MiRo-E at the Scuola Audiofonetica di Brescia - Exploratory analysis for an inclusive approach

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Abstract

The work presented in this paper is part of a collaboration between the *Scuola Audiofonetica di Brescia* and the Department of Human and Social Sciences of the University of Bergamo. It describes the introduction of an educational robotic platform, MiRo-E, into a school lessons that include students with hearing disabilities, specific learning disabilities and other special educational needs. The paper will give an introduction to the rationale behind the project and will describe the first exploratory results based on an initial qualitative evaluation.

Keywords

Educational Robotics, Inclusion, MiRo-E, Hearing Disabilities

1. Introduction

In the last two decades more and more educational robotic applications have emerged firmly placing social robots in the realm of effective tools for didactics (Belpaeme et al., 2018). Specific attention in this context has been paid to didactic approaches that promote the inclusion of children with special needs. The proposed solutions range from applications that facilitate the classroom attendance of children with physical impairments (Weibel et al., 2020) to robot-assisted therapy for children with various levels of Autism Spectrum Disorder (Cao et al., 2019).

The work presented here is part of a collaboration between the *Scuola Audiofonetica di Brescia* (hereafter SAB) and the Department of Human and Social Sciences of the University of Bergamo, within the framework of the three-year project "For ALL: Accessibility, Languages, Learning". The topics of this project are inclusive technologies (Lazzari, 2017) and the application of the principles of Universal Design for Learning (Rose et al., 2002) in the production of accessible teaching materials, which also includes interventions based on robotics and coding, for the design and implementation of laboratories for Science, Technology, Engineering, Arts and Mathematics (hereafter STEAM) education (Martín-Páez et al., 2019) in the first-grade secondary school *(scuola secondaria di primo grado*), and the introduction of coding and educational robotics in activities in nursery and primary school.

The objectives of the research presented in this paper are: (1) an increase in the use of technology in teaching practice through the implementation of robots and principles of computational thinking; (2) the development of digital competences for children in accordance with the European Union competences classified in the current DigCompEdu document (The Digital Competence Framework for Citizens); (3) the inclusion of students with disabilities in educational robotics activities (Lehmann, 2020), both to support logical-mathematical learning and to promote prosocial behavior and communication through the use of social robots as mediators (Besio et al., 2022); and (4) the improvement and extension of the content and experiences of the *Cognitive-Operational Education laboratory* approach *(Laboratorio di Educazione Cognitivistico-Operazionale)*, which is a didactic approach developed specifically for the inclusion of children with hearing disabilities at the SAB.

On a practical level, the aim, in collaboration with the teachers at the school, is to examine what methods and practices can promote the integration of digital technologies and robotics in concrete educational settings (e.g. computer science lessons), to study the effects of the robotic interventions via a structured experimental approach, and the creation of evaluation tools that can help to enhance coding and robotics-focused teaching.

In our work we use the MiRo-E robot, a platform developed by *Consequential Robotics* (www.miro-e.com) specifically for different educational contexts. MiRo-E has different sensors and actuators that enable it to communicate non-verbally and express simple emotional states via movements, and acoustic and visual stimuli. It can interact with its environment to a certain extent autonomously, based on the input of its sensors, or it can be controlled either directly via remote control or together with a dedicated software development environment called MiroCode. This software environment allows teachers and children to write simple programs in a block-based programming language on a workstation and then test these programs on the robot. Another important feature of the MiRo-E ecology is MiRoCloud, a dedicated software that allows teachers to easily assign groups of students access to the programming environment and in this to facilitate group work.

