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Robotics in Child Storytelling

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Abstract. Although the field of Educational Robotics (ER) has been growing over the last few years and its usefulness has been shown in many studies, its use in basic or elementary school levels has been scarce. This work intends to address the issue of demonstrating that ER makes a very useful tool at the elementary levels of learning, proposing a project-oriented approach, where interdisciplinary work uses children's stories and their imagination.

The project involved the use of Lego Mindstorms robotics kits by students with ages between 9 and 12 years old. It involved the construction and programming of robots, addressing the dramatization of the popular tales "Little Red Riding Hood" and "The Three little pigs" as the final goal. Also, other groups of students implemented fashion and dancing shows, also with robots.

Each of the robots performed as one of the characters of the story/ show, following a set of steps according to the script that was programmed by the students. The work involved also a previous step where the robots were built and "dressed" according to its role.

The final results show the applicability of ER to this level of learning/ teaching. The students were able to successfully complete the project, achieving the proposed aims and also showing high levels of motivation and enthusiasm through its whole duration. The work culminated with public shows that served as a way to involve the community.

Keywords: educational robotics, construction-nism, storytelling

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1. Introduction

The interest on robotics as an educational tool has increased substantially over the last few years.

In fact, many benefits have been claimed for this tool and many researchers stress that it can be a tremendous source of energy that can be used to motivate both adults' and children's learning.

Those who have used robots say that they spent thrilling moments, the atmosphere is vibrant and that they profited much from the experience.

Many believe that this interest can be used for educational purposes (Johnson, 2003).

Yet, before recommending the massive use of this tool in the different levels of teaching and education, it is necessary to study in depth some issues related to the true effectiveness of educational robotics in promoting the acquisition of skills and knowledge.

2. Objectives

In general, some important issues can be raised about educational robotics, being of foremost importance the following:

- What types of contents/skills can be learned / taught used the robotics as an educational tool?
- What age levels can be contemplated with robotics activities and how this are related with the answers in the previous question?
- What are the main differences between the type of learning promoted by robotics and other ways to learn/teach?
- Which factors in the student's social context can influence her feedback to robotics activities? In particular will the student's gender be a relevant factor in his motivation level and to determine the kind of activities that will be developed?
- What kind of activities can be developed to maximize the potential of robotics as an educational tool?

It is obvious that to obtain adequate answers to all these questions can be an overwhelming task that is quite far from being concluded.

3. Lego Mindstorms Platform

The Lego Company has a long tradition in the development and commercialization of toys with innovative features that put together the entertainment and the pedagogical components, an aspect that was never disregarded by the company.

Lego has been selling toys that integrate electronic components for nearly 30 years. Therefore, it is not cause for admiration that the company has searched for a leading role in the educational robotics arena. With this purpose, in the beginning of the 1980's, Lego searched by the MIT a collaboration in order to be able to develop robots that could be controlled by computer programs, in a way that could be interesting for children.

This collaboration was based on the pioneering work done by Seymour Papert at the MIT, namely with the development of the Logo language that allowed to program the movements of a turtle in a computer screen. As a result of this partnership, the Lego TC Logo came up in 1986, where robots built with Lego pieces could be programmed using Logo. This collaboration provided more fruits since in 1998, also with the participation of M. Resnick, with the appearance of the first Lego Mindstorms systems, named Robotics Invention System. The large potential of the RCX, the "brain" of the kit, as well as its numerous available programming interfaces changed the landscape of its buyers. Indeed, this kit was mainly acquired by adults (Teixeira 2006).

After a short period of enthusiasm, Lego entered a period where the strategy to invest on Robotics seemed to be compromised. This period was ended in 2006, with the release of the new Lego Mindstorms kit based on a new central processing unit, the NXT, that replaced the "old" RCX.

The Hardware of the Lego Mindstorms

The NXT is a programmable robot that has one (or more) motors enabling it to move (and much more), that can use the different sensors to get information from the environment and that is also able to emit sounds. The robot has also the capability of communicating with a personal computer, either through a cable or using the new Bluetooth communication abilities. The Lego Mindstorms kit has in its basis the following hardware components: a

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microprocessor, a battery, a transformer, cables, sensors (ultrasound, touch, sound, light), motors and numerous Lego pieces for constructing different models.

