Robotics@Montserrat: A case of Learning through robotics community in a school

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Abstract

Nowadays is well known that the learning of STEM (science, technology, engineering, and mathematics) can benefit from using Robotics technologies. Furthermore, robot-based educational activities can enhance not only the acquirement of concepts in other fields (e.g. literature, history) but even improve children emotional and social development. This paper describes how robotics has been introduced transversally at all k12 level in the school Montserrat in Barcelona, Spain. The infrastructure to support the program, the planning of the activities and research studies, a classification of these activities based on the children-robot interaction modality, and the details of some examples are described and discussed.

Author Keywords

Children; Robotics; Education; Learning; Engineering

ACM Classification Keywords

I.2.9. [Robotics]: Commercial robots and applications; D.2.2. [Design Tools and Techniques]: User interfaces.

Introduction

The use of robotics in education has traditionally been associated with teaching STEM or MINT (mathematics, information sciences, natural sciences, and technology). However, in early childhood education, technology can be
also applied to help children’s emotional and social development. Several studies point out that to educate people through interaction with robots add extra possibilities to the traditional approach focused on robot construction and programming. The main assumption in this approach is that interaction with robots can reinforce educative processes and outcomes such as conceptual learning and cognitive training, motivate students, support inquiry and raise awareness about robotics. The potential of robot-based activities in the scholar curriculum is based on constructionism. This educational approach proposes that computing technologies as well as tangible manipulative ones such as robotics, are powerful for educational purposes when used for supporting the design, the construction, and the programming of personally and epistemologically meaningful projects [1, 2]. From a constructionist perspective, there is a continuum of learning opportunities that extends from blocks to robots by engaging children in learning by design, learning by building, and learning by programming.

Robotics introduce a wonderful dimension to the learning experience because computational power is located not (only) on a screen but also on tangible objects. Learning through robotics enhances children engagement in activities based on manipulation, developing motor skills, hand-eye coordination and a way to understand abstract ideas. Moreover, robot-based activities provide an appropriate context for cooperative behaviour and teamwork. Literature reports valuable outcomes of technology-based educational programs such as (1) competence in intellectual endeavours; acquisition of computer literacy and technological fluency; (2) self-confidence in dealing with technical concepts and problems; (3) collaboration and cooperation competences; (4) use of technology for social purposes with peers and adults creating face-to-face or virtual communities and support networks; (5) awareness of their own personal values and respect of others, responsible use of technology; and (6) new ideas to apply technology to improve our environment (the school, the community, the society). As far as we know from literature, there has been two different approaches to introduce robotics in curricula, the first one emerges from the research labs and is transferred to school, the other one are limited (in time and scope) experiences in the field [3, 4].

This paper introduces the basics, fundamentals and first results of a new approach. Based on previous experience in applied research in the wild [5, 11], the goal of our project is to create an engaging dynamic learning environment (Living-Lab) in a primary and secondary school in Barcelona (Col.legi Montserrat), based on the principles of learning through robotics to enhance children, teachers and researchers achievements on updated scientific knowledge (technology, science and arts), research skills (curiosity, critical thinking, self-efficacy, teamwork, creativity, perseverance) and pro-social values and behaviours (like for diversity, respect, cooperation, inclusion).

The Environment
The Col.legi Montserrat [6] was founded in 1926, has a dynamic and global educational project, open to change and innovation that creates the perfect environment to run a project like the one introduced in this work. The key of the educational system is the attention to the multiple intelligence and to the diversity inspired in the works of pedagogues, psychologists and theorists of education like Decroly, Montessori, Malaguzzi, Piaget, Dewey, David Perkins, Robert Swartz, Howard Gardner, G Mills E. Bono, Heidi Andrade, E. Stephanakis, and Helen Barrett. The
school covers education from kindergarten to high school.

This Living Lab is managed by the Robotics Lab [7] that provides a complementary space (mainly the activities are run in the regular class-rooms), the robotic tools, the connection with the University Labs and the researchers, the connection with the products companies, and the human resources divided in manage area and academic section. At this moment, the early beginning of the project, the Robotics lab personal is composed by one persona with full-time dedication that manage both: space and materials, and academic contents.

The Robotic Activities
The Robotic activities are structured and planned correlated with the regular subjects that already exists in the school. For each novel activity is designed a pre and post test to answer the research questions: 1) A Understand and model the Game/activity dynamics and their potential to facilitate children learning process, 2) Observation of the engagement with the activity and emergence of intended behaviours, 3) Study how the introduction of such activity affects the rest of staff of the school, and 4) Create an exportable model applicable to other centers.