As mentioned above, the partner institute for this project is the *SAB*. This school follows an inclusive approach for children with hearing disabilities. It is also the focal point of the development of the *Cognitive-Operational Education laboratory* didactics approach *(laboratorio di Educazione Cognitivistico-Operazionale)* (Scattorelli and Taraschi, 2014), which is based on constructivist principles (Piaget, 1954) and encourages children to learn abstract logical-mathematical concepts via movements and actions. The background of the school gives us the possibility to test the robot not only in inclusion scenarios with children of different age groups but also to experiment with different didactic scenarios. The robot is currently used in the first-grade secondary school *(scuola secondaria di primo grado*), but we plan to use it also in nursery school *(scuola dell'infanzia)* and in primary school *(scuola primaria)* in the next scholastic year. The design of the interaction scenarios is tailored to the curricular requirements of the school and the needs of the children in their specific age groups. Most of the work discussed in this paper is concerned with the development stage of the robots implementation and based on exploratory instructional sessions with the teacher at the school. We will start by describing the specificities of the *SAB* and the *Cognitive-Operational Education laboratory* approach *(laboratorio di Educazione Cognitivistico-Operazionale),* of which the school is the proponent. In the second part we will describe our methodology, including an overview of the robot and the specific scenarios we are using in class. After this we will present some preliminary results based on an exploratory qualitative approach, in which we used the Metaplan method (Schnelle, 1979) to evaluate the initial attitude of the teachers towards robots. At the end we will discuss future plans and research directions.

2. Context

2.1. The Scuola Audiofonetica di Brescia

The *SAB* is a private institute, managed by the *Fondazione Bresciana per l'Educazione Mons. Giuseppe Cavalieri*, which in the current school year 2023/24 houses 582 pupils aged between 1 and 13 (from nursery to lower secondary school). This number includes 85 children with certified disabilities (62 with prevalent hearing impairments; 23 with other cognitive and learning disabilities). Approximately 26 percent of the deaf students have other associated disabilities and 45 percent come from families of non-Italian origin, which further increases the complexity of the teaching and other associated educational activities. All pupils with disabilities are integrated in ordinary classes, which makes the school a project of Italian national importance in which specialized teaching for deaf students is integrated with general teaching interventions. The school adopts a didactic approach that is driven by experiments in collaboration with the Cedisma center (Centre for Studies on Disability and Marginality) of the Catholic University of the Sacred Heart (Folci, 2020).

The teachers at the *SAB* use personalized teaching-learning processes in classes of 18-24 students, including students with certified disabilities, specific learning disabilities and other special educational needs. To be able to support this complex teaching responsibility, the school has an increased number of teachers and staff, which allows it to make teaching flexible and to personalize interventions. In the current scholastic year 2023-2024, 90 teachers, 8 communication assistants and 24 educators are employed by the school. Working alongside the teachers are a director, three coordinators, a contact person for inclusion and a school psychologist, five speech therapists (for deaf students), an audiologist/speech therapist and an audiometry specialist. The workshops (musical, cognitive-operational, artistic), as well as the flexible teaching methods tailored to small groups, allow for the creation of inclusive teaching that enhances differences and responds to the specific needs of students with disabilities (Scuola Audiofonetica, 2020).

2.2. The Cognitive-Operational Education Laboratory approach

The *Cognitive-Operational Education laboratory* was developed in the *SAB* in the early 1980s, as a result of research based on the observation of the learning strategies of children with hearing impairments, and on the need to propose inclusive teaching activities that strengthen their cognitive abilities in order to overcome the linguistic difficulties linked to more formal approaches in the study of mathematics and logic. The theoretical and practical framework, as well as the first experiments, were established by Pea et al. (Pea, 1987). This early work strongly supported the importance of physical-sensory and concrete experience in learning of topological concepts and in the understanding of spatial and temporal relationships, often difficult to acquire in the early years of nursery and primary school, in particular for deaf students or those with delays in language development.

The activities within the laboratory are offered to all children, deaf and hearing, in a dedicated and specially equipped space, which is large and free of traditional school furniture, so as to allow free movement. Wooden materials (e.g. numbers, letters, circles on the ground, etc.), objects specially arranged for orientation in space activities and reading/formalization of actions, mattresses, musical instruments and other structurally altered materials constitute the setting of the laboratory space.

The children are progressively accompanied on educational paths that develops in three phases:

Phase 1. Experiential phase in which reality is conceptualized via the body;

Phase 2. Symbolic phase in which the concepts become symbols and reality is codified through multiple representations (visual, auditory, tactile);

Phase 3. Abstraction phase in which the child conceptualizes what s/he has experienced.

According to this approach physical experience is fundamental for the development of personal identity and the cognitive processes that underlie logical-mathematical and spatial-temporal competences (LeBoulch, 1993), furthermore the child needs to be placed in a position to experiment, self-evaluate and correct herself in all phases of the process, experiencing errors as an integral part of the learning process.