3.2. Programming the robot: available software

The Lego Mindstorms Education NXT software allows us to explore in depth the potential of the robot. It integrates the Robot Educator, a tutorial with 39 activities that allows any new user to learn at its own pace. The initial screen gives access to two different areas: the Robot Education with tutorials and construction plans and the work area that allows the user to freely program the NXT, using a visual programming environment.

3.3. Advantages of using the Lego Mindstorms robot

The Lego Mindstorms robot fascinates all children (and adults) that contact it. It has attractive accessories that allow it to interact in several ways with the surrounding world. The available sensors allow a rich interaction between the robot and the children. There are no doubts that this can make an ideal tool to motivate students in the learning process, since it presents new challenges to develop several learning skills.

The advantages of using the Lego Mindstorms NXT robot are numerous: the fact that it is possible to use it in the classroom or outside the classroom in group work; it enables social and communication skills; it is possible to endow it with the form the users need or prefer; it facilitates a meaningful learning process; it allows multidisciplinarity, interdisciplinarity and transdisciplinarity; it is useful for teaching several contents related to Mathematics, Technological Education, Physics, Biology, Chemistry, Visual Education, among others.

4. State of the art in Educational Robotics

Over the last decades, in numerous places around the world, many experiments have been conducted using Robotics as an educational tool, with a special emphasis at the secondary or university levels, but involving in some cases the more elementary levels of teaching. Of course, Robotics can be thought as another content, to teach or explain to the students, in a traditional perspective (Teixeira, 2006). This is, typically, the approach followed by some university or more technical courses related with Electronics and automation contents.

We should face Educational Robotics under the perspective of a broad tool that can be used in all teaching/ learning levels and as a way to approach several different contents. This view can be well integrated in a constructivist approach to education. According to Chella (2002), Educational Robotics can be defined as an environment with several components (the computer, the robot and other electronic artefacts, the program) where the student builds and programs its robots, interacting with all the components and exploring concepts from distinct areas of knowledge.

Competitions are the best example of initiatives that involve a large number of participants (students, teachers and parents).

They are, for this reason, privileged as tools for the divulgation of robotics next to the younger. The major competitions are the First Lego League (FLL) that involves students between the ages of 9 and 16 years old and the RoboCup Junior, where each team has two autonomous robots that play a soccer game against another team in a 3 meter field.

Beyond competitions, other research works are being developed in several schools and have resulted in scientific publications. Within these examples, there are studies where students with ages between 10 and 18 participate in extra-curricular Robotics clubs (Costa and Fernandes, 2004-2005), (Teixeira, 2006), (Silva, 2007), as well as qualitative studies approaching the construction and programming of robots by elementary school students to dramatize a popular Portuguese tale (Ribeiro, 2006).

5. Constructionism

The origins of constructionism can be traced back to the group headed by Papert in the MIT in the 1960’s that was well known with the development of the Logo language. This group built a vision of education based on 4 basic ideas (Bers et al 2002):

- The constructionist philosophy of education involved the creation of computational environments where children can manipulate

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materials in an active way, playing with the, learning by doing, through the development of meaningful projects, shared with the community.

- The importance of concrete objects as a way to learn abstract phenomena. In this case, the computer allows creating and manipulating objects in the real and virtual worlds, thus making a tool of extreme relevance.
- The so called "powerful ideas" that reinforce the individual's capability to learn, allowing distinct ways of thinking, of using knowledge and of creating interpersonal relationships and epistemological with other domains of knowledge (Papert, 2000).
- The importance of self-reflection that happens when people are encouraged to explore their own process of thinking and their intellectual and emotional relationship with knowledge, as well as their life story that affects the individual learning experiences.

These four principles of the constructionist philosophy are a commonly accepted basis on the elementary education levels. On the other hand, those are fundamental to the development of Robotics activities.

