in the area of social communication and the deficit of imagination, the main difficulties lie in verbal and non-verbal language, in social interaction and in the restricted repertoire of behaviors, repetitive and stereotyped (Cottini et al., 2017). Hobson (1993a; 1993b) hypothesized that in autism the primary deficit lies in the direct perception of bodily expressions, highlighting how children with autism are unable to recognize emotions, especially if they are linked to the mental states of others. This difficulty can be linked to the lack of interest in people and the isolation that leads to the failure to acquire social rules. In fact, Wing and Attwood (1987) identified three categories of social behaviors that people with autism can exhibit: a) withdrawn behavior, that is the most widespread behavior, in which one tries to avoid physical contact and social interaction with the others; b) passive behavior, consists in relating to others to satisfy their needs and the approach by others is not rejected; c) active but bizarre behavior, those who are part of this category spontaneously initiate interactions with others, speaking specifically about their own interests but behaving inappropriately.

For this reason, there is a need to teach social skills to children with autism, through programmed teaching, in order to reduce problematic behaviors and promote school inclusion.

The teaching of Social Skills in children with ASD through play

Educators know how important it is to teach children with disabilities, not only school skills, but also social and emotional skills to reduce problematic situations. This awareness is deduced from the Law B. 94/142 of 1975 which highlights the need to teach, to pupils with disabilities, in environments common to pupils with typical development, in order to promote inclusion and scholastic success. Although we try to achieve these educational goals, to encourage school inclusion, children with disabilities are not always immediately accepted by classmates. Indeed, many studies (Allen et al., 1972; Bryan & Bryan, 1978; Strain et al., 1977) have highlighted how children with disabilities interact less than their peers, as they lack the so-called social skills that need to be learned through programmed teaching to successfully achieve integration. Scholars Cox and Gunn (1980) attempted to give an explanation to the lack of socially acceptable behavior, identifying the following reasons: a) the pupil does not know the right behavior to perform in a social situation; b) the pupil knows the behavior to be issued but has never implemented it; c) the pupil due to his emotionality is unable to perform adequate behavior. This lack could also be considered an absence of "behavioral flexibility" (McGinnis & Goldstein, 1992) which does not allow the child to adapt his behavior to the different situations that arise. One possible way to teach children social skills is to use the psychoeducational model of Structured Learning which involves: a) modeling, known as learning by imitation, in which the child learns "what to do"; b) role playing, simulation of a role (Mann, 1956) in which the child learns "how to do it"; c) informational feedback, to motivate the child to perform a certain attitude; d) generalization, i.e. the extension of the learned behavior in various situations

(McGinnis & Goldstein, 1992). In other words, in structured learning there is a model to follow (modeling technique) and an exercise to be performed to learn a behavior (role playing) that is reinforced (correctness feedback) to be acquired and extended in other situations (generalization).

Therefore, to practically act on the teaching of social skills, through structured learning, it is possible to arrange playful activities that stimulate the child to develop specific skills, such as motor, cognitive and verbal ones. Play, in particular, can help children with disabilities to enhance the interpersonal and social aspect through the use of toys in various activities. In the specific case, to favor the development of social skills it is possible to use a robot that can act as a toy or as a peer, and which possesses the following characteristics so as to appear: modular, configurable, adjustable, social and agentive (Pennazio, 2019). In other words, it is possible to arrange playful activities in which the child can initially work individually with the robot, focusing on some specific aspects, such as the recognition of emotions on the face of the automaton. The robot can be configured to show the different expressions of emotions on the face, trying to regulate the stimuli so as not to overload the child on a sensory level. Furthermore, the robot must appear "imperfect" (ibidem) in order not to create high expectations in the child and, a fundamental aspect not to be underestimated, must adapt to the educational context in which it is found. In this way the robot will be able to play the role of social mediator (Lytridis et al., 2019) which is placed between the teacher and the child, promoting communication and social interaction. The robot could teach social skills by acting as a model (modeling) and suggesting to the child to imitate some behaviors that he performs for social purposes (role playing); subsequently the robot can provide feedback to motivate the child to extend this attitude (generalization) in other social situations.

ASD-Robot: Design of the open-source robot

The following work presents a research aimed at the design and construction of a robot, called ASD-Robot, aimed at promoting the development of basic socio-relational skills in children with autism spectrum disorder. ASD-Robot was created in Laboratory H of the Department of Human Sciences, Philosophy and Education, of the University of Salerno. The robot prototype was designed using the Rhinoceros software and created using the Prusa MK3s printer. The robot t was designed specifically to create an open-source device available on the Lab H website (www.labh.it/asd-robot), customizable, in order to adapt to the needs of children with autism.

The robot is equipped with sensors and actuators which, through the movement of the limbs, allow it to interact with the child. On the face of the robot there is an LCD, connected to the LattePanda board, which displays the six primary emotions (happiness, sadness, anger, fear, disgust and surprise) as indicated in Paul Ekman's neuro-cultural theory of emotions (2013). The human face is the main channel for expressing emotions, which can be encoded through the conformations of the face, such as the eyebrows, the shape of the mouth, eyes and wrinkles (ibidem).

Using the program of Howlin's method (1999), Theory of mind (TOM), which aims to favor the development of the mentalization process (i.e. the understanding of one's own mental state and that of others). This program is divided into three parts: a) emotions; b) system of beliefs and false beliefs; c) symbolic and fictional game. In particular, focusing on the first part of the program, relating to the recognition of emotions through schematic drawings, it is possible to train children with autism to recognize emotions.

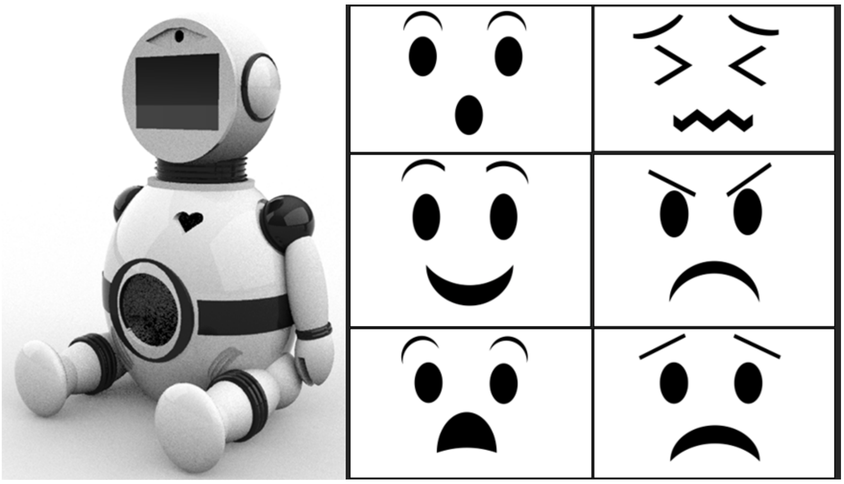


Fig. 1 - Recognition of emotions through schematic drawings on the face of ASD-Robot

ASD-Robot is equipped with a remote control integrated into the PC to manage the actions that the automaton must perform to provide appropriate feedback to the child based on the situation to be created.

As for the data analysis, robot will be a software (in testing phase) related to the tracking of ocular information and the recognition of the facial expressions of the child. This information can be useful to therapists and educators who intend to monitor the progress of the therapy and observe how the child relates to the robot, as it is possible to program the automaton to adapt to the specific needs of the child.

In children with Autism Spectrum Disorder, the diagnosis is often associated with an abnormality in the sensory perception of the outside world (Bogdashina, 2016), unlike typically developing children, they may exhibit hypersensitivity or hyposensitivity to external stimuli. These sensory difficulties can be studied with the use of the robot in a controlled context in which it is possible to program it in order to gradually reduce or expand the sensory stimuli to favor communication and social interaction.

Specifically, ASD-Robot refers to the K-12 age group and it is preferable for the robot to interact with autistic children with a high level of functioning, in such a way that they have already acquired the concept of emotion in order to work on the recognition of emotional states of others.

Congruence, Unconditional Positive Regard and Accurate Empathic Understanding in ASD-Robots didactical application

This paragraph will be shown why Rogers's three characteristics, or attributes, for a therapeutical relationship could be useful also in a didactical one based on emotions. Rogers propose as postulate three characteristics in a humanistic approach for an educational relationship: 1) Congruence; 2) Unconditional Positive Regard; 3) Accurate Empathic Understanding (Ariano, 1990; 1997; 2010; Digaetano, 2010). Based on the fact that Rogers referred these three attributes to the psychotherapeutic relationship, this paper discusses its transposition in the inclusive education.

More in detail, with the word Congruence he described a person who aligns the signals that come from verbal and non-verbal language, emotions and feelings. In general, congruence should be seen as a «mirror of clear water» (ibidem, p. 15) where the other interlocutor can look at himself with peacefulness. Thus, implies that the educator, that drives the activities, should be honest, open, integrated and genuine, during the teaching-learning process. However, some educators are not "prepared" to be congruent and ready to act in a peer and balanced way with a learner (here the first couple of problems opens up in a didactical application of Rogers theory). On the other hand, if congruence is used to better understand students' behaviours, beliefs, etc. this understanding is often not possible due to the fact that some age groups (such as adolescence) often congruence have not a high level. As will be seen, in the specific case of an activity done by ASD-Robot, the educator could verify an increase or decrease of congruence for an autistic child, when an interface is a machine, and it can record much useful information to increase especially congruence of the kid.

The second attribute, for the purposes of this paper, requires more detail than the first to be described. Unconditional Positive Regard means that the educator honestly cares for the person who is on the other side, i.e. behind her/him. Rogers is a vitalist and a positivist (ibidem, pp. 47-48). Vitalist means that, Rogers believed that life is much more than physical or chemical phenomena, and humans, according to the biopsychosocial model, should be studied with an interdisciplinary approach that explores the "sewing net" that is "plotted" between biological, psychological, and socio-environmental aspects and issues. As a positivist, Rogers try to find logically and admissible statements that can be scientifically confirmed. Indeed, he believes in the "power" of education and, at the same time, that people are inclining to improve their life and skills, as well as the bio-educational potential principle states (Frauenfelder, 2011; Aiello, Sharma & Sibilio, 2016). Rogers founded his definition of Unconditional Positive Regard by his experience and researches; he noted that through gratifications, rewards and prizes, tolerance, inclusion, etc. the teaching-learning process produced often positive results because it must lead to supporting, aiding, facilitating the child, it was based on the cognitive styles, potentials, as well as the limits, of the kids. The educator's great effort is not to be too biased towards one's self-control point of view, i.e. from an egocentric point of view (Berthoz, 2011) of the educational process and didactical activities. However, Unconditional Positive Regard is not always possible, even if it is desirable and desired by the educator, due to the fact that sometimes the educator is a person with emotions, preconceptions, limits, etc. moreover some activities could overcome a threshold where educator could lose her/his congruence in a teaching-learning process, this can happen due to many factors: simply tiredness, but also anger, sadness, ethical or moral issues. By way of sample, let's think about teenagers, when they live their life asking by themselves: “Why does it feel like no one likes me (also my parents, my educators, my therapist if I have one, etc.)?”. Maybe this is true; they really “catch” in an adult a conditional emotion or feeling. In these cases it would be better to highlight that emotions, cognitions, conducts, actions, also in adult are often not unconditional; students emotions, cognitions, conducts, actions condition their conduct and behavior. In the “real world” is quite hard to be unconditional by others, as a consequence, Rogers’ model tends towards utopia, however utopias can lead us towards paths of great scientific interest and awareness. By the way, there is a natural trend, for such kind of people, to not fulfil Unconditional Positive Regard, if a didactical activity is not well designed. For this reason, when a research activity is well planned, and when there is, for an educator, an “anxiety” of “fear” of failing Rogers’ postulate, it is better to introduce a nonstop supervision, improve self-awareness and self-efficacy to reduce risks of not being unconditioned.

Finally, the last of Rogers’ three attributes is Accurate Empathic Understanding. According to Rogers, it means that the relationship has to be deep, in term of feelings, cognition, and emotions to realize a meaningful learning (Padoan, 2012, p. 151); overall a class of theories and practices that combine psychological research and pedagogy model that takes into account the emotions, cognitions, behaviours of the human being in its most complete form, in other words in a model that is both holistic and phenomenological (Zavalloni, 1972; Grasselli, 2016). Empathy should be at the centre of such practices and theories to solve problems, to develop the educational relationship, and, last but not least, to explore authenticity through empathic communication schemes to know each other; for example, including verbal, non-verbal and symbolic languages. Sometimes, a child, an adolescent, an adult could not induce sympathy when an educator sees activities done together, although empathy could be seen as a true heterocentric change of perspective-taking (Berthoz, 2011) and sympathy is set aside in a professional approach. Understanding problems, facing tasks and explaining emotions arise when an educator tries to understand how the other lives the relationship in a specific moment. Once again, Rogers’ positive regards, described above, leads us to turn an educator’s impetus (in term of demotivation of those who leads the learning) en route for a new possibility of solving some difficulties that arise in the relationship. But this is true if the educator will find an empathic way to face every problem. Gentleness, mildness, blandness should drive didactics activities producing a “mild” revolution, “fruit” of the pedagogical relationship. Rogers was at the same time prophetic, theoretical and practical in his own psychological and psychotherapeutic research. He tried to create a relationship between peers able to configure a reticular model that is never conclusive but always in perpetual evolution; such as a protean factor that shapes the relationship in a systemic structure based on a relationship able to improve a double teaching-learning process: the educator start to better learn the special educational need of each learner, to shape the process, by the other side learner better understand the teaching style. If this educating relationship is not established, the teaching-learning process is "doomed" to failure. Is this kindness really necessary? In Rogers's beliefs, he already seems to "foretaste" the affirmative answer, speculatively speaking, even if sometimes it seems to need to speak or respond harshly some students to make them "repent", above all in the case of students (with autistic spectrum disorders) who will experience ASD-Robot, it is very difficult that the educator will be able to reproach without then realizing that this road, off the Rogers route, bring results, on the other hand, "the surest way" is to warn or always respond gently and be careful never to resent. Indeed, corrections made with a kindly zeal often do more harm than good, especially when the child gets upset rather than figuring out how to overcome a mistake.

Moreover, empathizing with the interlocutor does not absolutely mean identifying with the other (empathy ≠ identification); in fact, in the process of identifying a person feels within himself the emotions of those in front of him. Returning to the concept of the mirror of water. Educator's water does not still reflect but becomes "contaminated". Consequently, the ability to reflect by giving advice is lacking and, in the specific case of the educational process, the voluntary directionality of the teaching-learning process is lacking. Furthermore, Rogers's point of view about empathy, the educator must have an empathic attitude even when he works with a group, and not just with an individual, and welcoming and his role is to encourage the exchange and the comparison between the different conversers. Again, in the specific case of ASD-Robot, the educator could believe that the interaction human-machine could be engaged the didactical activities, etc. but this should be too positivist as a scientific approach. Realistically, it is necessary to evaluate case by case if the relationship between educator and learner, through a digital-robotic interface improves or worsens the relationship, if the relationship increases in meaning, but above all, if the vision of the educator in terms of unconditioning increases towards the other person seen through a robotic avatar. Furthermore, in the authentic empathic relationship, the child feels protected and free to act; the educator and learner can be spontaneous; in this relationship being oneself comes before doing; and it is hoped that this will happen, in this specific case, through the robotic-digital game.

Rogers promoted significant learning (Padoan, 2012, p. 151), that is, person-centred learning; it must be based on five factors: 1) "speak to the heart"; 2) "speak to the intellect"; 3) overturn the terms of traditional authoritarian control from above; 4) eliminate the factors that make it passive the student in the teaching-learning process; 5) the student is not forced to internalize the relationship without being able to act through feedback in the ongoing process. Rogers then indicated the practical conditions to ensure meaningful learning: 1) presence of an educator-facilitator, self-confident and confident in the ability of anyone (positivist vision); 2) determine a priori a sharing of decision-making responsibilities; 3) retrieval of resources by all the people involved, according to the different experiences; 4) initiative by the student in organizing their own learning; 5) care of a facilitating "climate", as a priority over the care of "contents" (ibidem). However, all these points, under certain conditions, are refutable. Point one because there are not always the necessary skills, point two because the assumption of responsibility may fail (in this regard, think of people who have addictions and therefore do not respect the given rules), point three and four when there is no engagement with respect to the activities to be carried out (done with a lot of boredom and automatism), finally, point five when it is not possible to improve and act on the surrounding environment.

In conclusion, this positive vision, in the first phase, that of the beginning of the research and experimentation activity, certainly contributes to the educator to face the experimentation, in this specific case with children who have autism spectrum disorders. However, as experimentation takes place, a vision of the limits of these three typical attributes of Rogers' psychological vision, which could be called a humanistic philosophy of human relations emerge (Ariano, 1990, pp. 57-48). This must be addressed through the modelling of more sophisticated human-machine interfaces more complex, educational interventions and above all aware of the fact that in some cases they could be ineffective. Nevertheless, these preliminary considerations on Rogers are useful because his contribution was fundamental for all the specialists who still study emotions and empathy today and is a good starting point that can always be updated.

Future perspectives and research horizons

As a future field of experimentation, taking advantage of the features of ASD-Robot, the project could also be introduced as a robot kit in secondary schools to foster in students the knowledge and use of tics, as they will be able to analyse the programming language and the structure of the robot to learn how to customize it. In this article we have also examined a way to proceed during the activities in which Robot, therapist/educator and child interact. This modality is one that takes into account three factors: 1) Congruence, that Rogers described as a person who aligns the signals that come from verbal and non-verbal language, emotions and feelings quality that even Zavalloni (1972) in the educational field has highlighted as an essential fact for an effective teaching-learning process that does not send double messages (Ariano, 1990; 1997; 2010), i.e. contradictory messages (the body says "one thing" and the words "another" or vice versa); 2) Unconditional Positive Regard means that the educator honestly cares for the person who is on the other side, that both Rogers' humanistic psychology and Zavalloni's educational vision pose as essential; 3) lastly, Accurate Empathic Understanding, the relationship should keep into account feelings, cognition, and emotions to realize meaningful learning, the idea that empathy is basic and fundamental is now widely shared, even though when children have ASD it is important to encourage the therapist to "get involved" when preparing activities of a playful nature, avoiding stressful situations. Zavalloni has been placed in the foreground of this article because he was the first professor of special pedagogy (until 1990) at La Sapienza University in Rome, and his challenge (curating humanistic psychology when behaviorzaism and cognitivism were the only two currents of reference that were considered in teacher professional development courses) was fundamental in seeking a new perspective to represent the teaching-learning process. On the other hand, Ariano's work (1990; 1997; 2010), always starts from Rogers but proposes and integrates the behaviorist, cognitivist and phenomenological vision through a hierarchical vision in which phenomenology proposes a vision of the world that gives meaning to action, cognitivism a functional way to receive them and behaviorism to verify in action if the functions have been well integrated. In future works, three areas will be studied in depth:

1. the practical technical one (release of new prototypes) based on new technologies such as the new version of Raspberry Pi, Lattepanda (a Computer with Windows as Operating System [OS] with integrated

Arduino), new materials for 3D printing (e.g. soft touch plastics), new online databases for emoticons, interconnectivity with other devices, new cameras, new mechanical motors, etc.;

2. the declination of the therapists' techniques in the use of ASD-Robot, accepting their requests according with Olga Bogdashina (2016) that encourages different sensory experiences to improve different perceptual worlds;
3. "broaden" the vision of Rogers' three factors from an educational point of view through two sub-areas:
   - deepen humanistic psychology starting from Rogers and beyond him, to see the practical and useful effects for the special pedagogy, with which he shares a certain vision in which man must be considered in his complete three-factor vision: biological-psychological-social as proposed for many years by Luc Ciompi (Ciompi, 1997; Bellopede, 2010) and, obviously, by the World Health Organization that int the 2007 wrote the International classification of functioning, disability and health: children and youth version (OMS, 2007), mainly as a tool for understanding disability, health and rehabilitation from special education point of view; This (integrative) approach is therefore centered on the dimensions of human functioning: cognitive, affective, behavioral and physiological. These are dimensions that are interrelated and mutually influence each other (Gargiulo, 2010), starting from this anthropological proposal, the need for a healthy lifestyle is evident and educational best practices;
   - to deepen the ideas already proposed by Zavalloni and other authors who have already made Rogers' approach familiar with its pedagogical aspect learner-centered education.

These 3 points (the third with two sub-factors) should be seen as research that can be linked to each other, but could also be linked to new research from Lab-H. The desire to investigate these issues is motivated by the relationship that robotics, in support of educators, can act as a technology to support education, well-being, care and personal autonomy. Progress in the medical field, in psychological and technological theories and practices, can give concrete benefits, if they act in synergy, to the daily life of each person and robotics is positioned exactly in this "riverbed" if well designed and used.