Through movement, motor act and action, the student plans sequences of movements aimed at a purpose, deciding if and when to implement them, perceives and structures the body scheme, consolidates space-time orientation, attention, short- and long-term memory; develops logic, imagination and creativity, exercises fine motor skills, executive functions and strengthens social skills.

The approach underlying the *Cognitive-Operational Education laboratory* of the *SAB* has strong theoretical and practical connections with the didactic approach of Seymour Papert (Papert, 1993). Both approaches focus on the prevalence of the physical dimension in the exploration of reality, the use of the body in space, and the active role of the child as protagonist in the learning process. For these same reasons it is easy to find significant correspondences with the most modem practices of unplugged coding and the embodied approach in STEAM learning: in this sense the school experience can be enhanced in the construction of a teaching framework consistent with the proposal of coding and educational robotics activities (Lehmann, 2020).

3. Method

3.1. Robotic Platform MiRo-E

From the beginning of the project, it was clear that a robotic platform was needed that can be adapted to the specificities of the inclusive approach of the *SAB* and to the needs of the different age groups that are involved in the project. Concretely that meant a robot that can express itself with nonverbal signals, such as differently colored lights and intuitively interpretable movements, and that has software which allows for the teaching of basic programming principles.

Considering the particular context situation, characterized by the presence of numerous pupils with disabilities and the notable age difference between the pupils receiving the intervention (from 3 to 13 years), a robot with social robotic characteristics was chosen, one that could be integrated into diverse educational contexts, and that would give both teachers and older children the opportunity to experiment with simple programming environments. Taking these points into consideration the decision was made for MiRo-E, a robotics platform developed by Consequential Robotics in collaboration with the University of Sheffield, UK.

MiRo-E is equipped with several sensors and actuators that allow it to express simple emotional states through movements and acoustic or visual signals. It can be controlled directly via remote control or it can be used in association with a dedicated development environment (MiroCode), which allows children to write simple programs in a block programming language (Blackly and Python) and test them in a 3D simulator before running them on the robot. MiRoCode allows for a variety of different didactic applications ranging from informatics to geometry.

Figure 1: MiRo-E developed by Consequential Robotics

The social characteristics of MiRo-E enable us to use it to encourage collaborative working and to facilitate social communication skills. These elements are an essential part of computational thinking competencies, which are crucial for future generations, so that they can face an increasingly digital world not as passive and unaware consumers of technologies and services, but as active participants in the development of these technologies (DigCompEdu, 2023).

3.2. Initial Evaluation -Attitude towards robots

In order to evaluate on one hand the attitude of the teachers towards digital technologies and robots in education prior to the start of the implementation of MiRo-E, and on the other hand the knowledge and perception of the children about robots we used the Metaplan® method with 20 teachers and with the students of classes involved in the pilot phase of the experiment (99 in total, attending two classes of primary school and three classes of secondary school).

The Metaplan® method (Schnelle, 1979) is a well-established evaluation approach that facilitates communication and social dynamics within a group of participants discussing a specific topic. It is used to classify and categorize problem dimensions and to weigh the importance of these problem dimensions from the perspective of the topic in question based on the responses of the participants. The strength of this approach is that it uses visualizations of the results of consecutive brainstorming sessions in order to reinforce discussions between participants to find categorizations that have the smallest degree of redundancy. During the brainstorming sessions each participant writes down keywords or makes small drawings illustrating their opinion on e.g. post-it notes. These post-it notes are then presented to everyone on a large whiteboard without necessarily making the creator's identity explicit and without creating hierarchies of greater or lesser value between the ideas. From the collection of all the posts, the non-predefined macro-categories that best describe the different ideas that emerged are then identified - with a comparison between participants and under the guidance of the researcher.

4. Results of initial evaluations

4.1. Results from the teacher group

Training meetings were organized for a selected group of teachers (20 teachers in total) from kindergarten, primary and lower secondary schools. The group was formed by bringing together science teachers with previous experience in teaching coding, with teachers that are directly involved in the application of activities within the *cognitive-operational education laboratory* of the *SAB*.

The objective was to discuss the application of educational technologies and social robots in education, with a specific focus on the importance of developing digital competence and a responsible use of digital technologies by students, the opportunity to facilitate inclusive teaching formats and the need to design (and implement) a digital curriculum. During the training, the teachers were introduced to the ministerial lines on computational thinking and digital competences, and to the potential of robotics in reinforcing these competences.