6. Potential of Educational Robotics in the teaching/ learning process

Curricular areas

Robotics has been used, over its path in Education, as a tool useful for the learning of distinct contents, as well as for the acquisition of numerous skills. Within this large set, the areas of Physics, Mathematics and Informatics are normally emphasized, being the ones more directly connected with Robotics. Regarding Physics, several are the sub-fields where many of the important concepts can be approached using Robotics based activities. The tasks that the robots perform are typically related with movement, involving numerous concepts from Mechanics. Informatics is directly approached by the activities concerning the robot's programming, as well as all the software tools involved. Underlying both fields we have the mother of all sciences, Mathematics. Robotics provides an excellent mean to make lots of different mathematical concepts, at all levels, into very tangible and useful concepts. Robotics makes possible to design activities that implement project based learning approaches.

Furthermore, Robotics also allows working concepts related to areas like Arts Education. In fact, when planning and building robots a number of skills related to these subjects come into play. On the other hand, some of the Robotics activities (e.g. competitions) have been developed in order to include Music and Dance as major areas, being approached activities that involve different types of choreographies.

Robotics in Basic/ Elementary Schools

We believe that Robotics can be used in the teaching/ learning of some of the contents and skills related to the major areas of basic or elementary school (i.e. within the first 4-5 years with students between 6 and 10 years old). Indeed, many of the major contents from areas like Mathematics, Sciences, Languages and Arts can be included into well designed and planned Robotics activities. An analysis to the curricula in the Portuguese system (CNEB, 2001) allowed identifying, for the main curricular areas, a set of application domains, learning experiences and contributions to reach the proposed basic skills. We believe that this study detailed below can be easily transposed to other countries and teaching systems.

Mathematics - The emphasis on Mathematics in this level should be focused in solving problems, thinking about them and communicating with others to exchange ideas. Robotics offers a field full of opportunities, allowing working on the main skills of the different domains, such as Arithmetic, Geometry, Algebra and general problem solving.

Sciences – Robotics can contribute for reaching the main aims in the teaching of natural and physical sciences, such as: acquiring a general understanding of the ideas and structures that explain scientific concepts; understanding and applying the procedures of the scientific research; questioning the impact of Science and Technology in our societies. Robotics is able to provide a set of learning experiments that include planning projects with certain aims, detailing the major steps, since the definition of a problem to the understanding and divulgation of the results and doing cooperative work.

Technological Education – Technological Education should be built upon the development and acquisition of skills in a sequence of learning steps along the elementary school levels. These should be able to integrate concepts and skills shared with other areas and promote the application of these concepts into new situations.

7. Methodology used in the study

The study we undertook is considered as a case study, since it can be included into a class of research studies where, for a number of reasons, it becomes very difficult or even impossible to generalize results, being the aim to describe a given educational phenomena. This option can be intentional or imposed by the nature of the study or by the available resources that prevent the researcher from controlling the events and manipulating the causes of the participant's behaviour (Yin, 1994). Merriam (1988) characterizes the study as a qualitative case study given its descriptive, inductive, particular and heuristic character.

Description of the study

This study involved the development of two Robotics projects, by a group of students from the 4th and 6th grade respectively. Lego Mindstorms kits (as described before) were used in both cases. The activities took place in the 3rd period (April to June) of the curricular year of 2006/2007. A work was developed including activities of Robotics in the curriculum of the two groups of students during these 3 months. One of the groups (4th grade) belonged to the EB1/JI elementary, included in the Gonçalo Sampaio group of schools from the city of Póvoa de Lanhoso in Portugal. The other group (6th grade) belonged to the Conservatório de Música Calouste Gulbenkian in Braga, Portugal. Both studies involved the participation of the students in activities that took 2 hours per week for about 12 weeks. The project ended with a final year party, where all students from the schools were present, as well as parents and teachers.