Conclusions

Robotics is one of the disciplines that will increasingly "break into" the school. Italian Ministry of Education (MIUR) highlighted that among the classes of "characterizing" content students should use educational robotics such as it is provided for by Directive 93 of 30 November 2009 and in decree 851 of 27 October 2015, in action # 17, of the PNSD (Piano Nazionale Scuola Digitale). In brief, robotics become a reality in the educational setting or activities. This should be appended because robot still not seem as terrible war machines such as in science fiction or cartoons of the Seventies. What has just been given is now taken for granted. What is not taken for granted is whether they can help children with ASD. Nowadays, there are robots for every age group, and it is not surprising to find National Operational Programs (for instance Italian's PON) that deal mainly with this specific field of ICT intersected with the education of students of every order and grade of schools but few researchers have developed robots completely programmed to support the child with autism or his educator (who, for example, follows the ABA method). ASD-Robot acts as an intermediary between the therapist and the child allowing the training of particular functions decided in advance by the therapist. There is a tendency to want to strengthen certain functions because they are individual as appropriate to the activities decided by the model followed by the therapist (for example, the ABA model). From a structural point of view ASD-Robot is an intelligent viewer (it is not a passive display but an active one because it is a real micro-computer) from a functional point of view it has been programmed to implement methods (or functions of those methods) that focus on the actual needs of the educational context. Note that since the project is open-source (both hardware and software parts) guarantee to each and every one to prevent eventual problems through the redesign/reprogramming/customization of the robot, acting on the specific component, able to solve the problem that arises. You can change the shape of the robot (acting on the 3D printing files), you can change the speed with which the robot interacts with the child (through the software), change the emoticons and the graphical interface that appears on the display, just to name a few examples. The prototype has already been tested by Laboratory H at the University of Salerno. This test took place in a school in Campania; this appends in an elementary school in Pagani, in the province of Salerno, where a 10-year-old autistic child interacted with the first prototype of the robot. Specifically, the therapist used the robot for a short period during therapy sessions with the ABA method (Applied Behavior Analysis), aimed at reducing the problematic and dysfunctional behavioural habits of the child through the implementation of adaptive behavioural rituals. This first experimentation showed that the interaction with the robot can reinforce the therapy and create meaningful situations to promote the child's learning. In fact, the next goal concerns the possibility of extending the test to more autistic subjects to analyse how these problems, especially at the social level, can change over time through support and interaction with the robot. The main challenge is to demonstrate the effectiveness of the use of robotics applied to a disability, and whether robots are truly able to provide relief from the isolation that characterizes autism spectrum disorder.

References

Aiello P., Sharma U. e Sibilio, M. (2016), "La centralità delle percezioni del docente nell'agire didattico inclusivo: perché una formazione docente in chiave semplessa?", *Italian Journal of Educational Research*, 16: 11-22.

Allen K.E., Benning P.M. and Drummond T.W. (1972), "Integration of normal and handicapped children in a behavior modification preschool: A case study", *Behavior analysis and education*, 127-141.

Ariano G. (1990), *La terapia centrata sulla persona*, Giuffrè, Milano.

Ariano G. (1997), *Psicoterapia d'integrazione strutturale - 1. epistemologia*, Armando. Roma.

Ariano G. (2010), *Integrazione, i volti della psicologia*, Sipintegrazioni, Casoria.

Baron-Cohen S. (2009), "Autism: The empathizing-systemizing (E-S) theory", *Ann N Y Acad Sci*, 1156: 68-80.

Bellopede L. (2010), *La psicoterapia secondo la teoria dei tre fattori di Luc Ciompi*, in Ariano G., a cura di, *Integrazione, i volti della psicologia* (pp. 47-60), Sipintegrazioni, Casoria.

Berthoz A. (2011), *La semplessità*, Codice, Torino.

Bogdashina O. (2016), *Sensory perceptual issues in autism and asperger syndrome: Different sensory experiences-different perceptual worlds*, Jessica Kingsley Publishers, London.

Ciompi L. (1997), *I fondamenti emozionali del pensiero*, CIC, Roma.

Conti D., Di Nuovo S., Buono S., Trubia G. and Di Nuovo A. (2015), *Use of robotics to stimulate imitation in children with Autism Spectrum Disorder: A pilot study in a clinical setting*, in *Proceedings of the 24th IEEE International Symposium on Robot and Human Interactive Communication*, Kobe, Japan.

Cottini L., Vivanti G. e Bonci B. (2017), *Autismo come e cosa fare con bambini e ragazzi a scuola*, Giunti, Firenze.

Cox R.D. and Gunn W.B. (1980), *Interpersonal skills in the schools: Assessment and curriculum development*, in *Social Competence* (pp. 113-132), Pergamon, New York.

Digaetano R. (2010), *Sulle orme di Rogers:…a ritroso…al di là*, in Ariano G., a cura di, *Integrazione, i volti della psicologia* (pp. 63-83), Sipintegrazioni, Casoria.

Dunst C.J., Trivette C.M., Prior J., Hamby D.W and Embler D. (2013), "Parents' judgments of the acceptability and importance of socially interactive robots for intervening with young children with disabilities", *Social Robots Research Reports*, 1: 1-5.

Duquette A., Michaud F. and Mercier H. (2008), "Exploring the use of a mobile robot as an imitation agent with children with low-functioning autism", *Autonomous Robots*, 24, 2: 147-157.

Ekman P. e Friesen W.V. (2013), *Giù la maschera: come riconoscere le emozioni dall'espressione del viso*, Giunti, Milano.

Frauenfelder E. (2011), "Una dinamica dialogica per la nascita delle Scienze bioeducative". *Studi sulla Formazione/Open Journal of Education*, 14, 1: 7-17.

Gargiulo G. (2010), *La Psicologia Pluralistica Integrata*, in Ariano G., a cura di, *Integrazione, i volti della psicologia* (pp.145-158), Sipintegrazioni, Casoria.

Grasselli B. (2016), *Roberto Zavalloni*, in Crispiani P., a cura di, *Storia della Pedagogia speciale. L'origine, lo sviluppo, la differenziazione* (pp. 516-532), ETS, Pisa.

Hobson R.P. (1993a), *Understanding persons: The role of affect*, in Baron-Cohen S., Tager-Flusberg H. and Cohen D., eds., *Understanding others minds*, Oxford University Press, Oxford.

Hobson R.P. (1993b), *Autism and the development of mind*, Erlbaum, Hillsdale, N.J.

Howlin P., Cohen S.B. e Hadwin J. (1999), *Teoria della mente e autismo. Insegnare a comprendere gli stati psichici dell'altro*, Erickson, Trento.

Lytridis C., Vrochidou E., Chatzistamatis S. and Kaburlasos V. (2019), *Social engagement interaction games between children with autism and humanoid robot NAO*, in Graña M. et al., eds., *Proceedings of the 9th International Conference on EUropean Transnational Educational (ICEUTE'18)* (pp. 562-570), San Sebastian, Spain: 6-8 June 2018.

Mann J.H. (1956),"Experimental evaluations of role-playing", *Psychological Bulletin*, 53: 227-234.

McGinnis E. e Goldstein A. (1992), *Manuale di insegnamento delle abilità sociali,* Erickson, Trento.

Organizzazione Mondiale della Sanità [OMS] (2007), ICF-CY. *Classificazione Internazionale del Funzionamento, della Disabilità e della Salute. Versione per bambini e adolescenti*, Erickson, Trento.

Padoan I. (2012), "Pensare l'Intercultura", *Pedagogia Oggi*, 1: 131-155.

Pennazio V. (2019), “Robotica e sviluppo delle abilità sociali nell’autismo. Una review critica”, *Mondo Digitale*, 2.
Robins B., Dautenhahn K., Nehaniv C.L., Mirza F. and Olsson L. (2005), *Sustaining interaction dynamics and engagement in dyadic childrobot interaction kinesics: Lessons learnt from an exploratory study*, in *Proceedings of the 14th IEEE International Workshop on Robot and Human Interactive Communication, RO-MAN2005*, Nashville, USA.
Wing L. & Attwood A. (1987), *Syndromes of autism and of atypical development*, in Cohen D.J., Donnellan A. and Paul R., eds., *Handbook of autism and pervasive developmental disorders*, Wiley, New York.
Xiao W., Li M., Chen M. and Barnawi A. (2020), “Deep interaction: Wearable robot-assisted emotion communication for enhancing perception and expression ability of children with Autism Spectrum Disorders”, *Future Generation Computer Systems,* 108: 709-716.
Zavalloni R. (1972). *La psicologia clinica nell’educazion*e, La Scuola, Brescia.

From roboethology to peer tutoring among adolescents in vulnerable contexts. A study on communicative mediation in the classroom

by *Valeria Cotza*, *Monica Roncen* and *Luisa Zecca*

The theoretical framework

The theoretical framework within which the present research was carried out is rooted in the cultural and ecological perspective of human development (Vygotskij, 1974; Rogoff, 1990), understood as a dynamic learning process that takes place in the surrounding environment. It is possible to distinguish four elements that characterise the model (Bronfenbrenner, 2005):

1. the evolutionary process, which encompasses the dynamic relationship between the individual and his or her reference context(s);
2. the person, identified in relation to – and as a function of – their cognitive, emotional and behavioural individuality;
3. the context, conceived as a system of relations between micro, meso, eso and macro dimensions (Bronfenbrenner, 1979);
4. the time, defined as the reference chronosystem of evolutionary dynamics.

Learning is understood as a complex and multiform process, the outcome of which is the result of the interaction of different factors (cognitive, sociocultural, affective); it can be defined as the change of an idea or content or the acquisition and modification of cognitions, knowledge and skills through processes of assimilation, re-elaboration and accommodation in the potential area of development. In this perspective, then, the concept of «communicative feedback with a formative purpose that characterises dialogue» is central, which is «a tool for sharing meaning in cognitive development and conceptual learning» (Zecca & Bozzi, 2021, p. 255); social interaction, in fact, influences learning possibilities, with the support of guidance provided by the relationship with an adult or a more experienced peer.

The quality of the "guided participatory" process put into practice by the more experienced seems to be decisive in the performance of shared problem solving activities (Liu et al., 2013; Jung and Won, 2018), particularly in stimulating curiosity and reasoning during workshops involving the use of educational robots (Stoeckelmayr et al., 2011; Fessakis et al., 2013), which involve the student in a global way (both cognitively, emotionally, physically and socially) and stimulate, through guided exploration, fine motor skills, eye-hand coordination, as well as the understanding of logical problems. The action that is carried out on these occasions by the more expert – be it an adult or a peer – is called "tutoring" or scaffolding and has the following characteristics (Wood et al., 1976; Nardacchione & Peconio, 2021):

- engagement: to attract students' attention and interest, to arouse motivation and activate their full involvement;
- simplification: reduce the task to the minimum steps as much as possible;
- guidance and encouragement: keep motivation high so that they can solve the task on their own;
- indication of critical points: explicitly highlighting the salient features and relevant aspects of the task, so that the student becomes aware of the discrepancies between what he/she has produced and what he/she would have to produce in order to reach the goal, i.e. what the adult would recognise as correct production;
- frustration control: guiding step-by-step reasoning and showing strategies to reduce children's/young people's stress;
- modelling: demonstrating solutions or solution strategies/models that can be processed and internalised by tutees and then imitated.

The participative accompaniment of an adult or a more experienced peer can thus lead to the acquisition of heuristic thinking processes, understood as a series of cognitive processes that enable the child/young person to «plan actions to achieve a goal, by means of strategies that can be defined as mental and material operations that enable a desired state to be reached or not reached» (Zecca & Bozzi, 2021, p. 256). The tutoring activity thus also seems to be decisive in learning the higher or second-order psychic functions (Vygotsky, 1974) typical of computational thinking: attention and memory consciously activated during a problem-solving experience, the capacity for deliberate planning and progressive devising of a solution (by means of abstraction, generalisation, decomposition, algorithmic thinking and debugging, i.e. error detection and correction), conceptualisation and the construction of logical reasoning.

As highlighted by Piaget's constructivism, learning is thus the result of an active construction of knowledge in interaction with the world, in which the construction and manipulation of physical objects/artefacts can play a fundamental role. Starting in the late 1960s, Papert (1980) was the first to realise the potential of robots and predict that they could facilitate learning. Robots, in fact, are configured as active learning mediators through which to think, «objects with which to reason» (Beltrametti et al., 2017, p. 124) – as advocated by Papert (1991) himself –, because they allow for a bodily and multimodal type of interaction; they are therefore relational objects, which facilitate the process of internalisation (Vygotskij, 1978), stimulating active involvement and motivation and maintaining a high level of immersion in the experience. Digital artefacts can therefore be considered instruments of semiotic mediation, which modify both speech modalities and knowledge models, enabling the transition from the so-called "classical mediation", that of the object (which uses different mediators, keeping the subject immobile, extraneous), to the mediation of the subject: in this case it is the subject, in fact, who assumes different postures towards the artefact, which, being digital, is infinitely reproducible; reproducibility modifies the posture of the subject (Rossi, 2016, p. 19).

Starting from knowledge constructed through situated actions, which structure a sense-motor intelligence to symbolic consciousness (Hoffmann & Pfeifer, 2018; Stoltz, 2018), robots can generate unconscious insights and pseudo-concepts. Indeed, as highlighted by Hoffmann and Pfeifer (2018, p. 9), «robots can be beneficial in operationalizing, formalizing and quantifying ideas, concepts and theories […] important for understanding cognition»: they embody – implicitly or explicitly – certain types of abstractions and fit perfectly into the embodied and pragmatic turn in cognitive science (Engel et al., 2013), according to which «cognition is bound to bodily and environmental elements, which cannot be described in the abstract and amodal terms of classical representational theory» (Caruana & Borghi, 2013, p. 28). In the organisation of concepts, even the most abstract ones, action and perception are therefore connected at the motor level; the concept is understood here as a modal synthesis, related to the sensory modalities involved in the perception of the content, thus to the modal functioning of the brain (Rivoltella & Rossi, 2019). Therefore, in accordance with the principle of embodiment as explained in the theoretical framework of Educational Robotic Applications (ERA: Catlin & Blamires, 2010), we can say that:

Embodiment in cognitive science claims three things:

1. Mind has evolved, not as a machine, but as an integrated element of an organism embedded in a society and in a physical temporal world.
2. Mind and body are intimately intertwined. They form an "adaptive system" – that works together to survive and thrive as their environment changes.
3. Most embodied cognitive processes are subconscious.

The 10 principles of ERA (Intelligence, Interaction, Embodiment, Student Engagement, Sustainable Learning, Personalisation, Teacher Pedagogy, Curriculum, Equity, Practical) aim to summarise «the value of robots and robotic activities in any educational context». Specifically, this framework aims to:

1. explain how robots promote learning and what the benefits are for teachers in schools;
2. provide a checklist for those who want to design educational robots and carry out activities related to them;
3. justify schools' investment in robotics technology;
4. emphasise the cognitive and developmental processes underlying the use of robots;
5. provide researchers with a series of statements to evaluate and reason about.

Embodied cognition, according to which «students learn by intentional and meaningful interactions with educational robots situated in the same space and time» (ibidem), therefore formed the cornerstone of this research. The activities also took the following dimensions of the ERA framework into strong consideration:

- Interaction: students are "active learners" whose multimodal interactions with the educational robots take place through a variety of semiotic systems; robots are in fact, as mentioned above, "transitional objects", "objects to think with" (Papert, 1980), cognitive artefacts that orient our mental operations;
- Involvement: educational robots foster a high degree of immersion in the experience and promote social interactions and positive emotional states, which in turn shape attitudes and environments conducive to learning and fun;

- Curriculum: the use of robots in education facilitates the teaching and learning process even in traditional curricular areas, proposing a flexible and dynamic model that promotes two-way interactions between student and robot, student and teacher, teacher and robot;
- Personalisation: educational robots make it possible to personalise learning experiences, constructing operational situations that meet the needs of each pupil and in which individual potential is stimulated; more specifically, the use of educational robotics activities:
  - supports students in the exploration of their own ideas and in personal and creative expression;
  - allows activities to be differentiated, offering different levels of difficulty;
  - engages students in multimodal experiences, thus catering for different learning styles.

The Laboratory of Educational Robotics in Monza

As part of the Horizon SwafS C4S Project ("Communities for Sciences - Towards promoting and inclusive approach in Science Education"), the research team of the University of Milano-Bicocca carried out 7 educational robotics workshops from February to April 2021, lasting approximately 90 minutes each, at the "Antonia Vita" Popular School in Monza (Lombardy). This school welcomes adolescents between 13 and 16 years old in conditions of severe discomfort and early school leaving and drop-out, many of them from disadvantaged socio-economic and cultural backgrounds and with learning difficulties (both certified and non- certified), with the aim of achieving the lower secondary school diploma. These activities have been conducted with Coderbot with a maximum of 9 students at a time, both boys and girls, following a protocol consisting of 5 different phases.

All activities have been video-recorded (with the consent of the parents of the minors) and partially transcribed; the research team is achieving and then discussing the results by leading the analysis using a tool named ODIS - Observation of the Discussion in the classroom.[1]

[1] The tool was presented for the first time by Perucchini P., Piastra S. and Zecca L. during a speech at the Seminar "Quali percorsi di ricerca inter- e trans- disciplinare?" of the SIRD-DGD Observatory - General Didactics and Disciplinary Didactics (Bologna, 30 January 2020). For the reference framework, see Zecca, 2012, in particular pp. 50-94.

Research questions

The main aim is to analyse in depth didactic mediation strategies (Rossi, 2016) in school environments characterised by strong socio-linguistic deprivation (Lumbelli, 1992), especially in relation to the mediation assumed by the adult or expert adults (Zecca & Bozzi, 2021) and the peer interaction that develops during peer education activities, where the role of mediator is played by the student-tutor. This is an area that has still been little investigated with respect to the 14-16 age group, in particular with respect to those adolescents coming from disadvantaged backgrounds, who use the so-called "restricted code" (Bernstein, 1971), characterised by the predictability and rigidity of the structure and the scarcity of formal elements in the organisation of the sentence, as well as by a concrete and descriptive rather than analytical and abstract content.

The first factor endogenous to the school system considered is therefore the interrelationship between students and teachers, in particular between student tutors and experienced adults. In this respect, the following research questions emerged.

- What are the characteristics of the more experienced adult's mediation strategies?
- What dialogue patterns are activated between the adult expert and the student-tutor?

The second endogenous factor considered was peer interaction, to investigate which peer tutoring activities were organised. Since

> […] peer tutoring can generate positive changes and enable participants to develop aptitude for initiative, goal setting and goal achieving, time and emotion management as well as empathy and the ability to establish relations with others. In particular, tutors indicated the improvement of key skills like the ability to establish relations with peers, to work hard at their goals, to take over responsibility and the ability to manage relations, rights and duties when working with others. (Schir & Basso, 2018)

the research team asked itself the following questions.

- Can peer tutoring be a good strategy to improve the learning of adolescents from socio-culturally disadvantaged backgrounds?
- What dialogue patterns are activated between student-tutors and student-tutees?

The robot

The robot chosen as the educational-technological mediator was Coderbot, a small robot-vehicle that can move in space, equipped with a camera, distance sensors, a microphone and a loudspeaker. It can be programmed (by children and young people from 6 years of age) to react in various ways to surrounding stimuli. It is based on a Raspberry PI board and uses a fairly simple Open Source graphic language system, Blockly, similar to the better known Scratch.

The stages and the course of the Laboratory

The research team carried out the design of the laboratory in several stages, both at the beginning, before the activities took place, and *in itinere*, in order to readjust the action plan to what emerged and was observed during the course of the meetings. The laboratory was therefore structured in five distinct and progressive phases, designed to accompany the student from knowledge of the robot to programming and problem-solving:

1. Engagement: at this stage, the research team tried to involve the girls and boys in order to engage them for the continuation of the activities;
2. Game of Science (GoS; Datteri & Zecca, 2016): adopting a robot-ethological approach, students were stimulated to observe Coderbot's behaviour and to make hypotheses, make predictions, test their ideas and identify possible explanations;
3. Algomotricity (Lonati et al., 2015): this phase involved the use of the unplugged mode both to promote more active participation and to start familiarising the students, through body simulation, with the language of Coderbot;
4. Training: in this phase, preparatory to the final peer tutoring phase, the research team trained 2 student-tutors on the main commands and functionalities of the robot, also stimulating the construction of programming problems;
5. Peer tutoring: the trained student-tutors each tutored a maximum of 3 student-tutees, to teach them how the robot works and to propose, in the event of a positive response from the tutees, previously constructed problems.

In order to identify the most suitable girls or boys to take on the role of student tutor, the students themselves were asked to tell us which classmates they considered most capable of explaining and supporting others in learning. The choice of students to be trained to take on the role of tutor was thus the result of a shared consultation process, which involved not only the students but also the School's educators. Indeed, educators were consulted on two specific aspects (Di Cesare & Giammetta, 2011, pp. 70-74):

1. students' communicative and relational competence;
2. their level of involvement and motivation for this type of activity.

The choice therefore fell on MN and NA, for different reasons:

- MN: after an initial moment of difficulty in the first meeting, where she felt that she «didn't understand anything», she became enthusiastic about the topic and from there showed an increasing degree of involvement; she is perceived by her peers as competent and able to explain without losing her calm and patience;
- NA: he presents himself as a credible interlocutor, as he has (more than MN) a high level of socio- cultural similarity with the recipients of the activities (ibidem, p. 71); he is loved by his peers (ibidem, p. 73); moreover, as he tends not to show a high degree of active participation in the curricular activities, the educators intend to encourage him, giving him responsibilities and giving him confidence and the chance to emerge.

The meetings were divided as follows.

Tab 1 - Overview of the phases and meetings of the Educational Robotics Laboratory in the Popular School in Monza

Phases	***Dating***
1. Engagement	**1. Focus group** on some key concepts, such as "robot" and "programming" - 10 February 2021
	2. Meeting with Coderbot inventor Roberto Previtera - 24 February 2021
2. Game of Science (GoS)	**2. Scientist's game with robo-ethological approach**, at the end ofthe previous meeting with the inventor of Coderbot - 24 February 2021
3. Algomotricity	**3. Body simulation / unplugged phase**: 2/3 students write on the board the commands with which to instruct the movement of a student playing the role of a robot - 3 March 2021

4. Training	**4. Start of student-tutor training** on robot functionality and controls, building on what was done in the previous unplugged phase - 10 March 2021
	5. Continuation of the training of 2 student-tutors, with the construction of a programming problem to be proposed to their peers at the next meeting - 17 March 2021
5. Peer tutoring	**6. First peer mentoring phase**: each of the 2 student-tutors mentors a maximum of 3 student-tutees, co-assisted by an experienced adult - 24 March 2021
	7. Second phase of peer tutoring: continuation without the support of the experienced adult - 7 April 2021

Results

In order to answer the research questions mentioned above, the analysis focused on the sixth meeting, the first of the Peer tutoring phase.