The group, heterogeneous in terms of training, age, professional experience and ability to use IT tools, immediately demonstrated different levels of interest and sharing in the integration of robots in teaching activities, from the enthusiasm for a new line of work, to the concern of lack of competence, up to the refusal to interact with artificial systems. However, even those who showed a resistance to work with robots still took part in the subsequent demonstration session with MiRo-E and participated in the brainstorming, with the Metaplan® method (Schnelle, 1979), aimed at identifying possible scenarios for the introduction of the robot in the classroom of the different age groups.

The core question for the teachers was: "In which concrete scenario do you think this robot could be used in your classroom?".

From the responses of the twenty teachers involved it was possible to identify two groups, with group (a) being more focused on didactic objectives, and group (b) being more oriented towards the concrete classroom settings.

The responses of group (a) can be summarized into three categories:

1. Use of the robot and programming environments to propose teaching activities relating to topological concepts and spatial relationships (Kindergarten and Primary School);
2. Use of the robot and programming environments to facilitate the development of logical-mathematical skills (Primary and Secondary School);
3. Use of the robot and programming environments to encourage the development of social skills.

Regarding the responses of group (b), the idea of working in a small group or with a 1:1 ratio in complex disability situations and in dedicated environments was found to be prevalent; furthermore, some teachers spontaneously highlighted the connections of content and context between the coding and robotics activities and those characterizing the school's cognitive-operational laboratory.

4.2. Results from the student group

After having carried out the training for teachers concerning the basic characteristics of MiRo-E and the MiroCode programming environment, we decided to involve students in pilot classes, to reassure the teachers about the easiness to integrate the robot into the classroom and to offer them opportunities to observe interaction dynamics. These pilot classes involved 99 students from the fifth grade primary and first-grade secondary classes of the school in a demonstration session with the robot and a discussion starting from the stimulus question «What is a robot?», from which reflections emerged on the subject of artificial intelligence, mind-body relationship, social and emotional dimensions, and current and future applications of robots in everyday life.

Also in this case the Metaplan® method was used to facilitate the sharing of ideas within groups homogeneous in age, but heterogeneous in experience, interests, and predisposition to the use of information technologies.

In particular, demonstration and brainstorming sessions were conducted with two primary school groups (45 pupils, including 4 with hearing disabilities and 3 with other disabilities, average age 9 years) and three secondary school groups (54 pupils, including 7 with hearing disabilities and 4 with other disabilities, average age 12 years). Disabilities other than deafness included mild intellectual disability, verbal dyspraxia, Down syndrome, mixed developmental disorder; and children with a Personalized Educational Plan (PDP) for specific learning disabilities or other special educational needs.

From the brainstorming with the students it was possible to identify 7 categories to represent the opinions of the children in response to the stimulus question "What is a robot?":

1. A robot is a form of Artificial Intelligence;
2. A robot is an object with human or animal features;
3. A robot is a useful tool for people with disabilities, who are ill or who need assistance;
4. A robot is an object "to be controlled" (interesting to note the choice of terms attributable to video games and electronic games);
5. A robot is something that will work for us or instead of us in the future;
6. A robot is an object that feels emotions;
7. A robot could be our friend in the future, a companion against loneliness.

From the students' answers it becomes clear that the idea of robots is already a part of the imagination - and in some cases also of the experience - of children of this age group, while Artificial Intelligence is more in their vocabulary than in the reality and knowledge of its meaning or implications.

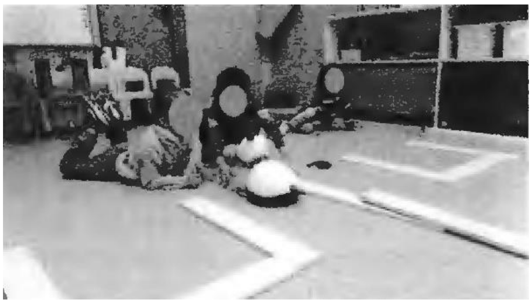

Figure 2: MiRo-E at the Scuola Audiofonetica di Brescia

The social dimension recognized in the robots and the projection of emotions onto technological artefacts points to the necessity to work with the teachers not only from a didactic perspective, but also from an educational perspective to address the underlying ethical issues.