Regarding the first group, the EB1/JI da Póvoa de Lanhoso is integrated into a group of schools where the first author was working over the last three years. The necessary robots were gently provided by a project coordinated by the University of Minho. The students opted, in this case, to dramatize a story and use this project as their contribution to the final year party. They decided to show their colleagues a different way of telling stories and chose the popular tale to the "Little Red Riding Hood". Within the group, the tasks were distributed by all: some were in charge of building the scenario (painting boxes, drawing trees), others designed and made the clothes for the robots, others built the robots using the Lego pieces, others programmed them and others still wrote the dialogues.

These students had never had the chance to see and touch a robot previously. The project was structures into 3 major steps: the preparation of the study including learning the basic of the Lego Mindstorms platform; the development of the story telling project; and, finally, the presentation of the final result to the community.

Regarding the second group, the Conservatório de Música Calouste Gulbenkian was one of the schools participating in the project leaded by the University of Minho. In this school, the option was to work with a group from the 6th grade, given the openness and flexibility shown by one of the teachers in order to have an available slot on the busy schedule of these students. The students in this group were all from a medium-high socioeconomic background, but had no previous contact with Robotics. In this school, Music is a major theme and students have little available time for other activities.

The available time was of 90 minutes per week and the group had 20 students. Initially, all members of the group were together making some activities to understand the platform and know how to build and program the robots. In a second stage, the group decided on the projects they would be involved and it was decided to divide the group into two sub-groups, working on different projects: the first opted for the dramatization of the story of the "Three Little Pigs" and the second decided to do a fashion show and also a dance choreography.

Within each session, in the first 45 minutes the 1st group was preparing the scenarios, the clothes for the story, while the 2nd group was programming the robots for the fashion parade and dance. In the second part of the session, there would be a switch, and the 1st group would go and program the robots for the story (e.g. setting the path for each robot and programming the movements), while the 2nd group would work on the characterization of their characters for the fashion show and the dance. In the 1st group, the programming was made in a collaborative way, but more towards the end 5 students were selected for each character, while the other five were working more on the dialogues and synchronization with the robots movements. In

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the fashion parade, they decided that each student would enter side by side with the robot and with similar clothes.

Characterization of the community and the subjects involved in the study

The students from the 4th grade had a previous history of participating in Informatics activities in their extra-curricular time in school. All students had a previous contact with computers, although there were dissimilarities within the group. This group had 11 students, 6 boys and 5 girls. To program the robots, the students made 5 groups, one per each character in the story. The groups had 2 elements (one with 3), where one of the students programmed and the other tested in the ground. They switched tasks regularly. In the final presentation, one the students were next to the robot to start it when appropriate and the other was the "voice" of the character.

This group was considered to be very noisy by their teachers, but during these activities they were always a disciplined group, obeying the rules with no problems and normally motivated by the activities and anxious to show their progress. Their previous background with computers made it easy to proceed with the programming activities. Whenever one student had any doubts, all the others were ready to help.

The 6th grade group from the Conservatório de Música Calouste Gulbenkian has good skills in working with computers. All students had a computer at home, but they had never contacted Robotics before. The group had 13 girls and 7 boys and the group division was made by alphabetical order. In general, the students had good results in their school subjects, although two of the students were weaker then the remaining. Since the first day, all students embraced the project with enthusiasm and good mood. The worked hard to develop the project in time since the weekly time was not much.

Data collection Instruments

In the study, distinct instruments were used to collect the data for the investigation. These were designed and implemented by the 1st author that collected all data and made its processing and interpretation. In this study, the following instruments were used: participating observation; video films of the sessions and analysis of the documents produced by the students (e.g. files with the robot programs).

In a qualitative study, the role of the researcher is primordial in the collection of the data. In this case, the direct observation of the events is very relevant (Bogdan and Bilken, 1994). In our case, the observation was participant since the researcher was also an active participant in the research. According to Vale (2000) the observation is the best techniques to compare what is said with what is done.

Cohen and Manion (1990) emphasize 3 advantages of video recording in the context of educational research: they allow a comprehensive record of behaviours, attitudes, reactions and dialogues, always available for future analysis; they improve the reliability of the study; they allow occurrences to be reviewed repeatedly. In this study, the direct observation and the videos served to allow the narration of the sessions and the main facts that occurred in each, as well as to list the dialogues between students and the researcher.