Tab 2 - Overview of the expert adults and students participating in the Peer tutoring phase

Peer tutoring phase			
Meeting	***Expert adults***	***Participating students***	
6	Cotza V., Zecca L.	Group A: - tutor: NA - tutee: RM, UC	Group B: - tutor: MN - tutee: AR, OA, RE
7	Cotza V., Zecca L.	Group A: - tutor: NA - tutee: RM, UC	Group B: - tutor: MN - tutee: OA, TE

The communicative functions of student-tutors

The analysis resulted in the coding of 167 verbal interventions by tutors, 73 from NA and 94 from MN. More specifically:

- G - Management: 71 in all, 26 from NA and 45 from MN;
- M - Moderation: 25 in all, 15 from NA and 10 from MN;
- O - Orientation: 32 in all, 12 from NA and 20 from MN;

- R - Reasoning: 25 in all, 14 from NA and 11 from MN;
- V - Evaluation: 14 in all, 6 NA and 8 MN.

Thus, with regard to the communicative functions used by the student tutors, the analysis process identified the following results.

Tab 3 - Overview of communicative functions used by student tutors

TEACHER/TUTOR CODES			***Group A - NA***		***Group B - MN***	
G - Management	**OP**	Organisational-Procedural	**36%**	**34,6%**	**48%**	**68,9%**
	CC	Conduct control		**38,5%**		**28,9%**
	REG	Recalling rules and values in interaction		26,9%		2,20%
M - Moderation	**DT**	Giving the floor a turn	21%	20%	11%	10%
	TT	Take the turn to speak		13,3%		10%
	IT	Ignoring the turn to speak		13,3%		10%
	RIC	Recapitulation (without development of reasoning)		**33,4%**		10%
	ICG	Invitation to participate or continue generic		13,3%		**40%**
	ICS	Invitation to continue specific		6,7%		20%
O - Orientation	**CONF**	Refutations	16%	8,3%	21%	20%
	COLL	Links		**33,3%**		**35%**
	INF	Adding information		**33,3%**		30%

	DC	Closed question		8,3%		10%
	IMB	Rhetorical intervention		16,8%		5%
R - Reasoning	**SPI**	Request for explanation, justification or argumentation	19%	7,1%	12%	0
	RIEP	Taking stock or summarising		28,6%		28,3%
	SC	Explaining cognitive strategies		14,3%		7,1%
	RA	Request for agreement		**35,7%**		0
	CONS	Request for consent		14,3%		**64,6%**
V - Evalutation	**FP**	Positive feedback	8%	**66,7%**	8%	**62,5%**
	FN	Negative feedback		33,3%		37,5%

The function most used by both student-tutors is the Management function: NA uses it at 36%, while MN as much as 48%. Within this, MN uses mainly the Organisational-Procedural function (68.9%), while NA, with a slightly higher percentage than OP, uses especially the Conduct Control function (38.5%). Compared to MN, which hardly uses it at all, NA then uses the Regulatory function more frequently, with a percentage of 26.9%.

After Management, the function most used by NA is Moderation, with a percentage of 21% (in particular the function of Recapitulation without development of reasoning), while the function most used by MN is Orientation, with a percentage of 21% (and in particular the function of Links, which reaches a percentage of 35%). Little used is the Reasoning function, with percentages of 19% (NA) and 12% (MN); in last position is the use of Evaluation, which stops at 8% for both tutors. In particular, as far as Reasoning is concerned, if NA often requires agreement (with a percentage of 35.7%), MN often requires consent, with a percentage, even, of 64.6%; with reference to Evaluation, on the other hand, both student- tutors resort mostly to positive Feedback (66.7% for NA, 62.5% for MN).

The communicative functions of the student-tutee

The process of coding the verbal interactions of student-tutee brought to light a function not yet foreseen by the ODIS categorisation relating to student communication, namely the function of Evaluation, subdivided into two types of intervention, Positive Feedback and Negative Feedback. This function, which the ODIS tool provides instead for teacher (or student-tutor) communication, is of particular importance here, since during peer education activities, which are characterised by reciprocal exchange, student-tutees can give feedback on the tutoring they have practised.

The analysis led to the coding of 89 verbal interactions by the student-tees, 16 from Group A and 73 from Group B. More specifically:

- A - Answers: 8 in total, 1 from Group A and 7 from Group B;
- C - Continuations: 19 in all, 5 from Group A and 14 from Group B;
- I - Initiatives, CHI: 10 in all, 1 from Group A and 9 from Group B;
- IP - Procedural Intervention, PROC: 14 in all, all from Group B;
- V - Evaluation: 38 in all, 9 from Group A and 29 from Group B.

Thus, with regard to the communicative functions used by the student-tutee, the analysis process identified the following results.

Tab 4 - Overview of the communicative functions used by the student-tutee

STUDENT CODES (-TUTEE)			***Group A - NA***		***Group B - MN***	
R - Answers	**NIMP**	Answer "n'importequisme"	6,25%	0	9,59%	28,57 %
	RSA	Answer without argumentation		0		14,29 %
	RCA	Response with argumentation		0		28,57 %
	COMPLI	Answer-completion		**100 %**		28,57 %

C - Continuation	**COLLS**	Non-argumented continuation	**31,25 %**	0	19,18 %	7,14%
	COMPLC	Continuation to completion		20%		14,29 %
	COLLA	Argumented continuation		**80%**		**78,57 %**
I - Initiatives	**CHI**	Questions of clarification	6,25%		12,33%	
IP – Procedural Intervention	**PROC**	Procedural intervention	0		19,18%	
V - Evaluation	**FP**	Positive feedback	**56,25 %**	0	**39,72 %**	**55,17 %**
	FN	Negative Feedback		**100 %**		44,83 %

Student-tutee in both groups tend to respond to NA and MN tutoring with evaluative interventions (56.25% and 39.72% respectively): while the feedback returned to NA is 100% negative, the feedback received by MN is predominantly positive, at 55.17% (negative feedback is 44.83%). Group A students then tend to react to NA tutoring by using the Continuation function (31.25%), mostly argued (C-COLLA); Group B students, on the other hand, react to MN tutoring in a more diversified manner, resorting, in addition to Evaluation, both to Continuation (19.18%), mostly argued, and to Procedural Intervention (19.18%), as well as to Questions of Clarification (12.33%). Little use was made of Responses, which stood at 6.25% for NA and 9.59% for MN.

Discussion of results and conclusions

The first aspect that emerges from the above results is the diversity between NA and MN with regard to tutoring style. The coding, in fact, highlights how MN predominantly resorts to verbal intervention, whereas in NA non-verbal communication and modelling are prevalent (out of 167 verbal interactions of the tutors, as many as 94 come from MN, 73 from NA, who always intervenes in a brief and concise manner). In particular, if NA's interventions are mainly aimed at controlling conduct, MN's are clearly of an organisational-procedural nature (G-OP: 68.9%, compared to 48% for the Management function): MN's tutoring is in fact characterised by a high structuring of the activities and a continuous stimulation to participation, through interventions that make explicit the deliveries («Now stand here next to me [addressed to RE], you have to give commands to OA»), establish the work to be done («We have to do a problem»), clarify the procedures («We can make it move from there, make it start from there [referring to the robot]»), verify that everyone is involved («Come on, come here! I'll explain it to you too»; «You hear me, right?») and offer support («I'll help you, but you have to give him commands»). While NA tutoring seems to elicit shared attention, which, however, does not stimulate student-teachers to take the initiative or actively intervene, MN tutoring, according to the coding, seems to solicit student-teachers to participate, with clarification questions, argued continuations and procedural interventions, through which the students themselves take on the function of Management.

MN's tutoring thus appears to be more effective than that practised by NA. This seems to be confirmed also by the feedbacks coming from the student tutees, who, on more than one occasion, explicitly state that they do not understand what NA is trying to explain to them or that they cannot carry out the activities, which NA always proposes with a low degree of structuring and involvement. Not surprisingly, the feedback received from NA is 100% negative, in contrast to the feedback generated by MN tutoring, which is overwhelmingly positive (55.17% vs. 44.83%).

The second aspect that emerges from the analysis of the meeting relates to the degree of autonomy of the tutors' conduct from the expert adult's verbal intervention. While on the one hand NA repeatedly asks for the adult's help, either verbally or with his gaze, not proceeding without having received it first, on the other hand MN rarely turns to the adult, preferring to work autonomously. In the first case the tutoring is thus strongly hetero- regulated, as NA needs constant feedback from the experienced adult in order to be able to continue to fulfil her tutoring role, whereas in the second case there is a shift from hetero-regulation to self-regulation, as MN tries to autonomously manage the tutoring task she has been assigned. In order to be able to carry it out autonomously, MN seems to refer to the example given by the expert adult during the previous laboratory phases (in particular those of Algomotricity and Training), starting from body simulation activities and then progressively approaching the understanding of computer language, through the learning of the main commands, in analogue and digital, and the guided construction of a programming problem. In the case of NA's tutoring we can therefore speak of a structured-syntonic directive mediation by the adult: the reciprocal and syntonic exchange is constant, the turn between adult and student-tutor alternates frequently and it is often the adult who directs the action, through positive or negative feedback and organisational-procedural interventions such as suggesting working methods and steps to move the activity forward. In the case of tutoring implemented by MN, the adult's mediation can instead be defined as syntonic-structured transformative orienteering: if on the one hand it shares with the previous typology the reciprocity of the participatory action, on the other hand it goes along with the tutor's tendency to conduct the task autonomously; the expert adult favours self-regulation, resorting only to sporadic verbal interventions, mostly managerial, orientative and reasoning (see also Zecca & Bozzi, 2021, p. 268).

Thus, different tutoring and mediation styles seem to activate different patterns in terms of dialogicality, involvement and regulation. Although MN's tutoring appears to be more effective than NA's, with student-tutees' responses oriented towards initiative, argumentation and even assumption of the management function, both do not achieve the tutees' self-regulation goal, as they do not manage to carry out any of the proposed tasks autonomously and are not stimulated to turn to more complex communicative functions, such as problematisation. Furthermore, although MN conducts part of the activity autonomously, both types of tutoring require the mediation (more or less syntonic and structured) of the expert adult, without which the activities would not be completed. In the light of this, we therefore hypothesise that in vulnerable educational and school contexts, characterised by strong linguistic deprivation, the peer tutoring strategy struggles to function, being not completely adequate to support the learning of socio-culturally disadvantaged students.

Looking ahead, the research proposes to design a much longer and more structured training phase for student-tutors, covering not only knowledge of the object and the ability to use it appropriately, but also the acquisition of forms and modes of communication appropriate to the context, both verbal and non-verbal.

References

Beltrametti M., Campolucci L., Maori D., Negrini L. e Sbaragli S. (2017), "La robotica educativa per l'apprendimento della matematica. Un'esperienza nella scuola elementare", *DdM - Didattica della matematica. Dalla ricerca alle pratiche d'aula*, 1: 123-144.

Bernstein B. (1971), *Class, codes and control: Theoretical studies towards a sociology of language*, Routledge & K. Paul, London.

Bronfenbrenner U. (1979), *The ecology of human development: Experiments by nature and design*, Harvard University Press, Cambridge, MA.

Bronfenbrenner U., ed. (2005), *Making human beings human: Bioecological perspectives on human development*, SAGE Publications, London.

Caruana F. e Borghi A.M. (2013), "Embodied Cognition: una nuova psicologia", *Giornale Italiano di Psicologia*, 40, 1: 23-48.

Catlin D. and Blamires, M. (2010), *The principles of Educational Robotic Applications (ERA): A framework for understanding and developing educational robots and their activities*, in Clayson J. and Kalaš I., eds., *Constructionism 2010: Constructionist approaches to creative learning, thinking and education: Lessons for the 21st century: Proceedings for Constructionism 2010: The 12th EuroLogo Conference*, Paris: 16-20 August.

Datteri E. and Zecca L. (2016), "The Game of Science: An experiment in synthetic roboethology with primary school children", *IEEE Robotics & Automation Magazine*, 23: 24-29.

Di Cesare G. e Giammetta R. (2011), *L'adolescenza come risorsa: una guida operativa alla peer education*, Carocci, Roma.

Engel A.K., Maye A., Kurthen M. and König P. (2013), "Where's the action? The pragmatic turn in cognitive science", *Trends in Cognitive Sciences*, 17, 5: 202-209.

Fessakis G., Gouli E. and Mavroudi E. (2013), "Problem solving by 5-6 years old kindergarten children in a computer programming environment: A case study", *Computers & Education*, 63: 87-97.

Hoffmann M. and Pfeifer R. (2018), *Robots as powerful allies for the study of embodied cognition from the bottom up*, in Newen A., de Bruin L. and Gallagher S., eds., *The Oxford Handbook of 4E Cognition* (pp. 841-862), Oxford University Press, Oxford.

Jung S.E. and Won E. (2018), "Systematic review of research trends in Robotics Education for young children", *Sustainability*, 10, 905.

Liu E.Z.F., Lin C.H., Liou P.Y., Feng H.C. and Hou H.T. (2013), "An analysis of teacher-student interaction patterns in a robotics course for kindergarten children: A pilot study", *Turkish Online Journal of Educational Technology*, 12, 1: 9-18.

Lonati V., Malchiodi D., Monga M. and Morpurgo A. (2015), *Is coding the way to go?*, in Brodnik A. and Vahrendhold J., eds., *Proceedings of ISSEP 2015* (pp. 165-174), Springer.

Lumbelli L. (1992), *Interazione verbale e deprivazione linguistica*, in Lugarini E. e Roncallo A., a cura di, *Lingua variabile. Sociolinguistica e didattica della lingua* (pp. 57-73), La Nuova Italia, Firenze.

Nardacchione G. and Peconio G. (2021), "Peer tutoring and scaffolding principle for inclusive teaching", *Elementa. Intersections between Philosophy, Epistemology and Empirical Perspectives*, 1, 2: 181-200.

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

Papert S. (1991), *Situating constructionism*, in Papert S. and Harel I., eds., *Constructionism*, Ablex Publishing Corporation, Norwood.

Rivoltella P.C. e Rossi P.G., a cura di (2019), *Tecnologie per l'educazione*, Pearson, Milano.

Rogoff B. (1990), *Apprenticeship in thinking: Cognitive development in social context*, Oxford University Press, Oxford.

Rossi P.G. (2016), "Gli artefatti digitali e i processi di mediazione didattica", *Pedagogia Oggi*, 2: 11-26.

Schir F. and Basso D. (2018), *Peer tutoring: Promoting wellbeing by encouraging cooperative attitudes within the school community*, in Carmo M., ed., *Education and New Developments 2018* (pp. 234-238), inSciencePress, Lisbon.

Stoeckelmayr K., Tesar M. and Hofmann A. (2011), *Kindergarten children programming robots: A first attempt*, in Stelzer R. and Jafarmadar K., eds., *Proceedings of the 2nd International Conference on Robotics in Education (RiE)* (pp. 185-192), INNOC - Austrian Society for Innovative Computer Sciences, Wien.

Stoltz T. (2018), "Consciousness in Piaget: Possibilities of understanding", *Psicologia: Reflexão e Crítica*, 31, 30: 1-9.

Vygotskij L.S. (1974), *Storia dello sviluppo delle funzioni psichiche superiori ed altri scritti*, Giunti-Barbera, Firenze.

Vygotskij L.S. (1978), *Mind in society. The development of higher psychological processes*, Harvard University Press, London.

Wood D., Bruner J.S. and Ross G. (1976), "The role of tutoring in problem solving", *Journal of Child Psychology and Psychiatry*, 17, 2: 89-100.

Zecca L. (2012), *Pensieri del fare. Verso una didattica meta-riflessiva*, Junior-Spaggiari, Parma.

Zecca L. e Bozzi G. (2021), *Tutoring nella programmazione robotica: prime esplorazioni con Cubetto nella scuola dell'infanzia*, in Bozzi G., Zecca L. e Datteri E., a cura di, *Interazione Bambini-Robot. Riflessioni teoriche, risultati sperimentali, esperienze* (pp. 251-273), Franco Angeli, Milano.

Experiencing educational robotics in cognitive and behavioural rehabilitation of the patients: An exploratory study to design inclusive environments

by *Lorella Gabriele* and *Eleonora Bilotta*

Introduction

Educational Robotics (ER) is a research field that uses small programmable or humanoid robots (Afari & Khine, 2017; Castro et al., 2018) to enhance learning or promote different cognitive skills in different educational contexts and in special education. Regarding the latter context, several studies (Daniela & Lytras, 2019; Kaburlasos & Vrochidou, 2019; Zhang et al., 2019) show how Educational Robotics can promote the development of cognitive, visual-perceptual, fine motor, emotional, and relational skills, i.e., in people with intellectual disabilities. The DSM-5 (Guha, 2014) considers intellectual disabilities as neurodevelopmental disorders that begin in childhood and are characterised by intellectual difficulties in conceptual, social, and practical areas of life. The impairment is present in one or more high-order ability areas and with varying degrees of severity: "mild", "moderate", "severe" and "profound". These deficits can affect the individual's space-time orientation, both in relationships with self and others, at the level of communication skills, planning and execution of certain tasks, disorders of intentionality and at the level of intelligence, limitations in the emotional, social and educational areas of the child, adolescent or adult. Several studies show that LEGO© building sets are a useful therapeutic cognitive tool to increase motivation and social skills and provide a medium with which children with social and communication impairments, as well as adults with various cognitive and behavioural disorders, can interact effectively.

This chapter presents an experience conducted by the Day Care Centre of Rende (Cosenza, Italy) and the Laboratory of Psychology and Cognitive

Sciences with a group of young and elderly people with various motor and intellectual disabilities. The aim of this research was to design multisensory learning environments for cognitive rehabilitation using Lego robotics kits to work on executive processes and fine motor skills.

The rest of the chapter is organised as follows. The background section provides an overview of the current state of the art regarding the use of learning robots and technologies in the rehabilitation of individuals with cognitive deficits. The methodology section describes the scope, participants, materials, procedure details, recording, a description of behavioural taxonomy, reliability analysis, and coding and sampling procedures. This is followed by an overview of the Coloured Progressive Matrices and the results of the observation. Finally, a discussion and some conclusions follow.

Background

According to the constructivist perspective (Piaget, 1967; Papert, 1991), learning is greatly enhanced when individuals – children, youth, elders and adults – are actively involved in creating meaning through the manipulation of hardware and software artefacts. Furthermore, Papert (1991) emphasises that the focus of the learning process should no longer be on the amount of knowledge acquired, but on the ability of individuals to construct deep and qualitative learning. In this view, robotic artefacts can be considered as learning objects that can help individuals to think them through and extend the knowledge they have acquired.

From a phylogenetic perspective, the manipulation and production of artefacts have contributed to both specialisation and the development of advanced cognitive functions in the human brain (Badzakova-Trajkov, Corballis & Haeberling, 2016).

As numerous researches have shown (see Table 1), manipulating cognitive objects by means of both digital technologies and real objects, such as with Lego Mindstorms, allows for the creation of advanced and fun learning environments that are particularly useful for establishing a real-world connection to the mental world of people with cognitive diseases or deficits.

As for the field of Educational robotics, it has rapidly assumed an important role at the international level, attracting the interest of various institutions, schools and universities, both from an educational and research point of view. Small programmable robots or humanoid robots are used in educational contexts to create entertaining, fun and perceptual experiences to promote learning and understanding, or in special education to develop skills to monitor and regulate cognition, to engage subjects with concrete tasks in everyday situations (Fridin, 2014), but also in rehabilitation and therapy and in education (Besio & Carnesecchi, 2014). In recent years, educational robotics has also been used in the rehabilitation of people with cognitive deficits (Fasola & Matarić, 2013). In particular, humanoid robots can act as peers and help children with autism to develop social and communication skills (Greczek, Kaszubksi, Atrash & Matarić, 2014). Conti, Di Nuovo and Buono (2015), Cook, Adams, Volden and Harbottle (2011), Bilotta, Gabriele, Servidio and Tavernise (2008) investigated the role of motor-manipulative behaviours in the use of technological tools. Studies by Corsi (2016) and Yin and Yin (2019) on the development of fine motor skills have shown that these skills develop over time and require continuous motor practise in both typical and atypical development.

Valadão et al. (2011) found that Lego tools encouraged subjects to try new things and to be creative, so the observed strong motivation and enthusiasm could be partly due to the appeal of novelty. Pierno, Mari, Lusher and Castiello (2008) reported that children with autism responded better to robotic coaching than to human one, suggesting that a socially simplified set of coaching stimuli is more effective for such children. Humanoid robots (e.g., NAO) have therapeutically relevant functions, such as providing education and feedback, assisting subjects in performing certain tasks, and can promote face-to-face social interaction, which is particularly important for metacognitive development.