5. Conclusions

The result of this first exploratory qualitative analysis points the future work of the project in at least two directions:

1) to valorize the students' potential in the inclusive approach that characterizes the mission of the *SAB* (area 5 of the DigCompEdu framework - 5.1 accessibility and inclusion; 5.2 differentiation and personalization; 5.3 active participation);

2) to support the development of the students' digital skills by helping them to use digital technologies creatively and responsibly (area 6 DigCompEdu),

The challenge lies in defining a setting in which coding activities are perceived by teachers and students as an opportunity to develop computational and critical thinking, where hypotheses, experimentation, observation and verification are the basis of a laboratory approach for discovery, and where programming is understood as a form of expressive-creative language, whether it takes place without the use of computers, through body movements, or whether it takes place on dedicated platforms or with a robot as a mediator. In this sense it is necessary to overcome the logic that sees the humanistic disciplines separated from the natural sciences, or that attributes responsibility for the planning and implementation of STEAM-oriented activities only to teachers of mathematics and natural sciences.

6. Future work

The MiRo-E robots will be implemented on a weekly basis during lessons starting from September 2023 in three different age groups. This process will be closely monitored with the help of different qualitative measures, evaluating the experience and impact of the use of the robot on the attitude and competences of both the teachers and the students.

In the first age group will be children in nursery school *(scuola dell 'infanzia)* from 3 to 6 years of age. The approach here will be the enactive robot-assisted didactics approach (Rossi, 2011; Lehmann, 2020) with the main function of the robot being a social mediator and a focal point for shared attention. This will be achieved via different types of group activities and interaction games in which the robot will be controlled remotely by the teacher.

The second group will consist of children in primary school *(scuola primaria)* from 6 to 11 years of age. In this age group, the approach will be the *"laboratorio di educazione operazionale"*, using the robot in different physical activities. In these activities, the robot will take on different roles. For the definition of these roles, the classification described by Belpaeme et al. (Belpaeme et al., 2018) will be followed. According to their classification, the most common roles a social robot can assume in educational contexts are the roles of novice, peer and tutor. For the activities at the *SAB*, this means that the robot will solve specific physical tasks, defined by the affordances of the classroom, together with a group of children in such a way that it either pretends to need help, motivates the children to do a task together, or gives instructions to the children. Similar to the previous group also in this group the robot will be controlled remotely.

The third age group will be children in first-grade secondary school *(scuola secondaria di primo grado)* from 11 to 14 years of age. For these children, the

MiRo-E will be used as a tool for STEAM education. The children will use MiRoCode to write small programs during informatics lessons. The topic of these programs will be decided by the teacher, based on the necessities of the school curriculum. After finishing their programs in MiRoCode the students will be able to test them on MiRo-E in the beginning of the following lesson.

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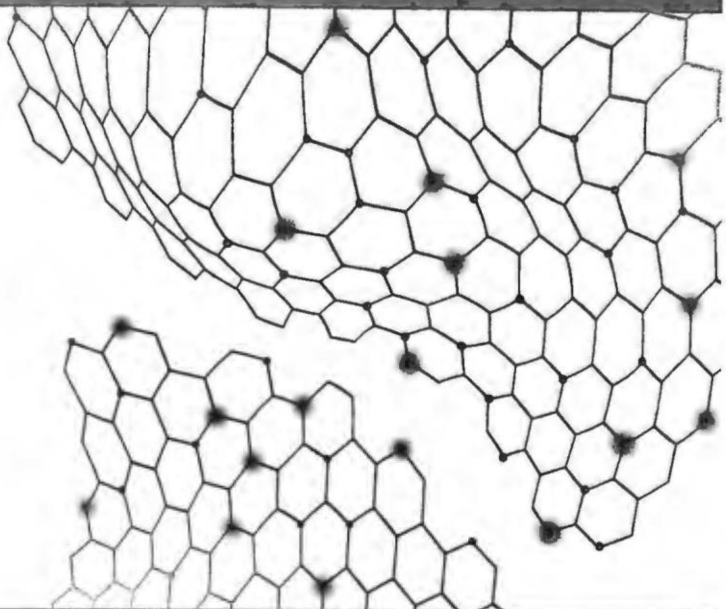
Child-Robot Interaction

Methods, Epistemology, Applications



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