One of the main instruments in the data collection relied on the files produced by the students when programming the robots. Any change in a program was kept for future analysis by creating consecutive versions of the files. After analyzing the files, we realized that, in the majority cases, these changes are not new blocks of code, but rather small changes in the timing of the actions within the blocks. Normally, the right actions were defined pretty soon in the process, but the exact timing was a process of trial-and-error. Therefore, the right program to implement a given path was reached after a considerable number of attempts, mainly for fine tuning of the times involved.

Results

a) Building the robots

In the beginning of the first building session, all were very committed and even the harder ones to convince were enthusiastic with the process of building the robots. When they managed to build a "car", the enthusiasm doubled and they competed to check what the fastest robot was.

b) Programming the robots

The students did not show major difficulties in solving the problems in the first list of proposed activities. The challenges that came next put them in a state of anxiety, and this lead to some problems when then rushed into solving problems as quickly as they could. Initially, the researcher created a script with activities to provide for an initial contact with the platform.

The students executed some tasks from the script and checked for the results. Then, orally, the researcher proposed some challenges and the students tried to solve it by programming the robot. In this stage, they programmed directly into the robot using the provided interface. Also, students tried to program a few "random" activities and to understand the result.

When the problems got tougher, they started to use the computers and the provided software, downloading the programs into the robot to test them. At this stage the students started to work with the sensors and create programs that would interact with the environment. This new stage is a big step in terms of complexity and it was visible that the students had more difficulties in getting the robot to behave the way they would like it to. Since, the scenarios and the paths for the robots were ready at this time, the students started to program their own robots and trying to solve the specific problems imposed by their tasks.

8. Conclusions

One of the motivations for this work is the relative inexistence of studies regarding the application of Robotics as an educational tool, in the context of the first years of teaching (elementary or basic school). This level has been somehow disregarded in these studies, maybe because most of the researchers do not believe that the tool can be applied with such younger children. This project aimed at providing a contribution towards this aim, by successfully conducting a study with students from the 4th and 6th grades.

The fact that it was possible to reach the main goals of this project, with both groups, given the underlying complexity involving the use of Robotics kits that implied both building and programming the robots for the specific tasks, is in itself a confirmation of the applicability of this tool to children of this age.

In this context, an additional factor to take under consideration is the broad scope of this work in terms of the curricular areas that were involved. In fact, additionally to the traditional areas of Science and Mathematics, this work reached other areas related to Arts and Languages, namely Drama, Plastic Expression, Music and Dance.

By providing a pedagogical context to the new technologies, we integrate in the curriculum a huge amount of available information. The main advantages are: it develops the critical thinking; it develops logical thinking; it increases the interaction and the autonomy in the learning process; and, it raises the interest and motivation for learning.

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Study the Leaf Character via Biomaterial Moisture Sensor

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Abstract. The manuscript reports the study of moisture variation in different plant leaf by biomaterial moisture sensor. The sensor verified the typical change in leaf character with respective leaf colour and its different species. The moisture sensing characteristics have been evaluated for different coloured leaves i.e. light green, dark green, yellow and dry leaf for three different plants, namely Hibiscus, Chandani and Rose. The sensing mechanism of such a sensor material is based on the polarization under the action of an external electric field. Furthermore, attempts have been made to correlate weight loss and sensitivity factor (SF) of different leaves of Hibiscus (Dark green leaf SF=130, Light green leaf SF=120, Yellow leaf SF=115, Dry leaf SF=100). Chandani (Dark green leaf SF=130, Light green leaf SF=120, Yellow leaf SF=115, Dry leaf SF=100). Rose (Dark green leaf SF=140, Light green leaf SF=130, Yellow leaf SF=155, Dry leaf SF=100). This study brings out the basic difference in change in colour maters with the moisture concentration in different leaves of different species. Thus, the most important application of the present biomaterial moisture sensor is to verify the moisture concentration and the quality of the foliage.

Introduction

Like most major agricultural crops and plants developments is negatively impact by moisture