Tab. 1 - A literature review outlined by collecting papers through sciencedirect platform, according to the criteria "publication date" set "2014 to present", "Robotics", "Lego", "disability", "digital toys"

Study	*Study design, Participants, Results*
Proença, Quaresma & Vieira (2014).	A platform with Personal Digital Assistant and two different modules of interact has been developed for children with multiple disabilities and facilitates their rehabilitation process using a ludic approach. The system can receive stimuli from the user and return real-time feedback thanks its flexibility and characteristic.
Lindsay, Hounsell & Cassiani (2017).	Authors presents a review of the literature to explore the role that LEGO® therapy can have on the social skills and inclusion of children and young people with ASD and to identify the common features of effective LEGO® therapy for children and young people

	with ASD. From a methodological point of view, a few studies have included a control group or standardised measures. Hence, the papers reviewed show that LEGO® activities have the potential to improve social and communication skills that are severely lacking in young people with ASD.
Ekin, Cagiltay & Karasu (2018).	This study examines the effectiveness of smart toys in teaching social studies concepts to children with intellectual disabilities (ID). A small group of three public primary school children with ID aged between 11 and 16 years and their teachers were included in the study. Each child was observed for a total of between 8 and 16 minutes over a 12-week period. The results demonstrate that the use of smart toys is beneficial and provides new opportunities for learning and practising several important cognitive and social skills. In addition, the results showed that the children were motivated and had the opportunity to practise problem solving, reasoning, perseverance and concentration, suggesting that smart toy applications are effective in teaching social science concepts or improving social interaction, communication, problem-based learning and literacy skills in children with ID.
Pivetti et al. (2020)	The authors analysed 15 scientific papers focused on the use of educational robotics activities with children (aged 3 to 19 years) with a diagnosis of neurodevelopmental disorders. The review of the papers showed that educational robotics has the potential to positively impact the areas of learning, engagement, communication and social interaction.
Beccaluva, Riccardi, Gianotti, Barbieri & Garzotto (2021)	12 children with cognitive impairment and their therapists participated in an exploratory study to evaluate a Tangible Visual Interface, named VIC composed by digitally enhanced cubes, a sensorized board, and a mobile app, that available multiple activities based on block manipulation and block placement. The participants evaluated the usability of VIC system. Results suggested that the functionality of the system could be an effective complement to existing practices in memory training.
Laurie, Manches & Fletcher-Watson (2021)	A sample of autistic children was observed in two different contexts: while playing with a digital and a non-digital robotic toy. The researchers measured social attention and engagement during free play in two experimental conditions. A mixed research design and repeated observation methods were used. Data analysis shows that digital toys can promote joint engagement in autistic children, as technology can intrinsically support more socially interactive play and social proximity. Moreover, through sensory experience, digital toys can encourage social interaction in autistic children.
Purnama, Herman, Hartono, Suryani & Sanjaya (2021)	Authors describe a tablet environment that use an assistive technology application specifically designed for children with Autism Spectrum. The educational software has been implemented taking into account three key factors of usability (portability, ease of use, and usefulness) and the key elements that emerged by the

literature review. The software technology presents three levels of difficulty.

Therefore, taking into account as the literature highlights, the activities related to the use of Educational Robotics kits allow to train and/or enhance fine motor skills and therefore to strengthen the distal muscles of the hands and improve eye-hand coordination.

Methodology

Scope

The present research aims to develop multisensory and inclusive learning environments using Educational Robotics in the cognitive and behavioural rehabilitation of individuals of different ages. We sought to answer the following questions.

1. Is the introduction of a robotic system able to increase the level of playfulness and sociability of people with severe motor disabilities?
2. Is it possible to simultaneously achieve a change in the visual-spatial and motor skills in people with severe motor disabilities?

Participants

The educational robotics activities were carried out with people attending a Day Care Centre[1] in Rende (Cosenza, Italy). Eleven young and adult people, aged 21 to 44, participated in the research activities (7 males and 4 females). Their disabilities were primarily intellectual disability combined with motor impairments. See Table 2 for a detailed description of the cognitive and behavioural deficits. All information was provided by the head of Day Care Centre. Each participant was identified by the first letter of their name for data protection reasons.

All participants had never used a Lego MindStorms NXT kit.

1. Agreement between the Laboratory of Psychology and Cognitive Science and the "Day Care Centre" Provincial Health Company, Rende, Cosenza.

Tab. 2 - Overview of the participants: the participant's name (the first letter of the name), gender, age and cognitive and behavioural deficits

Participants	*Sex*	*Age*	*Cognitive and behavioural deficits*
BR	F	41	Severe intellectual disability and motor impairment
RR	F	36	Moderate to severe intellectual disability, with behavioural disturbances
RP	F	42	Moderate to severe intellectual disability
AR	F	37	Intellectual disability due to head injury
VV	M	29	Spastic tetraparesis with moderate to severe intellectual disability
GM	M	44	Moderate to severe intellectual disability
GU	M	37	Moderate to severe intellectual disability
GF	M	25	Spastic tetraparesis
PL	M	32	Down syndrome with moderate intellectual disability
CL	M	21	Spastic tetraparesis
RW	M	26	Intellectual disability due perinatal anoxia

Materials

The materials used in the research activities included:

- Lego© Mindstorms NXT kit (see Figure 1), consisting of traditional Lego bricks, as well as sensors, motors and the microcomputer NXT. The user can assemble a robotics artefact very easily (also thanks to the instructions included in the kit, which illustrate how to build a robot step by step). When programmed, the NXT can receive input from the environment via the sensors, process the data and send the output to the motors. In this study, the robotic artefacts were programmed by the researchers to arouse the curiosity of the participants;
- Coloured Progressive Matrices (CPM), used to measure reasoning in typically developing children as well as children and mentally and physically impaired individuals in educational and clinical settings. It is a non-verbal test that is comparatively short and responsive and is therefore suitable for measuring the mental age of children who often have limited language comprehension and expressive ability,

or for measuring fluid intelligence, i.e. the ability to solve new problems without relying on prior knowledge or experience;
- a Sony video camera to record the behaviour of individuals.

Procedure

The activities were carried out from March to July within the educators of the centre. Two meetings were scheduled per week, each lasting about an hour and taking place in the centre's play area. All activities were planned in conjunction with the "Day Care Centre" in order to take in consideration her in-depth knowledge of the patients. The research schedule (see Figure 1) was structured as follows: 1) a Pre-test; 2) a familiarisation phase, free exploration and manipulation with Lego kits and robots; 3) an observation session; 4) a Post-test.

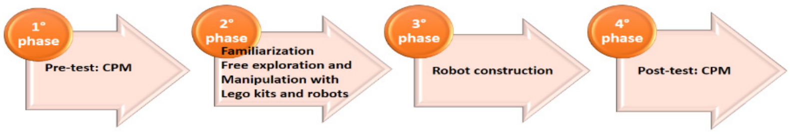


Fig. 1 - In the figure is sketched the overview of the education activities

In the first phase, the Coloured Progressive Matrices (CPM) (Raven & Raven, 1998) has been administered to participants to assess the cognitive abilities of the individuals involved in the study using a psychometric and standardised test. This test consists of three sets A, Ab and B, each set consisting of 12 matrices. Standard procedure was followed in administration. Thus, CPM was administered individually, in a quiet room, with no time limit, and subjects were told how to identify the missing piece. Respondents were asked to point to or say the number of one of the four pictures that best completed the stimulus. Two illustrative matrices with the relative items are shown in Fig. 2.

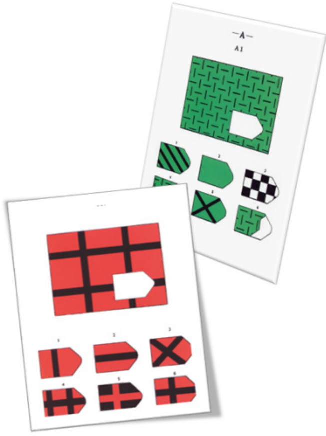


Fig. 2 - Two illustrative matrices of the CPM

In the second phase, careful preparation was needed so that those being observed could get used to the presence of the observers. When people know they are being observed and studied, they may behave differently than usual. Therefore, we explained the presence of the researchers to them and to reduce the "reactivity effect", we familiarised them with the guests of the Centre for a month.

During this period, a Lego Mindstorms NXT robot was used to arouse the curiosity of the young and adult guest of the Centre. The researchers showed them the different Lego robots (see Figure 3), programmed the artefacts to follow a black line, play a short melody and show some emoticons on the NXT display.

Fig. 3 - Lego kit and Robots used to arouse the curiosity of the young and adult people of the centre

The patients first interacted with the Lego Mindstorms NXT robots and then with the Lego bricks.

In the third phase (observation session), the participants worked individually with the Lego bricks. They were supported by a researcher who helped them to read the user manual or take small pieces, taking into account their motor and cognitive difficulties. The duration of this phase was two months. To check whether the activities with the Lego bricks had an effect, a retest with the Coloured Progressive Matrices was carried out.

Recording

In this study, we used the direct observation method, which is a non-intrusive method to record subjects performing specific tasks (Camaioni, Aureli & Perucchini, 2004; Venuti, 2007). Usually, this method allows recording the behaviour of one or more subjects (interacting with each other or with structured objects) using one or more video cameras. We planned to use a video camera placed in front of each subject as they manipulated and assembled the Lego bricks to build a small robot.

The learning setting was structured: five tables were set up for each group of participants with a Lego robotic kit and the user manual, as well as some baskets in which the different Lego bricks were placed.

The participants, divided into small groups, were video-observed during the construction of a robot, using the direct non-participant observation method. One observation session was conducted for each group. The observers were then trained to decode the video observations.

The behavioural taxonomy

We adapted the behavioural taxonomy standardised in Bilotta, Gabriele, Servidio & Tavernise (2008). A pilot observation was conducted to better understand how to decode all behaviours recorded.

Tab. 3 - The Behavioural taxonomy adopted to decodify the observational session recorded

Behavioural taxonomy	
Macro categories	*Micro categories*
Perceptual Behaviours (P): represent a form of perception linked to action. Through these behaviours, subjects do not interact directly with the Lego pieces, but observe the robot.	• To look at the pieces (PLP) • To read the instruction (PRI)
Motor-Manipulatory Behaviours (MM): this category includes all the behaviours through which subjects physically interact with the bricks (i.e., with the pieces of Lego robot).	*Exploratory (MME)*: Behaviours of manipulation of a brick orient to discover its characteristics, directly aimed at testing the manipulation action with some specific pieces. • To search among the pieces (MME-S) • To look for a piece (MME-L) • To take a piece (MME-T) *Object-Oriented (MMO)*. Subjects behaviours were driven by a specific goal (for example: to search specific pieces necessary to build a robotics structure, etc.). • To indicate a piece (MMO-I) • To give a piece to someone (MMO-G) • To choose a piece (MMO-C) • To manipulate the pieces (MMO-M) *Combinatorial (MMC)*. Behaviours that presupposed subjects' ability to connect the Lego pieces to each other. Subjects' behaviour was seen both as stimulus and goal-driven behaviour (for example, while children were holding different pieces, carefully examining them and trying to combine them, thus verifying which piece was complementary with another one).

	• To compare a piece to another (MMC-C) • To connect two pieces (MMC-CN) • To disassemble two pieces (MMC-D) • To test a connection of pieces (MMC-T) • To connect pieces creating a functional unit (MMC-F)
Functional-Conceptual behaviours (FC): indicate that subjects understand how the Lego robot works: subjects associate a function or a new function to a brick, and verify what they have already built.	• To attribute a new functionality to a piece (FCA) • To test a functional unit (FCT)

Source: Bilotta, Gabriele, Servidio & Tavernise, 2008.

Reliability analysis

Before the coding sessions began, we conducted a reliability analysis by matching the behavioural categories of the same events or actions. To check inter-coder reliability, a Cohen-Kappa value was calculated. The Cohen-Kappa value is an index that measures the degree of agreement between two groups of dichotomous values. To calculate the reliability value correctly, we used Towstopiat's (1984) study. Reliability tests were conducted to verify that all coders correctly identified the same taxonomy behaviour. The coders repeatedly watched clips of a video (15 minutes) randomly selected from the observation sessions. Their task was to identify the individual's behaviour as they interacted with the pieces of the Lego MindStorms kit and built the robot. The collected data from each observer was analysed using ComKappa software (Robinson & Bakeman, 1998). After this calculation, we obtained a Cohen-Kappa index of .70.

According to Wood (2007), a good reliability value for research purposes should be at least .60 or .70. The kappa value needs to be higher (.80 or .90) if the researcher needs to make decisions about specific individual abilities, such as scoring intelligence tests. For our research purposes, we have obtained a kappa index that is sufficient to begin the coding process.

Coding and sampling procedure

A training period was scheduled for all coders involved in the behavioural analysis. These activities helped the coders to gain confidence in using the observation method and to improve their skills. In the training sessions, the coders learned to apply the observation method in a controlled way using the behavioural taxonomy. The coders watched the videos of the observation session and continuously coded all the behavioural categories. The coders' task was to observe the subject's actions and record the behaviours listed in the taxonomy at the correct time. We used the recording method of Focal Subject Sampling. This method is used to analyse specific patterns of behaviour. The coder observes a single subject for a specified time and records the duration of all instances of a behaviour under study. For example, the individual behaviour "taking a piece" occurred when the subject grasped some object to connect pieces. The coder stopped the video recording and recorded the start and end times of the behaviour categories on the checklist.

Three coders, who were not familiar with the main hypotheses of the study, observed and coded the video. All observation sessions, which were coded into meaningful action units, were analysed for each behavioural category, for each group, for each subject in the group and for the duration of the session. The individual action units divided the subject's behaviour into exhaustive and mutually exclusive periods (Aureli, 1997) that characterised the individual's behaviour while interacting with the objects of the Lego MindStorms kit. These action units were exhaustive because they contained all possible categories needed to observe the subjects' behaviour during manipulatory activities, and they were mutually exclusive because the behavioural taxonomy contained specific categories associated to single behaviour. No subject could be simultaneously in states of exhaustive and mutually exclusive periods or in those not included in the behavioural taxonomy (Aureli, 1997). Both the frequency of each action and its duration were recorded.

After this initial observation phase, we started coding the video sessions in order to correctly identify the behavioural categories taking into account the duration according to the behavioural taxonomy (see Table 3).

Results and discussion

Results of the Coloured Progressive Matrices

Analysis of the results of the CPMs pre- and post-test showed no significant differences (see Fig. 4).

In particular, it was found that in the pre-test 91% of the participants had a IQ between 70-80, i.e. a low performance category, and 9% with a IQ of 110, corresponding to a medium to high performance category. At the post-test, 73% of participants had a IQ between 70-80, i.e. a low performance category, 18% had a IQ of 90, i.e. a medium-low performance category and 9% IQ of 130, i.e. a medium-high performance category.

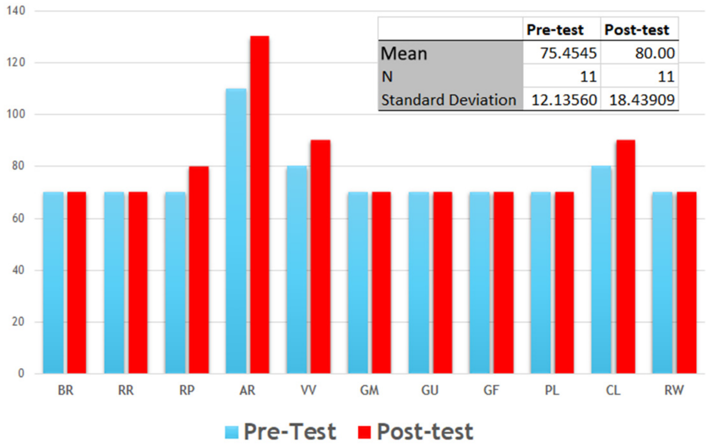


Fig. 4 - The graph compares the pre-test and post-test results of CPM

Results of observation sessions

In decoding the observation sessions, the different groups generally showed attitudes of cohesion, collaboration, enthusiasm, great curiosity, interest in the colour and the size of pieces.

However, we recorded data for each participant in relation to: (a) task performance (e.g., one participant with cognitive impairment required repeated assistance from the instructor to complete small tasks, as did one participant with attention problems in the presence of comorbidity); and (b) fine motor skills (e.g., 4 participants with both cognitive and motor problems had problems with the eye-hand coordination required to assemble the small pieces).

Therefore, below we report the frequency, indicated by *f* (number of behaviours occurred), and the duration, indicated by D (duration of behaviours in seconds), of the behaviours recorded during the observation in relation to items a) and b) and discuss them in relation to the type of disability, highlighting the strengths and weaknesses of each participant.

GF and BR

The first group consists of GF with spastic tetraparesis and BR with severe intellectual disability and motor impairment.

Both participants performed the construction and manipulation task with enthusiasm.

GF showed great difficulty, especially in the prehension of the pieces. Therefore, he was supported, guided and assisted in finding, constructing and connecting the elements of the robots.

BR had problems in focusing his attention: he connected the bricks and tried to assemble the parts of the robot, but needed constant guidance from the researcher with numerous prompts due to his attention difficulties.

GF recorded the highest duration in perceptual behaviour (to read the instructions D=2.52; *f*=11), motor manipulative - exploratory behaviour such as "to take a piece" (D=2.35; f=10), combinatorial behaviour (to connect two pieces D=2.17; *f*=6), object-oriented behaviour (to manipulate the pieces D=1.15; *f*=4).

BR recorded the highest duration in exploratory behaviours, followed by combinatorial and object-oriented behaviours. The behaviours with the highest total duration are "to connect two pieces" (D=4.09, *f*=18) and "to manipulate the pieces" (D=3.14; *f*=17), Perceptual behaviours (to read the instructions D=3.01; *f*=19).

RP and VV

The second group consisted of RP with moderate intellectual disability and behavioural problems and VV with spastic tetraparesis and moderate-severe intellectual disability. RP showed a great interest for “to search for a piece” and “to manipulate the pieces”, with an overall duration of 1.02 and 1.37, respectively. The highest frequency was recorded for the behaviour “to connect two pieces” (D= 2.02; *f*=9). VV recorded combinatorial behaviour more frequently: the action “to connect two pieces” had a total duration of 1.27. In addition, behaviours such as “to read the instructions” (*f*=2) and “to take a piece” (*f*=2) were used more frequently, although the durations were 0.19 and 0.21.

The group proved to be cohesive and cooperative and did not need any guidance or prompting.

LP and AR

The third group consisted of LP with Down syndrome and AR with Intellectual disability due to head injury and motor problems to the right hand. LP was very enthusiastic from the beginning of the educational activities, he had no difficulties in building the robot; AR showed good cooperation skills and great interest in the colours of the pieces and their size. Analysis of the data showed that LP recorded higher duration in “to connect two pieces” (D=2.29), followed by perceptual “to read the instructions” (D=2.09, *f*=18). AR also recorded a higher frequency in the combinatorial behaviours “to connect two pieces” (D=3.36; *f*=4), followed by “looking at pieces” (D=1.17; *f*=4), “to read the instructions” (D=1.07; *f*=8) and the exploratory behaviours “to search among the pieces” (D=0.44; *f*=3).

GU and GM

The fourth group consisted of GU with moderate to severe intellectual disability and sensory difficulties and GM with moderate to severe intellectual disability. Both group members have good comprehension skills, so they had no difficulty understanding the task they were asked to solve. However, the group was constantly guided throughout the activities. Both showed great curiosity and felt comfortable handling the pieces of the Lego kit.

GU recorded a longer duration in "to connect two pieces" (D=1.08, *f*=8), followed by the perceptual behaviours "to read the instructions" (D=0.53; *f*=7), "to search among the pieces" (D=0.55; *f*=8).

GM recorded higher duration and frequency for the perceptual behaviours "to read the instructions" (D=2.53; *f*=14), then "to manipulate the pieces" (D=2.11; *f*=5), followed by the combinatorial behaviours "to connect two pieces" (D=1.52; *f*=7).

CL, RP and RW

The fifth group consisted of three participants: CL with spastic tetraparesis, RP with moderate intellectual disability, RW with moderate intellectual disability due to perinatal anoxia and with perceptual difficulties.

The group worked calmly and independently, completed the different construction phases, cooperated and achieved excellent results. During the construction and connection of the parts, RW needed guidance to complete the different phases of the construction of the robot. CL recorded a longer duration and a higher frequency in the combinatorial behaviours "to connect two pieces" (D=6.37; *f*=25) and the perceptual behaviours "to read the instructions" (D=6.20; *f*=29). RP recorded longer duration and higher frequency in the perceptual behaviours "to look for a piece" (D=1.35; *f*=8), "to read the instructions" (D=1.27; *f*=8); "to search among the pieces" (D=1.11; *f*=6), "to manipulate the pieces" (D=1.09; *f*=6), "to connect two pieces" (D=1.05; *f*=7). RW recorded longer duration and higher frequency for "to manipulate the pieces" (D=1; *f*=2) and "to connect two pieces" (D=0.52; *f*=2).

Discussion

As highlighted in the two questions that guided the study, the goal of the research was both to obtain information about the level of playfulness and sociability that the use of Educational Robotics generates in people with disabilities during activities (an aspect that is often lacking in these disabilities), and to identify any changes in spatial behaviour and visual-motor coordination.

Descriptive observation showed that even participants who initially preferred the role of "spectator" gradually became enthusiastic and actively participated. The use of robotic aids fostered an attitude of cohesion, cooperation, enthusiasm, great curiosity, interest in the different shapes, colours of the different building blocks and the size of the parts in the different groups. The recorded data answer the first question guiding the research: a robotic system in the usual playful activities could increase the level of playfulness and sociability of people with intellectual disabilities.

Even though further rigorous research is needed to affirm that the use of robotic kits causes a change in visual-spatial and motor skills in people with intellectual disabilities, nevertheless we observed that during the activities participants were confident with the suggested tasks and the prompting has been gradually replaced by fading. At the beginning of the work session, the prompt technique was used, using verbal suggestions, cues, and pointing. Over time, as the participants became more autonomous, prompting was used only partially, and then the aids and instructions were gradually removed until the individual could perform the activity completely autonomously and correctly. Summing up, among the construction activities, video observed and decoded (Bilotta et al., 2008), "Combinatory Behaviours" (e.g. choosing a part or manipulating parts), followed by object-Oriented Behaviours (e.g., connecting two parts), and Perceptual Behaviours (e.g., looking at the parts or reading the instructions) had the highest frequency. In addition, combinatorial behaviours aimed at testing the functioning of the robot gearbox were more frequent. Most often, these behaviours were not aimed at building the robot. Only one group completed the task.