After setting up the activities the results will be analysed in terms of success in acquiring the academic items to learn (cognitive and affective characteristics of such learning process), the characteristics of robotic environments, and the engagement of the children during the activities. Finally, these activities are collected and reported in order to be applied in other centers, as long as a guideline to introduce all this teaching methods in a non-invasive way.

We can classify the robotic activities in three groups according to the following robot to child interaction models: 1) Designing Robots, 2) Use the robot as a facilitator, or 3) Use the robots as social partners (classmate, teacher, etc.). These three uses represents a transition of the robot from an object to a subject.

**Designing Robots**
This mode consist in using a robotic platform as LEGO Robotics System, Arduino, or similar, to solve a challenge introduced by the teacher. In this case the kids learn the concepts through the so called learning by building. The students need to have a previous knowledge about what is a robot in terms of sensing, processing, and actuating. From this point they need to know how a robotic system can be used to create an interactive tool that allows to prove, acquire or reproduce the previous mentioned challenge.

**Land-mine Robot Project**
Under the background of learn social core values through Design Thinking techniques, the teachers decided the topic about land mines. Following the Design Thinking rules, up to 10 groups of 6 children were made. The groups chose a country where that problem was relevant, design over paper a potential solution to avoid land mines, design a digital prototype on computers using LEGO Designer tool, built the prototype using LEGO Robotics and NXT-G Software and finally they test it. The results were presented in public and the evaluation was a peer review.

**Robot as facilitator**
It this case the use of the robot is based in the influence of a social presence to facilitate to perform complex or new tasks [8]. Previous studies we did in the field of Play-based Social training with Autistic Children provided good results [9, 10].
Good Habits Project
We planned an activity to teach healthy habits with this robotic platform. There were 4 robots for each group of 4 kids.

The robot is an iPod Touch 4G with a software structure composed of three main blocks: 1) The Pet Behavior module that decides the mood and physical state of the robot, 2) The Monitor module that collects all interaction data and the activities scores, and 3) The Trainer module, composed of the activity dispatcher, the connectivity module, and the activities controller. The secondary CPU is a LEGO Brick CPU that manages the movements of the robot.

The activities in the monitor module follow a specific sequence defined by the technician previously. Finally, when the activities are finished the process goes to the Feed the robot view where different dishes are shown (pasta, vegetables, fast food, etc.) to let the kid feed the robot. Depending on how the kids feed it, the robot starts moving slowly (trashy food) or faster (healthy food). Also, an image of a man on the iPod screen is shown to let the kid see if it is getting fat or slim. It is all about to rehearse healthy habits.

Robots as social partners
This third way of interaction is the most complex one, where the robot has the highest level of autonomy, and it performs the role of partner (coach, assistant, companion). In one of the examples is a personal companion to help doing homework at home, while in the second one is a teacher assistant giving some directions to the students.

Long-term engagement
We are doing a study based in [11] with a group of 46 children, all of them using the same platform explained before, but half of them have a customized robot with their topics of interest collected from a questionnaire filled in by the parents, which asked about hobbies, language preference (Spanish or Catalan), music, etc. The students receive a training session about using the robot, as well as a short manual about how to proceed to start and stop the robot, and to solve the common unexpected issues that could occur. This process takes one week where they do the exercises together with a technician. The weeks 2, 3 and 4 they do the activities at home. The aim of the study is to find an evidence that the customization of a robot increases the engagement interacting with it.

Robotic Teacher Assistant
During the background of the 2013 European Robotics Week, we organize a Robotics Workshop where students learn about the fundamentals of Robotics and Artificial Intelligence in three blocks: 1) using hexobugs the children could understand the concepts of sensing and acting, 2) using LEGO Robotics the concept of process information acquired and act, and 3) through PLEO Robot how artificial emotions can be implemented in a Robot.

During the 1 hour long workshop the REEM Robot from PAL Robotics were assisting the teacher introducing the activities and solving the most common questions about the three blocks explained (Fig. 1). In this case we wanted to measure the social present of the robot compared to the human teacher.

Conclusions and Future Directions
In the introduction of robotics to the school we have considered the two approaches of educational robotics: a
Robot considered as a complex and fascinating object that allows to understand the world we live in a very interactive and attractive way (maths, physics, materials, technology, language, etc.) and as a social actor, which achieves its educational objectives through its social dimension.

During the implementation of the project we have faced the three phases of being introduced to something new by teachers and students: Scepticism, Curiosity, and Acceptance. The fact that teachers were not required to have any special training or extra work by using robotics in their classrooms has empowered the positive perception of Robotics. In addition, a change of attitude have been observed from an initial passive role where the activities were mostly proposed by the specialist to a more proactive attitude by the end of the course.

We expect to have the full integration of robotics in the third year of implementing the project, when everyone is familiar with the applicability, about how to use it, and can innovate in an autonomy way as happens today with the computers and internet.

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