Conclusions

The study confirms that it is possible to create highly stimulating, enjoyable learning environments that are useful for connecting with the mental world of individuals with disabilities or cognitive deficits and that allow them to work on attention, perception, spatial orientation, execution, and planning of small tasks.

The CPM test (Raven & Raven, 1998) allows the assessment of cognitive development and each of the CPM sets (A, Ab and B) provides specific information about the thinking skills of individuals. In particular, the A series requires identification skills, i.e., recognising identities based on various cues such as shape, colour, size, direction, orientation. The Ab series, for example, requires the ability to identify the corresponding terms of a configuration. Finally, the B-series requires the ability to think analogically and conceptually, i.e., the discovery of more abstract and formal relationships according to an operational-deductive logic.

These cognitive skills are reflected in the approach to building a Lego robot, which requires handling Lego parts, selecting the right parts by considering colour, size, and shape, and the ability to think logically by grasping the similarities between what is depicted on the instructions and what the individual builds.

In our opinion, quantitative data collected through standardised testing is just as important as qualitative and descriptive data about each individual's strengths and weaknesses. Therefore, a structured learning environment based on playful, fun, and engaging activities allows to collect information about executive functioning, reasoning, problem solving, and fine motor skills of the individuals involved in the proposed activities.

The explanatory research conducted made it possible to gather useful knowledge for the inclusion of Lego therapy into the behavioural rehabilitation activities carried out by the specialists of the "Day Care Centre". Keeping in mind that the emotional context also influences subsequent memory performance and personalization (Li & Wong, 2020) and is recognised as one of the mechanisms to create positive learning contexts, thus improving an individual's performance.

Nevertheless, even if empirical and still not experimental, this research provides educators with clear and immediate applicable indications on the effectiveness of the adopted approach, with suggestions on "how to work", "under what circumstances", "within which context", "through which type of technologies" and "what skills will be trained".

References

Afari E. and Khine M.S. (2017), "Robotics as an educational tool: Impact of lego Mindstorms", *International Journal of Information and Education Technology*, 7, 6: 437-442. https://doi.org/10.18178/ijiet.2017.7.6.908

Aureli T. (1997), *L'osservazione del comportamento del bambino*, il Mulino, Bologna.

Badzakova-Trajkov G., Corballis M.C. and Häberling I.S. (2016), "Complementarity or independence of hemispheric specializations? A brief review", *Neuropsychologia*, 93: 386-393.

Beccaluva E., Riccardi F., Gianotti M., Barbieri J. and Garzotto F. (2021), "VIC—A Tangible User Interface to train memory skills in children with Intellectual Disability", *International Journal of Child-Computer Interaction*, 100376.

Besio S. and Carnesecchi M. (2014), *The Challenge for a research network on Play for Children with disabilities*.

Bilotta E., Gabriele L., Servidio R. and Tavernise A. (2008), "Motor-manipulatory behaviours and learning: An observational study", *International Journal of Online Engineering (iJOE)*, 4, 3: 13-17. ISSN: 1861-2121. Appeared also in: *Proceedings of Interactive Computer Aided Learning* – ICL2007, Villach, Austria: 26-28 September 2007.

Camaioni L., Aureli T. e Perucchini P. (2004), *Osservare e valutare il comportamento infantile*, il Mulino, Bologna.

Castro E., Cecchi F., Valente M., Buselli E., Salvini P. and Dario P. (2018), "Can educational robotics introduce young children to robotics and how can we measure it?", *Journal of Computer Assisted Learning*, 34, 6: 970-977.

Collins A. and Halverson R. (2018), *Rethinking education in the age of technology: The digital revolution and schooling in America*, Teachers College Press.

Conti D., Di Nuovo S., Buono S., Trubia G. and Di Nuovo A. (2015, August), *Use of robotics to stimulate imitation in children with Autism Spectrum Disorder: A pilot study in a clinical setting*, in *2015 24th IEEE international symposium on robot and human interactive communication (RO-MAN)* (pp. 1-6), IEEE.

Cook A.M., Adams K., Volden J., Harbottle N. and Harbottle C. (2011), "Using Lego robots to estimate cognitive ability in children who have severe physical disabilities", *Disability and Rehabilitation: Assistive Technology*, 6, 4: 338-346.

Corsi C., Santos M.M.D., de Andrade Perez Marques L. and Rocha, N.A.C.F. (2016), "Impact of extrinsic factors on fine motor performance of children attending day care", *Revista Paulista de Pediatria*, 34: 439-446.

Daniela L. and Lytras M.D. (2019), "Educational robotics for inclusive education", *Technology, knowledge and learning*, 24, 2: 219-225.

DiCarlo C.F., Reid D.H. and Stricklin S.B. (2003), "Increasing toy play among toddlers with multiple disabilities in an inclusive classroom: A more-to-less, child-directed intervention continuum", *Research in Developmental Disabilities*, 24, 3: 195-209.

Ekin C.C., Cagiltay K. and Karasu, N. (2018), "Effectiveness of smart toy applications in teaching children with intellectual disability", *Journal of Systems Architecture*, 89: 41-48.

Fasola J. and Matarić M.J. (2013), “A socially assistive robot exercise coach for the elderly”, *Journal of Human-Robot Interaction*, 2, 2: 3-32.
Fridin M. (2014), “Storytelling by a kindergarten social assistive robot: A tool for constructive learning in preschool education”, *Computers & Education*, 70: 53-64. https://doi.org/10.1016/j.compedu.2013.07.043
Greczek J., Kaszubski E., Atrash A. and Matarić M. (2014, August), *Graded cueing feedback in robot-mediated imitation practice for children with autism spectrum disorders*, in *The 23rd IEEE international symposium on robot and human interactive communication* (pp. 561-566), IEEE.
Guha M. (2014), “Diagnostic and statistical manual of mental disorders: DSM-5”, *Reference Reviews*.
Kaburlasos V.G. and Vrochidou E. (2019), *Social robots for pedagogical rehabilitation: trends and novel modeling principles*, in *Cyber-Physical Systems for Social Applications* (pp. 1-21), IGI global.
Laurie M.H., Manches A. and Fletcher-Watson S. (2021), “The role of robotic toys in shaping play and joint engagement in autistic children: Implications for future design”, *International Journal of Child-Computer Interaction*, 100384.
Li K.C. and Wong B.T.M. (2020), “Features and trends of personalised learning: A review of journal publications from 2001 to 2018”, *Interactive Learning Environments*, 1-14.
Lindsay S., Hounsell K.G. and Cassiani C. (2017), “A scoping review of the role of LEGO® therapy for improving inclusion and social skills among children and youth with autism”, *Disability and health journal*, 10, 2: 173-182.
Papert S. (1986), *Constructionism: A new opportunity for elementary science education*. A MIT proposal to the National Science Foundation.
Piaget J. (1971), *L’epistemologia genetica*, trad. it. Laterza, Roma-Bari.
Pierno A.C., Mari M., Lusher D. and Castiello U. (2008), “Robotic movement elicits visuomotor priming in children with autism”, *Neuropsychologia*, 46, 2: 448-454.
Pivetti M., Di Battista S., Agatolio F., Simaku B., Moro M. and Menegatti E. (2020), “Educational Robotics for children with neurodevelopmental disorders: A systematic review”, *Heliyon*, 6, 10: e05160.
Proença J.P., Quaresma C. and Vieira P. (2014), “New application: adaptation of toys for children with multiple disabilities”, *Procedia Technology*, 17: 351-358.
Purnama Y., Herman F.A., Hartono J., Suryani D. and Sanjaya G. (2021), “Educational software as assistive technologies for children with autism spectrum disorder”, *Procedia Computer Science*, 179: 6-16.
Raven J.C. and Raven J. (1998), *Progressive matrices couleur/colored progressive matrices*, Centre de Psychologie Appliquée, Paris.
Robinson B.F. and Bakeman R. (1998), *ComKappa: A Windows’ 95 program for calculating kappa and related statistics*.
Towstopiat O. (1984), “A review of reliability procedures for measuring observer agreement”, *Contemporary Educational Psychology*, 9, 4: 333-352.

Valadão C., Bastos T.F., Bôrtole M., Perim V., Celino D., Rodor F., Gonçalves A. and Ferasoli H. (2011), *Educational Robotics as a learning aid for disabled children*, in *Biosignals and Biorobotics Conference (BRC)* (pp. 6-8), January. http://dx.doi.org/10.1109/BRC.2011.5740667
Venuti P. (2001), *L'osservazione del comportamento: ricerca psicologica e pratica clinica*, Carocci, Roma.
Wood B.L., Cheah P.A., Lim J., Ritz T., Miller B.D., Stern T. and Ballow M. (2007), "Reliability and validity of the Asthma Trigger Inventory applied to a pediatric population", *Journal of Pediatric Psychology*, 32, 5: 552-560.
Yin C.L.C. and Yin T.K. (2019, December), *A review on the efficacy of physical therapy intervention on motor skills of children with autism spectrum disorder*, in *3rd International Conference on Special Education (ICSE 2019)* (pp. 39-43), Atlantis Press.
Zhang Y., Song W., Tan Z., Zhu H., Wang Y., Lam C.M. … and Yi L. (2019), "Could social robots facilitate children with autism spectrum disorders in learning distrust and deception?", *Computers in Human Behavior*, 98: 140-149.

Section 2

Experiences

Beyond barriers. Inclusion and innovation through the use of educational robotic environments

by *Daniela Di Donato* and *Paola Mattioli*

For inclusive teaching

In Italy, the definition of inclusive teaching is relatively recent. Studies and research on the classroom as an educational context capable of welcoming every child on a social and affective level (Cottini, 2004; 2017; Ianes, 2001) and the evolution of the legislation, which in 2012 introduced the category of Special Educational Needs, have generated an idea of inclusion focused on the enhancement of individual differences, rather than on the distinction of the difficulties of some.

In short, the processes must concern all children, regardless of their physical, intellectual, social, emotional and linguistic conditions (Morganti & Bocci, 2017).

At the international level, this approach is proven by the proposal of the Universal Design for Learning (Savia, 2016) and the Index for Inclusion (Booth & Ainscow, 2014). The dimension described by the Index's indicators for inclusion exalts the classroom as a group of people, each of whom has the right to develop his or her potential, in a climate that is participatory, encouraging and based on mutual respect.

Inclusion and Educational Robotics

The writer Isaac Asimov said that there is nothing more different from us than a robot and this is what makes human beings feel more similar to each other. Perhaps the universal value of the human-robot relationship is also in this extreme difference, it ignites curiosity and provokes reactions.

Educational robotics exploits robots as a tool to bring children and young people closer to new technologies, but also as a means to develop in them both disciplinary and transversal skills.

Robots, in an indirect or direct way, are part of our lives and in the field of educational robotics children and teachers work together in groups to creatively implement the programming of the available robots. They develop processes in which both the child and the robot have a role and interact.

Educational robotics was born in the late 1960s thanks to Seymour Papert, a professor at MIT, one of the first to realize how robotics could positively influence learning.

Pedagogist and computer scientist, he collaborated with Jean Piaget and immediately saw in computer programming the tool to teach from an early age how to reason and solve problems effectively.

With this goal he created LOGO in 1967, the first programming language dedicated to elementary school students, along with Wally Feurseig and Cynthia Solomon.

One of the most famous robots created by Papert and his team is precisely known as the LOGO turtle, a large programmable hemisphere with wheels to move, and markers on the bottom to draw.

Using the LOGO language, also created by Papert, children could make the hemisphere perform various operations, such as drawing geometric shapes. LOGO became popular in schools, but unfortunately was later abandoned.

What Papert had clearly described was the value of process and reflection on process as the main key to stimulating learning, rather than application of rules or repetition (Papert, 1984).

In the didactic experiences linked to educational robotics, children learn by doing and above all by experimenting with what is proposed to them, fully realizing constructivist teaching.

In the programming of the robot, the management of error becomes fundamental; it is no longer a reason for frustration, but the starting point for reflecting on new possible solutions.

If we were to identify the main educational functions of the robot in education, we could mention at least three:

1. the robot as mediator: as an object and subject of experience, the robot is exposed to the interpretation of multiple points of view,

without ever losing its effectiveness. Through this function, the child learns a way of structuring his or her thinking about the universe (Bateson, 1996);

2. the robot as a meaningful experience: the robot generates multiple teachable moments and it is through this generative spark, that the activity is recognized as meaningful and pupils are shown to be motivated to learn (Bybee, 2016);
3. the robot as a symbolic artifact: every human being tends to bring the technological artifact inside his way of experiencing, making it become a tool to enlarge the area of the body's sensibility towards the world (Benanti, 2016).

This is also why promoting educational environments simultaneously oriented towards autonomy and cooperation overcomes the barriers naturally posed by educational systems and reaches beyond and to all (Resnick, 2020).

The introduction of digital technologies in the space of children at school must be considered an opportunity to develop citizenship, a key competence for the construction of democracy, and citizenship also takes a digital form, which must be experienced and crossed with children (Lorenzoni, 2016).

First experiences with robots

Robotics is something children love. They like building, testing and improving their projects. This is an important practice that will help their creativity to be always trained. We often think of creativity as something linked only to arts, but each sector of our life needs creativity. Robotics also needs creativity to solve the problems one can find coding a robot.

Unfortunately, nowadays only few students still have this opportunity. If students meet a passionate teacher they can hope to test robotics in their curriculum, otherwise they will not have experience about it.

I often meet teachers that are afraid of using robotics at school because they think their students know the topic more than them. When I started using my first robot at school I didn't know anything about it. One student had brought his new robot to school and seeing their interest I used it to explain addition and subtraction on the line of numbers.

After this experience I bought my first robot and built it at school asking students for help. The presence of the robot was so engaging that all the students participated in an active way. From that moment we had the possibility to use two robots for our classes and students loved to create situations where the robot could interact.

Using the robot in class gave each student the opportunity to be more confident with the activity because giving instructions to the robot there was the possibility to see if the idea worked or not.

When you code a robot to do something you can see immediately if your idea works or not and this is really helpful for those students that often are afraid to say what they think. If you decide to bring robotics in your lesson, the first robot for students, even before kindergarten age, will surely be Cubetto, a nice robot made of wood created from PrimoToys. This robot has a platform that you use to code the robot self, you can make this using simple pieces that indicate the street to the robot. The material of this robot makes you think of Montessori schools because it remembers a lot of the elements of her method.

Students love this robot because they can try solutions to the challenge the teacher proposes and have instantly the feedback observing the lights on the platform.

The second robot we used at school and that you can use in a robotics curriculum is Blue Bot, a nice robot with the shape of a bee. It has arrows over the body that students use to code it. It is more difficult than Cubetto because when the robot is walking the student doesn't have lights to follow directions, for this motivation this one is better in a second step if you want to follow a robotics curriculum.

Students love using robotics at school because using these instruments is engaging for them. Often teachers think of robotics as something they have to do more in their works, but the secret is to let students explore and learn with them.

We need to think of robotics as instruments that we can use in our school days in activities of each subject.

For example if we have to teach the division in syllables we can prepare cards with different syllables to pose on the playground. Then students have to code the robot to collect the right syllables for the word the teacher asks for.

This is only an example that we can repeat in math or other subjects. We can read them a story, drawing the scenes of the story in little cards to pose on the playground and after the reading ask them to collect the images in the right order they listened to. Each card they collect will be posed in sequence, in this way students will work on language, coding and space-time line re-building the story with the images collected.

If the school has the possibility, it may engage one class or more in robotics competitions such as the First Lego League. Students in all the world from 6 years to high school practice a lot for this competition.

This is a competition divided in two phases, explore for younger and challenge for high school students. In the high school participants will have real robotics matches. Each year there is a different argument that participants will develop during the year until the final exhibition. The students participating in the explore competition will build a robotic model and a show poster to expose their research.

This competition is really engaging because students will address the topic from different points of view, exploring different subjects in a multi-disciplinary learning. In this competition it is really important the team working skill that will grow up during the weeks. Each student can find a role in the group and students will help each one for the common goal.

Design examples with robots

To summarize the experiences described, we used the following table, which identifies three moments of learning: the challenge, the educational and instructional goal, and the outcome.

Tab. 1 - Synthesis of the paths designed and implemented in classroom

	Challenge	***Learning Goal***	***Learning experience***
1	*Storytelling with Cubetto*	*Linking storytelling to robotics*	*#Stream*
2	*Building a path*	*Collaborate for a Project*	*Coding express Lego*
3	*Tangible programming*	*Mistake as learning*	*M-Tiny*
4	*Recognizing emotions*	*Get excited for the robot*	*Programming Codey Rockey screen*
5	*Programming Ozobot*	*Working about learning process*	*Designing an environment and a story*
6	*Building a programming environment “drag and drop”*	*Orient yourself in the space*	*Understanding how it works with Lego WeDo*

In Storytelling with Cubetto, the common thread was the story and the space-timeline. First, the children reasoned about the narrative sequences and the series of actions to be performed by the robot, so that it would follow the imagined path exactly (Figures 1 and 2).

Then they carried out a real transfer: the child took the place and appearance of the robot, to move along the path first imagined and then physically crossed (Figure 3).

After performing the design activity, the whole person participates in the experience, mind and body, in a pedagogical key consistent with embodied cognition (Clark, 1997).

Fig. 1 - Elaboration by Paola Mattioli

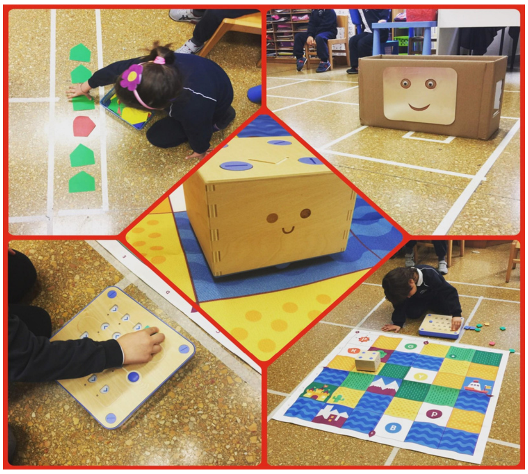


Fig. 2 - Elaboration by Paola Mattioli

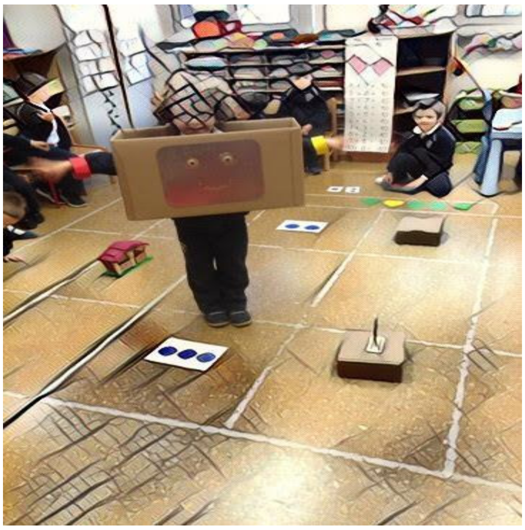
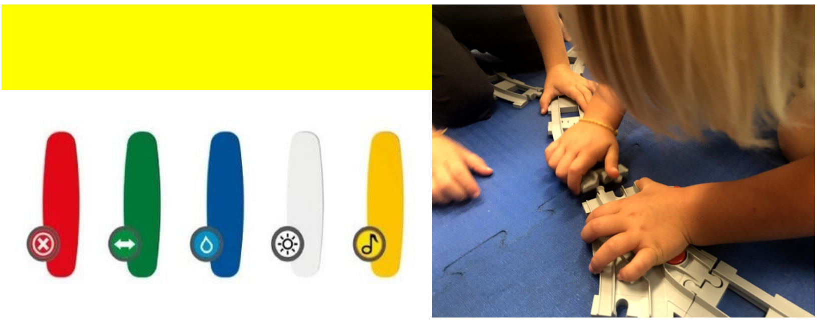


Fig. 3 - Elaboration by Paola Mattioli

Lego's Coding Express is a creative set with DUPLO bricks and allows kindergarten children to learn the first concepts related to coding, to try their hand at problem solving, critical thinking, collaborative work, sequencing, social and emotional skills (Figure 4).

The first challenge to propose students is building the path with the tracks. Students are asked to collaborate to decide the best design and it isn't an easy task. Then they can test the train using the colored blocks that you insert in the tracks. When the train passes over them will read the message producing the action.

For example, when the train passes over the yellow block it will produce sounds; when the train will pass over the green block it will change its direction.



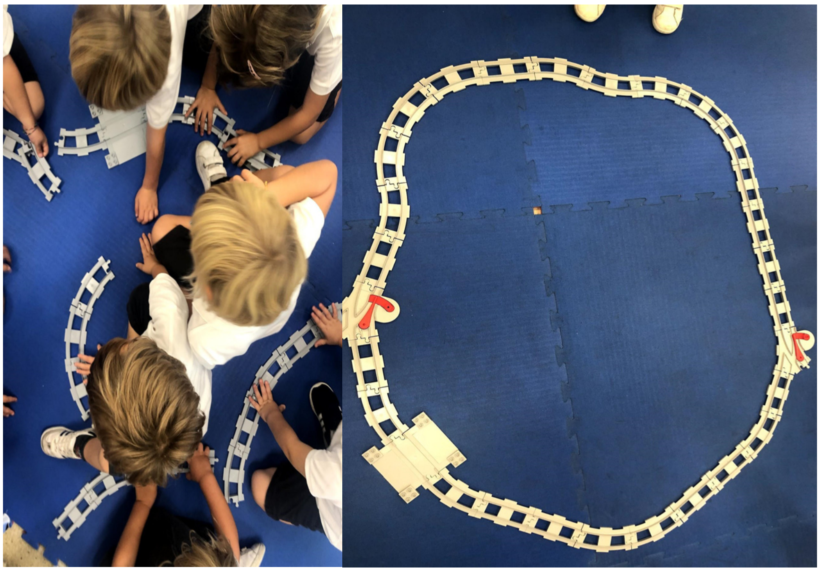


Fig. 4 - Challenge with Coding Express Lego - Elaboration by Paola Mattioli

The experience with mTiny uses tangible programming: blocks are read by a pen, which sends commands to the robot. mTiny is a perfect robot for preschool, it has the shape of a little Panda that students love.

Children build the path with puzzle blocks and have immediate feedback on whether there is a programmed error in the sequence (Figures 5 and 6).

This robot is really engaging for students because the robot has a screen where it shows the eyes of the Panda making visible the emotions it feels. This robot is a first step to talk about emotion and robotics.

Fig. 5 - Elaboration by Paola Mattioli

Fig. 6 - Elaboration by Paola Mattioli

Codey Rocky makes it easy to experiment with concepts like coding, artificial intelligence and the internet of things. The most striking aspect of this robot is the emotions it arouses in children.

You can, in fact, program the image of the screen and it is easy for children to get excited about the heart-shaped eyes.

The Ozobot, on the other hand, is a small robot that fits in the fist of your hand, but it has all the components to make it irresistible to children's eyes.

It moves and executes commands given by the combination of 4 colors and in its advanced version (Evo) can be programmed with OzoBlocky from the App (Figures 7, 8, 9, 10).

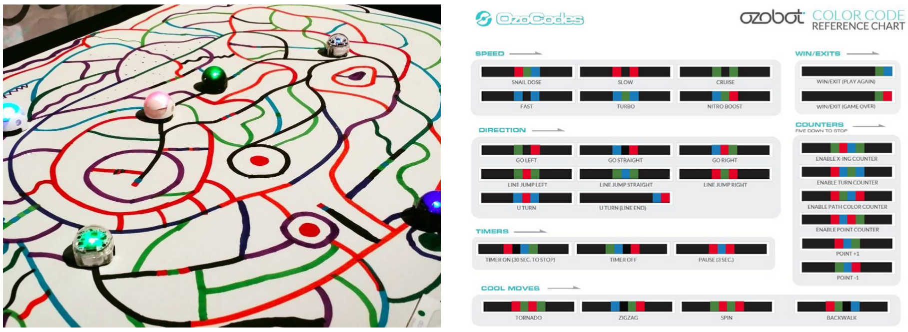


Fig. 7 - Elaboration by Paola Mattioli

Fig. 8 - Ozobot - Elaboration by Paola Mattioli

Fig. 9 - Project for Ozobot - Elaboration by Paola Mattioli

Lego WeDo is a kit that through a combination of bricks, a rich set of STEAM lessons ready on the Lego Education website, and a "drag and drop" programming environment makes classroom activities really exciting for all children.

As a first experience, it's important that children try out and understand how the motors, tilt and motion sensor work.

To do this, three activities are proposed to build a rover called Milo that perfectly accompanies children in the discovery of these components (Figure 10).

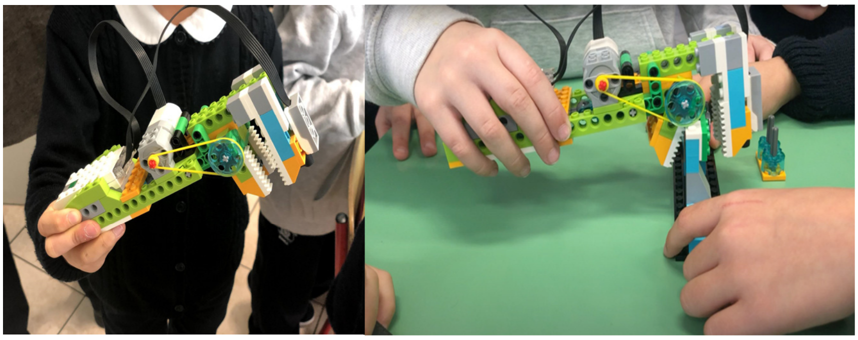


Fig. 10 - Picture shows a robotic hand built by 2nd graders. This project permitted us to talk about prosthesis and aids for people in need - Elaboration by Paola Mattioli

Conclusions

The school practice of educational robotics creatively develops the guidelines of Media Education already contained in the National Indications of 2012 (MIUR, 2012).

In the main document for the design of educational pathways, the "new scenarios" created by digital educational technologies manifest at the same time the call to a widespread and collaborative knowledge and the launch of a challenge: both aspects will then be contextualized by the National Digital School Plan (PNSD: Piano Nazionale Scuola Digitale) in the sphere of digital skills, to be acquired starting from kindergarten, and in the lines of the European Digital Agenda of 2020, as a goal to be renewed for every citizen.

Bruner would remind us that all this is part of a cultural dimension, where culture is what helps shape ideas and behaviors and provides us with the tools with which we build our world and conceptions of ourselves and our capabilities (Bruner, 1997).

It is really about participating in cultural change that can become structural change in the way we teach and learn in school.

Promoting autonomy and valuing individual differences is not only a step towards an inclusive environment, but it becomes a shared need for educational research.

Experiences could this move from pioneering events to systematic projects, so as to provide a solid foundation for anyone who approaches this effective methodology, to bring it into their classrooms and their professional contexts.

References

Beck A.T., Rush A.J., Shaw B.F. and Emery G. (1979), *Cognitive Therapy of Depression*, Guilford Press, New York (trad. it.: *Terapia cognitiva della depressione,* Boringhieri, Torino, 1987).

Benanti P. (2016), *La condizione tecno-umana. Domande di senso nell'era della tecnologia*, Edizioni Dehoniane, Bologna.

Booth T. e Ainscow M. (2014), *Il nuovo Index per l'inclusione*, Carocci, Roma.

Bybee R.W. (2016), *The BSCS 5E Instructional Model: Creating Teachable Moments*. NSTA Press, Arlington, USA.

Clark A. (1997), *Being there: Putting body, brain, and world together again*, The MIT Press, Cambridge, MA (trad. it. *Dare corpo alla mente*, Mc-Graw Hill, Milano, 1999).

Cottini L. (2004), *Didattica speciale e integrazione scolastica*, Carocci, Roma.

Cottini L. (2017), *Didattica speciale e inclusione scolastica*, Carocci, Roma.

Holbert N., Berland M., Kafai Yasmin B., a cura di (2020), *Designing Constructionist Futures. The art, theory and practice of Learning designs,* The MIT Press, Cambridge, Massachusetts.

Ianes D. (2001), *Didattica speciale per l'integrazione*, Erickson, Trento.

Ianes D. e Demo H. (2020), *Non uno di meno. Didattica e inclusione scolastica,* Franco Angeli, Milano.

IBE-UNESCO (2016), *Training Tools for Curriculum Development Reaching Out to all Learners: A Resource Pack For Supporting Inclusive Education*, International Bureau of Education-UNESCO.

Lorenzoni F. (2016, March), "Una scuola artigianale", *Bambini*, 31-34.

MIUR (2012), *Indicazioni nazionali per il curricolo della scuola dell'infanzia e del primo ciclo di istruzione*, Roma.

Morganti A. e Bocci F. (2017), *Didattica inclusiva nella scuola primaria*, Giunti, Firenze.

Papert S. (1984), *Mindstorms: bambini computers e creatività*, Emme Edizioni, Milano.

Savia G. (2016), *Universal Design for Learning. La progettazione universale per l'Apprendimento per una didattica inclusiva*, Erickson, Trento.

Robotics and educational care for students at risk of dropping out of school: Theories and proposals for action[2]

by *Sonia Boldrini*

Educational Robotics in schools

Educational Robotics is by its nature transverse to school subjects. Far from the robotics to which students approach in higher technical studies, educational robotics isn't a subject which can be compared to the others during the first cycle of education. It is a teaching methodology which provides the creation of a robot and its programming, but its purposes and objectives are geared towards personal development and both instructional and transversal skills, which are not connected with a subject but which concern fundamental attitudes and values even outside of school. Doing robotics means, in fact, designing and collaborating in a group, communicating with classmates while respecting other's point of view, observing the relationships between phenomena while checking information and looking for any errors to improve the performance, in summary organizing your own learning and, in this way, **learning to learn**.

Therefore, technology becomes an instrument for the purposes of both teaching and education. The robots force kids to design, communicate between them, collaborate to solve problems, assess a process and make decisions. During the educational robotic courses, the student is at the center: he is the real protagonist of the learning process which must be individualized.

Educational Robotics, which always takes place in a collaborative context, often makes use of the peer education: the educator takes the role of the guide and director, but he is not at the center of the process, which instead

[2] Traduzione di Beatrice Maggi.

sees the kids as protagonists who learn by making and playing, in what is defined as learning by doing.

Introducing educational robotics in school means making the learning engaging not only for the STEAM subjects (acronym of Science, Technology, Engineering, Art and Mathematics) but also for the liberal arts: in fact it is integrable with any contest and takes the form of a game in which the child tries and experiments solutions to various problems.

Students at risk of ESL: What the school can do

The phenomenon of early school leaving, which in the last ten years in Italy has dropped from 20,8% to 13,8% (MIUR data), is still a social problem which cannot be defined as marginal. In the Report published in January 2018 about the contrast/conflict of educational failure, the Ministry of Education points out that Early School Leaving «isn't just a dysfunction of the school; for the education and training system it's not a problem, it's the problem. But, even more, the dispersal is the cause and also the consequence of the growth failure and, at the same time, of the democratic deficit in the mechanisms of social mobility of our Nation and it is the indicator of a deficiency in our system in terms of equity» (MIUR, 2018).

The consequence for these kids concerns primarily the missed opportunity of personal development and access to the job market, but this also turns into the risk of getting caught up in addiction or delinquency and being excluded from different possibilities as the active exercise of their own citizenship and their own rights.

For this reason, the educational institutions can't avoid implementing prevention projects which keep these kids connected to the school, which remain their safe place par excellence.

What has to move every group of educators is the need of offering to the students a chance for redemption from the role which the society (and sometimes themselves) has assigned to them: a role from which is difficult to get out of due to their own cultural and family background.

Also, the school, especially compulsory education, must give the kids a place where to create, and where to be the protagonists of their own expression and their learning; it must give them a completely different perspective from the one that is traditionally offered by schools. To make this happen, it's necessary to design a learning environment free from predetermined instructive sequences.

Educational care: The cornerstones

Educational care, pedagogical category par excellence, can be considered as the basis of every intervention for kids coming from fragile communities. The cornerstones of educational care translate into a set of attitudes which the educator must consciously and deliberately implement in the educational relationship, in particular for children at risk of early school leaving.

First of all, it's essential to guarantee **closeness**, which means a constant presence that allows to initiate a dialogue and to build a trustful relationship over time. This means that the educator has to be available when kids are in school: this creates a positive circle that makes them come back to school and that translates into a more stable school attendance long term.

Once a first relationship is established, the educator will be able to establish a **dialogue** based on active listening and empathy. There are many purposes: redirect the kids, encourage them to take part in building their future, being the protagonists of their own choices, detaching themselves from the role that the social environment has given them.

Another cornerstone of educational care is the **support** during difficult times. When a relationship is established with students who are highly at risk of dropping out, you have to predict a series of moments in which the kids surrender to the demotivation caused by a zeroing of their own self esteem. The processes of familiarization with school always take a long time: it's physiological that down times take turns with moments in which kids seem more available and motivated. It is necessary that the educator is able to stand by, respecting their own time both in their work and their openness to dialogue.

The relationship of care includes that at the end the educator is an example for the learners, the first one to exercise care in what you're doing, while transmitting passion for what is being built. In this way, he will help the kids daily in becoming aware of what they are doing, what they're able to do, while teaching how to **take care of themselves**, setting the stage for learning how to cultivate their education during their lifetime.

It certainly isn't a simple path: the sporadic presence of these kids at school represents the first big obstacle in order to build an educational relationship based on dialogue. This is why robotics might be considered a more effective methodology than others, mainly in the age group of the secondary school.

Educational Robotics and the recovery of social unrest

The constructionism's approach contextualized by the robotics is able to guide the kids to build their own knowledge, to educate them to the protagonism and to start a process of social redemption that is made possible by the change of perspective: from the margins of the training programme, that too often is set on a midline on which there are the majority of students, they find themselves at the center of this process, thought for them and adjusted to their needs continuously. It is not about lowering the goals, but centering them in the zone of proximal development of each of these kids, so that they can perceive that their path is not unsuccessful, but still in progress.

The path of discovery, self-care and care about your own education starts from the protagonism of the kids, that gets them closer to their social redemption from their coetaneous, from their teachers and, even more so, from the context that has given them a role from which they struggle to break away.

Educational robotics also follows a **trial and error approach** that gives the students the possibility to apprehend and to be aware of their own path, creating a positive circle where they can acquire social, educational and metacognition skills. The engagement that is triggered during the initial attempt is kept and it motivates the kids to keep going on. The word "error" is banned from the educational robotic courses: the attempts that the students make might not immediately reach the set goal, but they are just a way to reach something else. Every kid is encouraged to find more functional alternatives: this way they don't look at the mistake as a defeat, but as an occasion to learn.

From the point of view of teaching, the model of educational robotics is similar to that of personal talents (Baldacci, 2015). This model is based on the dominance of the training "subject" rather than the "object" of training and the "Product" rather than the "Process".

The model centred on the development of personal talents focuses not so much on the general mental processes which are put in place during the learning, but on the specific and concrete skills, starting from the peculiar cognitive skills of an individual, from his forma mentis. Unlike other approaches in which the focus is to teach the basic skills that everyone should obtain, the model of personal talents «favours what qualitatively differentiates every individual from others, what distinguishes his cognitive individuality» (Baldacci, 2015, p. 36).

In this approach you move away from the approval of the training courses in order to approach the expression of the potential of every individual who is training, to give space to different languages and media that allow the gaining of diversified and personalised abilities.

This kind of teaching satisfies individual training needs, by respecting any individual's learning style: in a context of high risk of early school leaving, this teaching method allows the most vulnerable kids to recognise, cultivate and enhance their personal talents. This type of school places as its purpose the full accomplishment of every individual, preventing in this way some forms of social discomfort created by cultural exclusion.

Educational Robotics: Intervention proposals

From a design perspective, educational intervention has to be arranged in agreement with the class council, which identifies the general purposes and goals regarding the needs that are identified inside the school and the specific goals of every student.

In this context we will try to build a design proposal that can be adapted in specific school contexts.

The general aims of a recovery project aimed at pupils at ESL risk are:

- to create a connection with students that the school is losing;
- to give them a new place to create, express themselves and learn;
- to offer a learning environment free from predetermined instructive sequences.

For the realization of the interventions it is necessary that the Institute is equipped with educational robotics kits and spaces dedicated to activities such as Tinkering, for example a creative Atelier.

We can identify three phases of intervention.

1. Docking and definition of the supplement background

Focus: ensuring the return in the teaching programming.

The young people to whom it is proposed to build a robot usually show an immediate interest, both for the peculiarity of the proposal and for the opportunity to spend time outside the context of the class.

The construction of the robot is always an opportunity for dialogue and building a first relationship between the boy and the educator, because you are in a situation of unexpected relaxation.

This time allows the educator to identify the attitudes and talents of the children, and then propose a personalized and motivating path, which effectively responds to the educational needs of the subjects, always in agreement with the teachers of the class councils.

The students are proposed to undertake a multidisciplinary path that involves the use and programming of the robot, in parallel with activities that respect the aptitudes identified. In this way, outside the class group where these children often feel marginalized or in which they have a role that does not allow them to show any interest in educational activities, they will feel freer to have a more and more active role in the planned path. Once a context has been identified within which the boy feels engaged, it becomes a sort of background that, mediated by the use of the robot, allows to approach the various disciplines in a transversal, integrated way.

This type of programming, defined for integrating backgrounds, provides that the set of activities carried out refer to a unifying structure, which allows the connection between the different activities and the different skills exercised. Within the background can acquire meaning different experiences that are unified by the use of certain media.

It is essential that the background supplement is established together with the boy and that, above all, is consistent with his training needs and his personal talents.

2. Route production

Focus: development of disciplinary and transversal skills.

In this phase, the students elaborate their own path in which the robot acts as a common thread. Within the integrator background identified, the robots ensure the connection to the various disciplines, in a sort of hyper-storytelling.

The programming of the robot allows the development of some basic skills of the mathematical-scientific area, which depend on the software you decide to use. The other disciplines are linked from time to time in different ways; fundamental is the dialogue built in the educational relationship, which allows the adult to identify possible disciplinary links that go to enrich the educational path of children.

This is certainly the most substantial and demanding phase from the point of view of the acquisition of skills, but the engagement created by the robot guarantees the continuity of the students' commitment.

3. Preparation for a project sharing event and conclusion

Focus: social redemption.

As the realization of the project progresses, the boy is proposed to share also with the companions what produced. With this proposal we want to create the opportunity to enhance the specificity of each of the children, focusing on the potential hitherto unexpressed and thus redeeming their image both in the peer group and towards the teachers.

For kids this is the hardest part, because they find themselves showing their peers a personality that the group did not give them a way to express.

Social discomfort leads these subjects to interpret roles in the group that mask the discomfort itself, sometimes building roles and behaviors that become difficult to unhinge.

For this reason, for many young people to show themselves as "winners" in a didactic context is as new as it is difficult, because it places them in the group of peers in a new perspective, unexpected as it is difficult to keep outside the design context.

The social redemption of these children remains the ultimate goal of this project: for this reason, it is essential that the hanging up with the school and with the context of the class and a consequent gradual return in the teaching programming. Therefore, it is considered fundamental that the educational intervention is prolonged in time and that there are moments of verification both in progress and in the end.

Examples of implementation

In the school years between 2016 and 2019, educational robotics projects aimed at the recovery of pupils at risk ESL were carried out at the Istituto Comprensivo of San Colombano al Lambro, in the province of Milan. The interventions were addressed to individual pupils of the secondary school of first grade of the second and third classes, two of which were characterized by selective mutism. Specifically, these were laboratory activities during which Lego EV3 and Wedo 2.0 robots were used.

Below we have chosen to describe some details of their project path, both to help the reader to define some practical aspects of the realization of the project, and to further clarify the importance of individualization of this type of path.

Giovanni

Giovanni was a second grader. He attended very irregularly; his behavior towards his classmates and teachers was affected by his instability. He did not study, did not perform the assigned tasks, made long absences during which he was unavailable.

He was integrated into the class group, in which he had a rebellious role; he argued that the disciplinary measures against him were unjust and that there was a kind of fury against him.

The proposal to go to the Atelier and build a robot was welcomed by Giovanni with moderate enthusiasm: it was an opportunity to leave the class again.

At that time the Atelier was being completed: the furniture was coming but the robots were already available. Giovanni was the first to use one, even before the inauguration of the Creative Atelier.

This situation, in addition to the curiosity he immediately demonstrated for the robot, put him in a position to decide immediately that the project interested him. He mounted the LEGO EV3 robot in no time and started programming it intuitively.

For Giovanni it was quite simple: he had strong logical skills and, despite having a very low average in mathematics, he was very easy to calculate trajectories and program the software of the robot.

Giovanni often worked with Leonardo, a classmate with completely different problems that due to its particular characteristics made the meetings rich in movement and undermined the concentration of both Giovanni and the teacher.

Giovanni was interested in getting out of secondary school as quickly as possible; for this reason, he was asked to try to recover the middle grades of some subjects through a series of activities related to the robot.

He chose to deepen a science topic: the respiratory system.

He drew on a large billboard a respiratory system on which the robot simulated the path of the air in and out. The robot was programmed to travel from the nose to the alveoli, stopping at each step to give time to Giovanni to explain the physiological process and then start again through the signal to a sensor.

It was in this way that John demonstrated to himself that he was able to complete a project, to study, to repeat a lesson and to tutor a companion who was much more in difficulty.

He was asked to write a text on his experience, thus recovering the vote of Italian language.

In the spring of 2018 the science project was brought by Giovanni to Microsoft Edu Day in Milan, during which he explained to secondary school students and their professors what he had built and how he had designed it, generating in himself the perception of a social redemption being really possible.

Giovanni ended the year with a promotion, but above all with a more regular school attendance.

Andrea

Andrea was a third grader. He had behind him a broken and culturally poor family; he was not integrated with the class group nor did he relate to the teachers. He was in a situation of selective muteness so as to compromise any kind of relationship and integration with peers and teachers, who did not even know the sound of his voice.

Andrea entered the Atelier as a child in a playground: in a very short time despite his extreme shyness and his reluctance to communicate, he told that engines were his passion and that after school he worked as a mechanic.

The robots were therefore an opportunity for him to exercise a true passion in a context that until then he perceived as hostile.

His teaching skills bound the choice of the robot to a LEGO WEDO 2.0, simpler than the EV3 in both construction and programming, but more creative in construction and less demanding in time.

Andrea began with simple constructions during which he unexpectedly began to tell a lot about himself: he chose each time a construction that recalled something already experienced, like a small kart (which he had built himself in reality) or mechanical arms similar to the tools he used in the workshop.

During the first weeks it was thus possible to establish a relationship of trust and moderate openness. Andrea told of another passion of his: that of history. He knew everything about world wars, airships, submarines, tanks and war machines. He knew the story and proved several times that in class, during the lessons, he was anything but estranged.

Towards the end of the year he was able to show some of his companions some robots and explain how they work.

He chose during the meetings of the project to prepare an essay for the license exam that would include the machines used in wars, but ranged to include all disciplines. During the exam he managed to present his presentation, with great pride and emotion.

Marco

Marco, of Chinese descent, was a third-grader. He moved very recently for work, only living with his father who was always away from home for work. Marco was not integrated in the class group; he spoke very little and only with monosyllables, he often fell asleep in class.

Marco, like the other boys, immediately showed himself well disposed towards the experience of robotics: he said it was a way to get out of class, where he did not want to be because there was no other of Eastern origin.

Marco was asked to assemble a LEGO EV3 robot, although his previous skills were lacking. The choice, however, proved to be adequate to those that then emerged as his needs: this type of robot requires great concentration, precision and continuity of work. Marco expressed his difficulties in a short time: the relational problems within the family context were further aggravated by a dependence on video games that then emerged and that was the cause of his extreme fatigue.

Marco was unable to stop playing video games: he spent all night in front of the screen.

As for the other boys, however, it was possible to identify his passions and create a background that allowed him to become the protagonist of both the content and the objectives of the path.

Marco was fond of Japanese houses, architecture and design. He decided to design a map of a Japanese house and to program the robot to tour the house during which Marco could explain some architectural and cultural features.

Marco also took this project to the license exam.

His dependence on video games was gradually reduced.

In all three cases, the class councils noted the acquisition of disciplinary skills, an improvement in the relationship with the peer group and an increase in personal self-esteem, as well as the development of transversal skills such as design, communication, collaboration, problem-solving skills, an increased sense of personal responsibility and, above all, learning to learn.

Conclusion

The projects carried out in the Istituto Comprensivo of San Colombano al Lambro are an example of how robots can be an educational vehicle in situations of particular fragility. The playful aspect of this type of intervention, however, must not mislead: the educator who undertakes this type of path cannot ignore a serious pedagogical training before technological.

If well designed, this type of educational intervention can make a difference for those socially marginalized children that the school still fails to include often because of its rigidity, especially in secondary school, where an educational approach respectful of their real needs is still often denied.

References

Baldacci M., a cura di (2015), *I modelli della didattica*, Carocci. Roma.

Cambi F. (2014), *La cura di sé come processo formativo. Tra adultità e scuola*, Laterza, Bari.

Sitography

www.scuoladirobotica.it
https://www.miur.gov.it/-/dispersione-scolastica-e-poverta-educativa-presentato-il-documento-finale-della-cabina-di-regia-fedeli-rossi-doria-serve-piano-nazionale-coinvolgere-t

An inclusive summer camp based on coding and educational robotics to discover the planet Mars through digital storytelling with Scratch

by *Maura Sandri* and *Gabriella D'Orsi*

Introduction

This work presents a summer camp organized under the national educational programme (PON) "Social inclusion and fight against marginalization" held in 2018 and based on digital storytelling with Scratch, addressed to 18 male students and 12 female students of a lower secondary school. Its main goals were to rebalance situations of socio-economic disadvantage in an area on the outskirts of an important metropolitan city and to help break down gender stereotypes persisting in our society, which pose an obstacle preventing girls from accessing STEM (Science, Technology, Engineering and Mathematics) disciplines, while strengthening key competences defined in the reference framework indicated by the European Parliament (2006/962/EC). In the awareness that it is possible to stem the growing epidemic of learning disabilities and school dropout by providing a wide variety of experiences available to students, it was decided to engage them with interesting activities to keep up with the changing world, using technology.

The methodology adopted in the summer camp is the TMI (Think-Make-Improve) and the learning tools used were coding and educational robotics, which are suitable for preparing practical and motivating activities that can fuel interest and curiosity (Eguchi, 2010; Alimisis, 2013) and to ensure the involvement of those who experience a special educational need. As demonstrated by research conducted in this area (Resnick et al., 1996; Alimisis, 2009), robotics has entered not only rehabilitation contexts but also educational and school environments of all orders and grades, focusing each time on different perspectives: inclusive, interdisciplinary, specific to single subjects (Pennazio, 2018). In an educational context, robotics represents a new field of research which, inspired by the elaborations of the constructivist paradigm (Piaget & Inhelder, 1970), subsequently revisited by the constructionist approach of Papert (1980; 1992), considers robotic technologies as "objects-with-which-to-think" (Harel & Papert, 1991). The strong link with the narrative approach is the strength of educational robotic systems of this type. In such a structured "technological environment" sociality, shared work and the co-construction of knowledge are promoted (Ackermann, 2002; Pennazio, 2017).

The common thread of the summer camp, led by an astrophysics researcher, was space exploration. The activity consisted in organizing contents of different formats within a coherent system, supported by an open narrative structure, in order to create a story to be developed with Scratch. The participants, organized in groups, practiced the four macro-areas of coding, musical language, textual language, and graphic language. The last two days of camp were entirely dedicated to the assembly and programming of the educational robot Mbot, both affordable and easily accessible, through which it is possible to experiment with fundamental concepts related to the robotic exploration of planet Mars.

Skills developed in the project

In accordance with the recommendations indicated by the European Parliament (2006/962/CE) regarding the skills necessary to adapt flexibly to a world characterized by strong interconnection, the summer camp has tried to enhance some of the key skills defined in the reference framework. In particular:

1. *Communication in the mother tongue* – Communication in one's mother tongue is the ability to express and interpret concepts, thoughts, feelings, facts, and opinions in both oral and written form, as well as to interact creatively on a linguistic level in various contexts. During the two weeks, the students practiced both their oral and written communication skills, discussing the design choices, seeking, collecting and processing information, critically analyzing the reference texts, formulating arguments in a convincing and context-appropriate way, composing the screenplay of an opera and presenting the project to fellow students and teachers. As the context was that

of a summer camp, it was particularly easy to maintain a positive and serene attitude, with the exception of a couple of episodes, a critical and constructive dialogue.

2. *Communication in foreign languages* – Since most state-of-the-art information relating to the scientific topic in question is in English, the students practiced their oral and written comprehension skills through the analysis of information sources (primarily the scientific websites of the two government agencies ESA and NASA, or the English Wikipedia). While the majority decided to carry out the project in Italian, starting from translated content in English, some preferred to develop the project in English, with both audio and text contributions.

3. *Mathematical skills in science and technology* – Mathematical skills is the ability to develop and apply mathematical thinking to solve problems not only in the school environment but in any daily situation that requires it. As part of the digital storytelling with Scratch, moving and sizing objects on stage in order to create perspective effects involves the application of indexed mathematical formulas within programming cycles. In this case, mathematics combined with coding allows one to add three-dimensionality to the scene. The skills acquired in the scientific field – in particular relating to planet Mars and its exploration, introduced by the astrophysicist and independently examined in depth by the participants through research – allowed them to understand, represent and talk about phenomena that occur on the red planet (sandstorms, color of sunrises and sunsets, different movements with respect to the Earth due to the different gravity) as well as the appearance of some characteristic morphologies (canyons, craters, volcanoes, plateaus). Mathematical and scientific knowledge have been put into practice thanks to the skills in the technological field, through coding with Scratch, the use of specific tools to create new sprites and give voice (through audio content acquisition and manipulation software) to the programs, and through examples of educational robotics. By presenting realistic missions on the Martian surface – past, present and future – it was possible to contribute to student developing critical thinking to recognize the basic aspects of scientific investigation and to be able to communicate conclusions and reasoning.

4. *Digital skills* – Digital skills consist in knowing how to use information society technology with familiarity and a critical spirit. Participants used

computers to find, evaluate, produce, present, and exchange information. They did this using text editing applications, spreadsheets, image and sound editing applications, audio and video format converters, approaching new computer applications and exploring their functions and potential. They also used other electronic devices (microphones, video cameras, cell phones) to acquire audio and video material useful for the development of the story and the documentation of the project. With regard to the storage, management and use of information, the issue of source reliability was discussed in depth and the restrictions related to copyright in the use of content were presented, as well as the risks associated with the Internet. An attempt was made to promote awareness of how ITEs (information technology and equipment) can assist creativity and innovation, warning participants about the issues related to the validity and reliability of the available information and the legal and ethical principles that arise in its use.

5. *Learning to learn* – Learning to learn is the ability to persevere in learning, managing time and information effectively, both individually and in groups. The students had two weeks to think, develop and implement their project. Participants worked collaboratively, learning to seize the benefits that can come from a heterogeneous group. An attempt was made to help them organize their learning, independently assess their work and seek advice, information and support, both by addressing their peers from other groups and via the reference figures present in the classroom. Special emphasis was placed on always keeping a positive attitude, which includes motivation and confidence to persevere. Addressing problems in order to solve them is useful both to the learning process itself and to manage obstacles and change.

6. *Social skills* – Collaborating with peers in the implementation of the activities and projects, respecting the common rules and assimilating the sense and need for respect for civil coexistence, committing to completing the project work undertaken: these are the social skills that we tried to carry out in the various groups. The common basis of these skills includes the ability to communicate constructively in different environments, to manifest tolerance, to express and to understand different points of view. One should be able to handle stress and frustration and express them constructively, distinguishing between the personal and professional spheres. This has not always been the case, especially in some groups.

Think-Make-Improve methodology

According to the constructionist philosophy, people learn best when they are engaged in personally designing and building their artifacts by sharing them within a community because, by building an external object to reflect upon, they also feed their internal knowledge (Bers et al., 2002). The experience presented here is based on the Think-Make-Improve (TMI) methodology taken up by Martinez and Stager (2013), which allows one to reach the desired artifact starting from an idea and the search for the solution to all the problems that arise in the making. This method helps planning with a problem-solving approach and avoids proceeding towards the solution in a random fashion, but rather by reasoning before facing the problem and analyzing what has been done once the solution has been achieved. It starts with the contextualization of the challenge, the organization of the work and the start of the activity.

The students, organized in groups of up to six and as heterogeneous as possible, confront each other and eventually reach a shared solution. In this phase, they were granted plenty of time necessary to understand how to face the challenge, with support when needed to evaluate some aspects related to the feasibility and implementation difficulty of the proposed ideas. Next came the content preparation (images, texts, audio and video) and the program development, which takes place through mediation between the members of each group. Initially, the design is done on paper, through flowcharts and algorithms, and then moves on to the implementation of the code. Step by step, checking the functionality of the program leads to its improvement. Mistakes become ideas for redesign. At this stage, a reflective attitude allows one to recognize the error as an opportunity for improvement. By doing so, learning is authentic and there is a strengthening of motivation, persistence in the face of the challenge. The desire for experimentation grows because it becomes clear that, by experimenting and making mistakes, we learn and improve. Some more easily, some less, students learn to manage the frustration induced by seeing that what has been achieved does not always conform to the original idea. In this case, we start with the idea to rework the path.

The iterative design methodology can also be found in the words of John Dewey, initiator of pedagogical activism: «Once more, it is part of the educator's responsibility to see equally to two things: First, that the problem grows out of the conditions of the experience being had in the present and that it is within the range of the capacity of students; and, secondly, that it is such that it arouses in the learner an active quest for information and for production of new ideas. The new facts and new ideas thus obtained become the ground for further experiences in which new problems me presented. The process is a continuous spiral» (Dewey, 2014). This continuous spiral process is very similar to what is experienced daily in the world of scientific research.

If Dewey already talks about the laboratory activity as an activity where different phases follow one another – planning, action, experimentation, testing, feedback, adjustment, and then returning to action again – we find remarkable similarities with the thought process that Resnick (2007; 2018) used in his experiments at Lifelong Kindergarten: it is always a guided practical and cyclical process, where, in Resnick's case, the dimension of play and personal attitude is introduced (Di Stasio & Nulli, 2021). A playful dimension that has also been pursued in the summer camp.

Coding and Educational Robotics

Whereas the common thread of the summer camp is space exploration, the tool through which the participants were able to make their "journey" and develop their creativity is coding, a transversal discipline based on computational thinking. When you want to give life to an idea through coding, the concepts underlying that idea must be very clear to those who practice it, in order to be able to exhaustively define the steps (algorithms) to be performed by the programmable device. The programming exercise allows one to dig deeper – raising doubts, proposing solutions and investigating the possible paths that can be taken to reach the solution – and inevitably leads to a better understanding of the concepts themselves. In this context, Scratch is a very powerful tool. It is a visual programming environment, developed by the Lifelong Kindergarten research group at the Multimedia Lab of MIT in Boston, particularly suitable for teaching the basics of programming to students, even very young ones, to develop computational thinking and problem solving skills.

Organization of the summer camp

The summer camp took place during ten meetings lasting three hours each, for two weeks (30 hours in total). 18 male students and 12 female students from a lower secondary school participated. The participants were divided into groups, as heterogeneous as possible, of maximum six each. Each group defined the story to be developed, identifying the main characters and the setting on the red planet. The groups worked independently. During the entire duration of the summer camp, the four macro-areas of coding (development of the story), musical language (creation of the soundtrack with musical instruments), textual language (creation of dialogues and narration) and graphic language (creation and adaptation of sprites and backgrounds) were developed in each group. The researcher and tutor acted as facilitators of the learning process.

In order to provide a scientific background for the development of the adventures on the red planet, in the first meeting students were provided with basic astronomy concepts related to the solar system and Mars, including recent photographs and videos from NASA and ESA, and to the exploration of the planet (probes, landers and rovers of NASA and ESA, with particular reference to those that in the summer of 2018 were operational on the planet, Curiosity and Opportunity). A few possible missions to be developed were also presented: looking for past forms of life, building an environment in which one could live, growing vegetables, exploring cavities, looking for water underground, and leaving towards Earth. In the first meeting, the issue of source reliability and image copyright was dealt with in depth, which is fundamental when creating content intended for publication.

Digital Storytelling with Scratch

All participants had already used Scratch at school, already since primary school. Nevertheless, the basics of programming with Scratch were revised: interface and terminology of the working environment, execution of a single command and sequence of executions, loops, conditional constructs, variables and lists, operators, messages and timing of events, cloning, use of sounds and costumes. In addition, graphic elements useful for the creation of sprites and backgrounds were explored (such as the difference between bitmap and vector images, image resolution) and examples of digital storytelling with open structure Scratch were presented. Digital storytelling is a narrative created with digital tools that consists of organizing content of various formats (video, audio, images, texts, maps) in a coherent system, supported by a narrative structure, in order to obtain a story. Having defined the initial idea through a short description or a map, the students searched on the internet for the material necessary to investigate the topic of interest in depth. They wrote the story by defining the style of the narrative and translated the story into a script. Once this was done, they took care of collecting images and recording audio and video material. To do this, they were able to occupy various classrooms in the school, transforming them into recording studios. Next, they edited the material together using Scratch.

A description of some of the students' artifacts is reported, highlighting their peculiarities and strengths.

An encounter with the Curiosity rover

The group that developed this project was made up of four girls and two boys, who decided to tell the fantastic story of their encounter with the Curiosity rover, which has been exploring the Martian surface since 2012. Three scenes were represented. In the first one, the blue dawn rises on the red planet, gradually illuminating the rocky outcrops on the horizon. The Sun, much farther from Mars than it is from Earth, appears smaller in the sky than we see it from our planet. In the second scene the main characters of the story appear, obviously dressed in the classic spacesuit that allows extra-vehicular walks: four female astronauts, a male astronaut and the small rover, who tells them about its recent discovery of organic molecules on the planet. In the third scene, the explorers come across the remains of Schiaparelli, the ESA lander that failed its landing maneuver on 19 October 2016 and crashed on the Martian surface. Curiosity tells them the reasons that led to the mission's failure. All the images used (for backgrounds and sprites) are realistic and taken from the NASA and ESA websites. The dialogues were reported in the comics, as text, and reproduced as audio, obtained using a mobile phone sound recording application or directly with Scratch, in case the computer used was equipped with a microphone. The role of "Curiosity" was played by a dyslexic boy, who managed very well, and with great satisfaction, to give his voice to the robot. The soundtrack that accompanies the story, in the scenes without narration, is original, created during the hours of the summer camp on the piano by a boy who had a problem related to language, due to a hearing system damage. Only recently he had been able to hear normally, thanks to an external device, and his desire to devote himself almost entirely to the soundtrack (helped by another younger boy, from another group), as well as inserting it into the Scratch program, was seconded.

Storytelling through the map

The group that developed this project consisted of four young people who decided to accompany the user in the discovery of the red planet using an interactive map. The protagonist of the adventure is mBot, with a sprite specially created and equipped with multiple costumes. There are about twenty scenes available but they do not follow one another, as in the case of the previous project, but it is the user who chooses where to go. The story begins with a rocket that starts from Earth and arrives on Mars, reproducing the correct changing perspective. Once on Mars, mBot is released from the satellite and lands on the Martian surface. Subsequently, a map of Mars appears with ten points of interest visited by Curiosity: clicking on these, the main characters is projected onto the chosen location, with a change of background and the main character in the foreground, starting to describe the place through recorded audio. Images and descriptions are realistic, taken from the NASA website dedicated to Curiosity, suitably translated from English into Italian, and summarized by the students. The members of the group divided the places of interest and, once the texts were prepared and the audio contributions were recorded, they developed the code together. In one of the destinations of the project, they also set up a "pong" type game, to insert the playful dimension in their product.

A spy in space

The artifact was produced by two girls. It is a very articulated fantastic story, represented with extreme attention to detail. A researcher is presenting at a conference a mission devoted to the search for water on Mars. Already in this scene it is evident how the two authors paid attention to details, for example by changing the image on the "laptop sprite" at the same time as that projected on the "big screen sprite". After the explanation, the scene changes and moves to a shot of the rocket with the hatch open waiting for the astronauts to arrive. Before their entry, a small dog slips into the rocket and inside finds a robot that turns out to be a spy with the aim of finding out what humans are up to on the red planet. Once the astronauts have also arrived, the rocket closes its hatch and starts, after the countdown. In the next scene, footage of the Solar System planets appears and the voiceover explains why the robot wants to hijack the rocket towards Jupiter, away from humans from Mars. The story continues, until the dog and the robot end up becoming friends, although they will have to say goodbye because the dog prefers to return to Earth, while the robot wants to be dropped off on Mars. The soundtrack was composed by the two students using the electric piano and the mandolin. The creativity of the authors is impressive, as are the technical solutions that allowed them to implement the idea.

Digital storytelling with an open narrative structure

Also in this case, the story that is told is fantastic but, unlike the other examples of digital storytelling reported, its structure is open: the user can choose what to do and, based on his or her choice, the story takes different routes. The group that carried out this project preferred to use English, also for the audio content. From a technical point of view, the students were able to reproduce a sandstorm, a very common phenomenon on the planet Mars, using cloning.

Educational Robotics with mBot

Once the digital storytelling part was over, the last two days (therefore six hours) were entirely dedicated to educational robotics with the assembly of the mBot robot and its programming via mBlock (a programming environment based on Scratch). Each pair of students was given an mBot kit to assemble, following the instructions in the package. The groups assembled the robot in complete autonomy, in some cases asking for the collaboration of fellow students. It is worth noticing the great dexterity and skills of some students with specific learning disorders who, in addition to quickly assembling their robot, helped several other groups in the construction.

While still in the context of the exploration of planet Mars, the similarities between the little robot and Mars robots were discussed and various programming challenges were proposed with mBlock:

- to drive the mBot by turning on the two lights;
- to make the mBot stop at an obstacle, using the ultrasonic sensor;
- to make the mBot follow a path, thanks to the infrared sensor;
- to program the mBot to move autonomously.

To face these challenges, the students familiarized themselves with the sensors available in the mBot basic kit. The ultrasonic sensor – positioned in the robot's eyes (one eye is the ultrasound transmitter, the other is the receiver) – allows mBot to know the distance to the object in front of it, without touching it. The transmitter emits an ultrasonic signal that is reflected by the object and returns to the receiver. By measuring the interval between the instant the signal started and the instant the reflected one was received – knowing that sound propagates at a speed of about 344 meters per second (in air at room temperature) – the distance between the robot and the object can be calculated.

To follow a given path, such as a black line on a white background, mBot uses two infrared sensors located frontally and facing downwards. When the infrared radiation emitted by the transmitter reaches a white background, it is reflected and the sensor is able to detect it. When it hits the black line instead, it is absorbed and the sensor detects nothing. There are two sensors and four possible combinations, corresponding to four values returned by the line tracking sensor: once these are read, they allow the robot (the programmer) to decide which way to move in order to stay on the line.

The final challenge presented the students with the problem of remote control of a robot on Mars, linked to the fact that by sending a command from Earth, the robot will receive it only after several minutes. This is because Mars is 12.7 light minutes from the Sun (meaning that sunlight takes 12.7 minutes to reach Mars) while Earth is 8.3 light minutes from the Sun. Both planets revolve around the Sun at different speeds. So, depending on where the two planets are located relative to one another, mBot may have to wait a long time before receiving commands. Participants simulated the delay in receiving commands from mBot: the code is very similar to that used to drive mBot in the first challenge, the only difference being the need to wait for a "delay" before executing the command.

The students then experienced what it means for mBot to receive a command several seconds after the command was given. It became clear that it is not practicable to pilot the robot from Earth, because the control would not be timely: the robot would risk colliding with the obstacles it encounters along its path. The students thus understood that, in this case, it is essential to instruct the robot so that it can figure out for itself what to do when it encounters an obstacle. In other words, they need to program it, i.e. to create a code (very similar to the one created in the first challenges) and transfer it to its internal memory, so that it can execute the commands independent of us, even on Mars.

Evaluation

The project presented here was an opportunity for the participants to be active protagonists within the school community. The activities of the project, with a laboratory and operational style, worked on the motivation and involvement of the students, through strategies such as cooperative learning, moments of peer tutoring, enhancement of multiple intelligences and creativity, also thanks to the use of multimedia and digital tools. Students built new skills through an inductive process that tested new and previous skills. They understood that nothing important works the first time: the only way to do the right thing is to carefully observe what happened when it didn't work (Stager, 2006). An evaluation was conducted throughout the experience, in the least intrusive way possible, listening to the discussions within the various groups from aside and observing, without interfering, the artifacts take shape. At the end of the summer camp, the various groups presented their artifacts and were asked to evaluate the project and the experience (methodology, organization, content, learning) by highlighting strengths and weaknesses, always trying to keep criticism constructive. One of the major difficulties encountered was related to the relational aspects, rather than the technical and implementation aspects of the proposed challenges.

Conclusions

The learning outcome in a lab activity such as the one presented is determined by the planning and management methods of teachers and educators, who must know how to combine different aspects: an appropriate theoretical background, the skills of the people involved, the curriculum, and the organization of the learning environment. The synergy between the world of scientific research – in particular research linked to the development of technologies to observe the universe – and the school world has allowed us to complete this inclusive experience that managed to excite students and contributed significantly to developing computational thinking, team working, problem solving aptitude and digital skills, in a particularly interesting context involving the STEM disciplines: space exploration.

References

Ackermann E. (2002), "Ambienti di gioco programmabili: cos'è possibile per un bambino di quattro anni", *TD-Tecnologie Didattiche*, 27: 48-55.

Alimisis D. (2009), *Teacher Education on Robotics enhanced Constructivist Pedagogical Methods*, School of Pedagogical and Technological Education (ASPETE).

Alimisis D. (2013), "Educational robotics: Open questions and new challenges", *Themes in Science & Technology Education*, 6, 1: pp. 63-71.

Bers M.U., Ponte I., Juelich C., Viera A. and Schenker J. (2002), "Teachers as sesigners: Integrating robotics in early childhood education", *Information Technology in Childhood Education Annual*, 1: 123-145.

Dewey J. (1910), *How we think*, Prometheus Books, New York.

Di Stasio M. e Nulli G. (2021), *Interfacce tangibili per la didattica disciplinare del Primo Ciclo. Dalla sperimentazione alla formazione*, in *Interazione Bambini-Robot: riflessioni teoriche, risultati sperimentali, esperienze*, FrancoAngeli, Milano.

Eguchi A. (2010), *What is educational robotics? Theories behind it and practical implementation*, in Gibson D. and Dodge B., eds., *Proceedings of Society for Information Technology & Teacher Education International Conference 2010* (pp. 4006-4014), AACE, Chesapeake, VA.

Harel I. and Papert S. (1991), *Constructionism*, Ablex Publishing Corporation, New Jersey.

Martinez S.L. and Stanger G. (2013), *Invent tolLearn: Making, tinkering, and engineering in the classroom*, Constructing Modern Knowledge Press.

Papert S. (1980), *Mindstorms: Computers, children and powerful ideas*, Basic Books, New York.
Papert S. (1992), *The children's machine*, Basic Books, New York.
Pennazio V. (2017), "Social Robotic to help children with autism in the Interaction through imitation", *REM*, 9: 10-16, ISSN: 2037-0830.
Pennazio V. (2018), *Il laboratorio di robotica inclusiva nei percorsi di formazione di insegnanti ed educatori sociali*, in *Inclusione 3.0* (pp. 208-231), Franco Angeli, Milano.
Piaget J. e Inhelder B. (1970), *La psicologia del bambino*, Einaudi, Torino.
Resnick M. (2007), "Sowing the seeds for a more creative society", *Learning & Leading with Technology*, 35, 4: 18-22.
Resnick M. (2018), *Come i bambini. Immagina, crea, gioca e condividi. Coltivare la creatività con il Lifelong Kindergarten del MIT*, Erickson, Trento.
Resnick M., Martin F.G., Sargent R. and Silverman B. (1996), "Programmable bricks: Toys to think with", *IBM Systems Journal*, 35, 3-4: 443-452.
Stager G.S. (2006), *An investigation of Constructionism in the Maine Youth Center* (Ph.D.), The University of Melbourne, Melbourne.

When robotics helps to overcome barriers and grow up

by *Emanuela Scaioli*

I will describe a three-year experience of a girl affected by autistic spectrum, in our Robotic Lab at Secondary school.

She is involved in building and programming robots in team, projecting scientific activities and preparing robotic competitions.

She gradually overcomes isolation and hostility experienced in the classroom, promotes peer relationships in non-assessment context, engages emotionally and operationally in the group, and enhances potential and different skills.

Robotics Lab in the 1st Year

For Anne[3], with a severe autistic spectrum, a school in sixth grade is a trauma. She is repetitive and slow in the execution of gestures, rigid in her posture, habitual, and above all impatient of an environment that is unknown to her, too noisy, fast, unpredictable. Finding the keys to open the door of isolation and accompanying Anne to the exit are difficult challenges. One of the challenges of educating adolescents with autism spectrum disorders is to find activities that are interesting and engaging. In agreement with her family, teachers, and educators, the Educational Robotics Lab offers an opportunity for Anne to live a new experience with different classmates and teachers.

[3] Anne is an invented name.

The educational Robotics Laboratory (Fig. 1) promotes the participation of students in their own learning process. The aims are to create an active relationship with reality and favourite teamwork. Thus, students will reach a deeper understanding of digital and transverse skills.

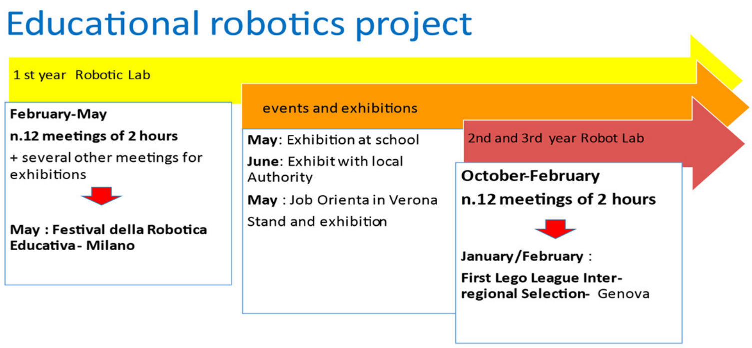


Fig. 1 - Educational robotics project

The window to the world of robotics opens up new frontiers, stimulates planning, collaborative work.

The creation of paths and participation in competitions brings out the continuous alternation of trial and error, developing the acceptance of error as a resource and its correction as a group achievement.

The proposal of the robotics activity can become an opportunity for integration, for the expression of different intelligences that, without evaluative pressures, express the best of themselves in playful way that makes explicit methods, aims, timing, and checks.

In Fig. 2 we can find the milestones of our Robotics Lab.

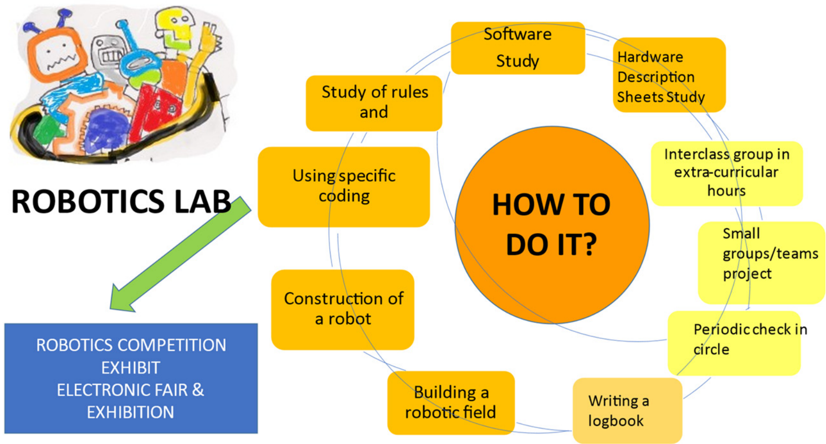


Fig. 2 - Milestones of our Robotics Lab

Anne redefines her perception of others and of herself, but, above all, she feels part of a group.

At first, she relies on adults, the programmed robots leave her indifferent. Then the change is coming day by day. Anne finds her role in her group as a graphic designer. The robotics laboratory becomes a place of emancipation. She begins to design, to confront herself, to build, or rather to reconstruct. Not only robots but her own identity.

Anne's products speak for themselves: the logos on the designed team T-shirt, the hanging posters, the requests to classmates for clarification, the critical and sometimes biting remarks, the slow but steady operational and emotional involvement.

Her family is involved too and always present. Anne takes part in competitions (FLL), with clear and close objectives. During the collaborative Bridge competition (Fig. 3) we decided to reduce the hours for the whole team not to make Anne suffer. Support teacher came with us. Our fears proved unfounded, especially when, back home on the train after a long day, we heard her running and to the worried parents: «Higher and higher… to infinity!».

Anne doesn't miss a robotics meeting and is a reference for her classmates. She keeps on drawing… «because», she says, «I don't get along well with computers, paper is better!».

Fig.3 - Collaborative Bridge competition in the 1st year

Robotics Lab in the 2nd Year

Anne attended the Robotics Lab with constancy, registering progress in socialisation. During the second year we suggested new goals with a scientific theme and related robotic games.

First Lego League is a worldwide competition for successive qualifications in science and robotics among teams of young people who design, build and program autonomous robots, applying them to real problems of great general, ecological, economic, social interest, to find innovative solutions.

F.L.L. combines a scientific research phase, a public communication of the results and a real robotics competition.

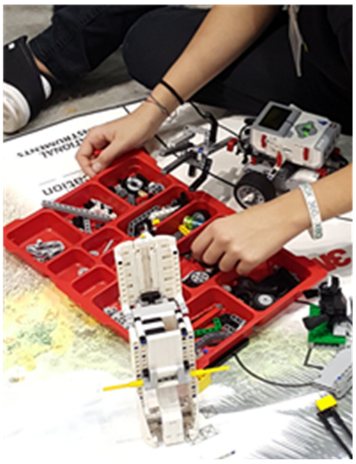


Fig.4 - F.L.L. Animal Allies competition - Building robots

Core Values is the most measured category in the 21st century skills (Usart, 2019).

The Core Values evaluation rubric contains the main skill areas, inspiration, teamwork and gracious professionalism. Inspiration is evaluated based on discovery, team spirit and integration, while teamwork is evaluated based on effectiveness, efficiency and kids do the work referring to appropriate balance between team responsibility and coach guidance.

Gracious professionalism is evaluated based on inclusion, respect and "coopertition" – spirit of friendly competition and cooperation with others.

In the FLL Animal Allies competition in seventh grade, Anne draws her fantastic pictures to prepare the Core Values poster on Inclusion. She chooses the parrot, «because», she says, «it gives a voice to those who don't have one».

Fig. 5 - Inclusion in Core Values Poster with a parrot and our robotics Team

There is constant contact with the support teacher and the educator. Each outing is planned with them and the route is calibrated to suit his ability to hold. The family is also involved. Anne participates without support in competitions (First Lego League), with clear goals and close in time.

Robotics Lab in the 3rd Year

Anne does not miss an appointment. The robotics experience improves her self-awareness, classroom relationships, and influences future school choice.

Programs like FIRST robotics will help any student have positive post-secondary outcomes due to its propensity to engage students ineducational activities as a part of a team (Fisher, 2019).

In Verona, at annual Job Orienta Fair, A., now an eighth grader, becomes the protagonist of the challenge with the public: *Make your robot dance*! by inviting the public to program a robot to make it dance.

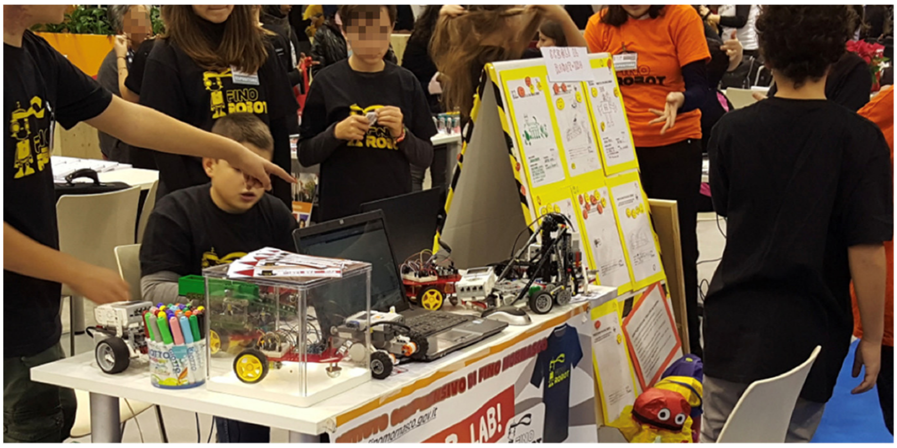


Fig. 6 - Job Orienta Fair and Dancing Robot Challenge

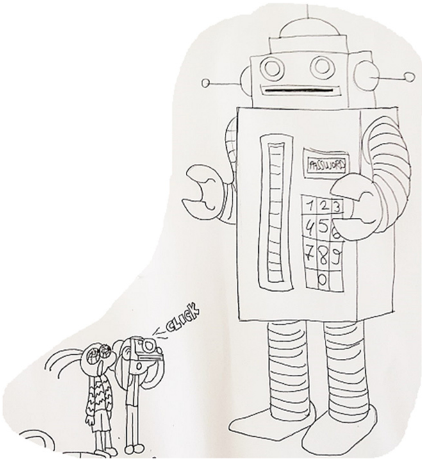
She draws herself on the board with the marker and signs "Draftsman". In the third year competition she gets to be spokesperson for the F.L.L. team on the science project Hydro Dynamics. «Me and my colleagues», Anne says to the jury. The barriers of isolation have finally fallen.

Fig. 7 - Robotic Team and Scientific Project during F.L.L. Hydro Dynamics Competition

The robotics experience improves her self-awareness, her relationships in class and influences her future choice of school.

Anne wants to leave a mark on the wall of the laboratory, before finishing the three years of secondary school: a big robot painted with her original and creative hand.

Fig. 8 - Anne's Project for our Lab wall



Conclusions

This experience seems to confirm that Robotics labs are a very strong instrument for teachers to inhance awareness and selfcare in children with authistic spectrum.

Relationship with robots and a new relation with companies in teams with strong core values and clear targets allow to overcome barriers and grow.

It is a long-term challenge, made of patience, continuous reflection and trials and errors, but it can be a success with confidence in parents, educators and school teachers.

References

Afari E. and Khine M.S. (2017), "Robotics as an Educational Tool: Impact of Lego Mindstorms", *International Journal of Information and Education Technology*. Available in: http://www.ijiet.org/show-88-1038-1.html

Benitti F.B.V. (2012), “Exploring the educational potential of robotics in schools: A systematic review”, *Computers & Education*, 58, 3: 978-988.
Cabibihan J.-J., Javed H., Ang Jr M. and Aljunied S.M. (2013), “Why robots? A survey on the roles and benefits of social robots for the therapy of children with autism”, *International Journal of Social Robotics*, 593-618. doi 10.1007/s12369-013-0202-2
Costa S., Santos C., Soares F., Ferreira M. and Moreira F. (2010), *Promoting interaction amongst autistic adolescents using robots*, in *Proceedings of the International Conference of the Engineering in Medicine and Biology Society (EMBC)* (pp. 3856-3859), IEEE.
Fisher K.M., Karin M., Gallegos B. and Bousfield T. (2019), *Students with autism spectrum disorders who participate in FIRST Robotics*, in *Proceedings of the Interdisciplinary STEM Teaching and Learning Conference*, vol. 3, article 5. doi: 10.20429/stem.2019.030105 https://digitalcommons.georgiasouthern.edu/stem_proceedings/vol3/iss1/5
Pennazio V., Fedeli L., Datteri E. e Crifaci G. (2020), “Robotica e mondi virtuali per lo sviluppo delle abilità sociali nei bambini con autismo: una riflessione metodologica”, *Sistemi Intelligenti*, 33: 1: 139-154. Available in: https://www.rivisteweb.it/doi/10.1422/96285
Pucciarelli M., Virgulti L., Farina E. and Datteri E. (2020), “Robot non umanoidi e non sociali per lo studio dell'attribuzione di intenzionalità in bambini con autismo”, *Sistemi Intelligenti*, 33, 1: 107-122. Available in: https://www.rivisteweb.it/doi/10.1422/96283
Usart M., Schina D., Esteve-Gonzalez V. and Gisbert M. (2019), *Are 21st Century Skills Evaluated in Robotics Competitions? The Case of First LEGO League Competition*, in *Proceedings of the 11th International Conference on Computer Supported Education* (pp. 445-452), CSEDU 2019.

The Authors

Daniela Bagattini, INDIRE.

Michele Baldassarre, University of Bari.

Eleonora Bilotta, University of Calabria, Rende (CZ).

Sonia Boldrini, IC “Don Gnocchi” San Colombano al Lambro (MI).

Lucia Campitiello, University of Salerno.

Valeria Cotza, University of Milano-Bicocca.

Gabriella D’Orsi, IC Ozzano Emilia (BO).

Edoardo Datteri, University of Milano-Bicocca.

Daniela Di Donato, Sapienza University of Rome.

Stefano Di Tore, University of Salerno.

Carmela Esposito, University of Milano-Bicocca.

Eleonora Farina, University of Milano-Bicocca.

Lorella Gabriele, University of Calabria, Rende (CZ).

Gabriel Lemkow-Tovias, University of Vic-University of Central Catalonia (UVic-UCC), Manresa, Spain.

Paola Mattioli, Fondazione Istituto Marymount, Rome.

Beatrice Miotti, INDIRE.

Monica Roncen, University of Milano-Bicocca.

Maura Sandri, INAF OAS Bologna.

Lia Daniela Sasanelli, University of Bari.

Emanuela Scaioli, IC Fino Mornasco (CO).

Matteo Schianchi, University of Milano-Bicocca.

Michele Domenico Todino, University of Salerno.

Serena Sabrina Vadalà, University of Milano-Bicocca.

Laura Zampini, University of Milano-Bicocca.

Luisa Zecca, University of Milano-Bicocca.

Media e tecnologie per la didattica
Open Access - diretta da P.C. Rivoltella, P.G. Rossi

Ultimi volumi pubblicati:

MARIO GIAMPAOLO, *Problem based learning on-line.* Modelli, strumenti e casi per lo sviluppo professionale (E-book).

GILDA BOZZI, EDOARDO DATTERI, LUISA ZECCA (a cura di), *Interazione bambini-robot.* Riflessioni teoriche, risultati sperimentali, esperienze (E-book).

HAGEN LEHMANN, *Social Robots for Enactive Didactics* (E-book).

FABIO NASCIMBENI, *Open Education.* Oer, mooc e pratiche didattiche aperte verso l'inclusione digitale educativa (E-book).

VALERIA PIRAS, MARIA CECILIA REYES, GUGLIELMO TRENTIN, *Come disegnare un corso online.* Criteri di progettazione didattica e della comunicazione (E-book).

GIUSI ANTONIA TOTO, *Expertise docente.* Teorie, modelli didattici e strumenti innovativi (E-book).

PAOLO FEDERIGHI, MARIA RANIERI, GIANFRANCO BANDINI (a cura di), *Digital scholarship tra ricerca e didattica.* Studi, ricerche, esperienze (E-book).

ALESSANDRO SORIANI, *Sottobanco.* L'influenza delle tecnologie sul clima di classe (E-book).

LAURA FEDELI, *La ricerca scientifica al tempo dei social media* (E-book).

PIER GIUSEPPE ROSSI, LORELLA GIANNANDREA (a cura di), *Technologies and trust* (E-book).

STEFANO DI TORE, *La tecnologia della parola.* Didattica inclusiva e lettura (E-book).

ROSARIA PACE, GIUSEPPINA RITA JOSE MANGIONE, PIERPAOLO LIMONE (a cura di), *Educazione e mondo del lavoro.* Figure di accompagnamento e potenzialità delle nuove tecnologie nei servizi di bilancio delle competenze e nell'orientamento professionale (E-book).

ROSARIA PACE, GIUSEPPINA RITA JOSE MANGIONE, PIERPAOLO LIMONE (a cura di), *Dimensione didattica, tecnologica e organizzativa.* La costruzione del processo di innovazione a scuola (E-book).

Media e tecnologie per la didattica
diretta da P.C. Rivoltella, P.G. Rossi

Ultimi volumi pubblicati:

PIER CESARE RIVOLTELLA, *La scala e il tempio.* Metodi e strumenti per costruire Comunità con le Tecnologie (disponibile anche in e-book).

CHIARA PANCIROLI (a cura di), *Animazione digitale per la didattica.*

LAURA CORAZZA, *Apprendere con i video digitali.* Per una formazione online aperta a tutti.

DIANA LAURILLARD, *Insegnamento come scienza della progettazione.* Costruire modelli pedagogici per apprendere con le tecnologie (disponibile anche in e-book).

LUCA FERRARI, *Il digitale a scuola.* Per una implementazione sostenibile (disponibile anche in e-book).

LAURA FEDELI, *Embodiment e mondi virtuali.* Implicazioni didattiche (disponibile anche in e-book).

CRISTINA GAGGIOLI, *La classe oltre le mura.* Gamificare per includere.

PIER GIUSEPPE ROSSI, MAILA PENTUCCI, *Progettazione come azione simulata.* Didattica dei processi e degli eco-sistemi (disponibile anche in e-book).

FILIPPO BRUNI, ANDREA GARAVAGLIA, LIVIA PETTI (a cura di), *Media education in Italia.* Oggetti e ambiti della formazione (disponibile anche in e-book).

VITTORIO MIDORO (a cura di), *La scuola ai tempi del digitale.* Istruzioni per costruire una scuola nuova (disponibile anche in e-book).

GIANMARIA OTTOLINI, PIER CESARE RIVOLTELLA (a cura di), *Il tunnel e il kayak.* Teoria e metodo della peer & media education (disponibile anche in e-book).

CHIARA LAICI, *Il feedback come pratica trasformativa nella didattica universitaria* (E-book).

PIER CESARE RIVOLTELLA (a cura di), *Smart future.* Teaching, Digital Media and Inclusion (E-book).

PIER CESARE RIVOLTELLA (a cura di), *Smart Future.* Didattica, media digitali e inclusione (disponibile anche in e-book).