Growing up with robots

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Abstract. *The ability to understand interact use and control robots and automated machines or tools is becoming a major need. This is a topic rather appealing to our young students. On the other hand this is a topic involving many different subjects of science and technology that should be studied in an integrated and interrelated way. In this communication we will present our experience in implementing teams of school students that develop their own robots to play cooperatively in robotics competitions. The pedagogical strategy employed will be presented as well as the basic characteristics of the robots to be built, the competition rules and the outcomes of the projects developed in different schools with students 10 to 18 years old.*

Keywords. Robotics, Science education, School, Hands-on experiments.

1. Introduction

Piaget's theory of cognitive development [1] is considered a fundamental pedagogical tool that in different approaches, educators at different levels and situation widely use.

The vast majority of students have tendency to learn in a concrete manner by experiencing or feeling, and process the information actively by experimenting doing or acting upon [2].

Hands-on experimental activities have long time proved to be one of the most effective ways to drive the students to a successful learning of science and technology [3].

Constructivism is a pedagogical approach were in a structured way the learning process is centred in the process of building or constructing something [4].

The development of computers and computer science gave the educator of science and technology new invaluable tools [5] that soon lead to new approaches to constructivism [6] and to the use of the concept of artificial life as a reality every day closer to our lives. The idea of using the construction of robots or automated systems as a pedagogical tool [7] emerged naturally and is proving to be very effective in science and technology education in different age or development levels.

The process of conceptualisation design and construction of a robot leads the students to positive cognitive development. The students as to, both, on one hand understand a real dynamic object, mechanism or living being in their complexity, and, on the other hand to reproduce and integrate those concepts and behaviours in a simplified, as needed or required, but effective artificial mechanism. More than a mere mechanism it may be considered to be an artificial organism.

The students have to realize accept and cope with the difference between the real situation they are dealing with and the artificial "organism" they built and that behave according to the "will" and control and conception capability of the students them selves.

2. School' robotics. An experiment.

In July 2004 the world championship of the Robocup Junior League will take place in Lisbon [8]. The Robocup Junior League is an initiative that supports local, regional and international robotic events for young students. Essentially robots or teams of robots idealised constructed and programmed by groups of school students have to compete in a number of competitions from robotic dance to football. The pedagogical approach lays on the autonomous voluntary and committed learning by practice and hands on experimental activities. Students with different interests and strengths will work together as a team to achieve a common goal.

"RoboCupJunior aims at bringing together many of these ideas, promoting project-oriented, team-based education, giving children with a

variety of interests and abilities an opportunity to pick their own challenges while contributing to the progress of the whole" [8].

Responding to a call from the Portuguese Unidade Ciência Viva [9] of the former Ministry of Science and Technology, the first author induced and presented, three pedagogical projects aiming the development of teams of robots to participate in the Robocup2004 world championship. The projects were located in three different schools on the Minho northwest region of Portugal.

The Basic and Secondary School of Celorico de Basto lays in a rural area that in spite of the improvements in the last years has a limited access to science and culture.

The College Teresiano of Braga is a traditional and prestigious basic school in the town of Braga. The school as a strong catholic focus as the city of Braga it self.

The third one is a vocational school (CENATEX) in the industrial town of Guimarães with older students that will in most cases leave the school directly to a technical employment in the industries of the region.

2.1. Growing up with robots

The students develop their activities working in teams, in a methodical, autonomous and responsible way.

They learn by working and integrating knowledge and competences in a wide range of subjects: mathematics, physics and mechanics, electricity and electro-mechanics, construction and design, electronics and computers, programming and artificial intelligence… Not only had they chosen the types and characteristics of the robots and teams to be established as they choose their own ways of solving the problems that might appear along the way. They project, develop and improve their own robots. Aiming to participate in festivals workshops and competitions, working and learning how to understand and use technologies and activities already of great importance and that in a few years will become fundamental in our everyday life: robots and automation, programming and artificial intelligence.

All three projects [10] were structured in four main phases:

1. presentation and popularization and motivation of teachers and students for the theme.
2. establishment of the conditions that may allow the students involved of each team to form, the autonomous development of their activities.
3. development of the robots teams, the knowledge and expected competences.
4. participation in tournaments, competitions and activities of demonstration/popularization of robotics, automation and artificial intelligence.

Figure 1. The Robocup 2004 logo.

The projects involved the establishment of 18 robotic teams built by almost 100 students. Many more students from 10 years old up to 18 years old were involved in support groups or fan clubs. Indirectly nearly one thousand students from these and other schools of the region take contact with robotics in lectures, demonstrations or festival organised by or with the participation of our students.

3. Types and main rules of the competitions

There are 3 types of ROBOCUP JUNIOR [8] competitions: soccer, dance and rescue. The two first ones will be described in more detail below.

In the football competition on or two robots play against others in a small soccer field colour-coded in shades of grey and using a special IR light emitting ball, with rules that "approaches" those of regular soccer.

In the rescue competition the robots have to race to rescue "victims" from artificial disaster scenarios including uneven terrain and different obstacles.

In dance one or more robots perform a choreography according to music chosen by the team, eventually in an appropriate scenario.

In all competitions there are two age levels: primary (up to 14 years old) and secondary (from 15 to 18 years old).

3.1. Robotic Soccer Junior

Teams of autonomous mobile robots play games in a rectangular field with ground colour-coded in shades of grey. In the robotic soccer are used contact, light and infrared light sensors that allow the robots to identify the field, the opponents, and the ball. Other sensors may also be used. Thus the robot is a structure somewhat complex requiring important programming skills. Teams must be prepared to calibrate their robots based on the lighting conditions at the venue.

Figure 2. Rules must be obeyed!

The need of controlling in a well balanced way the movement of the robots according to the readings of the sensors that the robot should have, renders the building and programming of this type o robots a complex task. Upon the age level different kinds of robots were assembled and programmed [10].

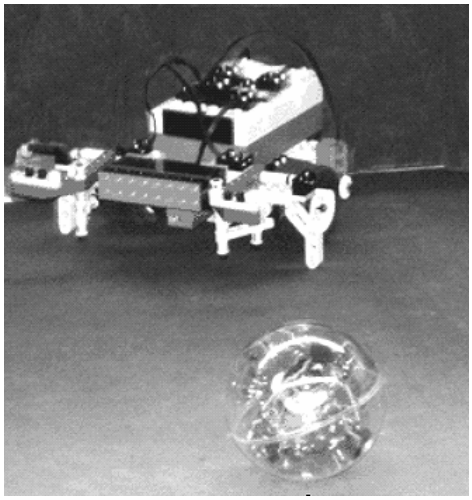

Figure 2. To find the IR ball… the first major difficulty…

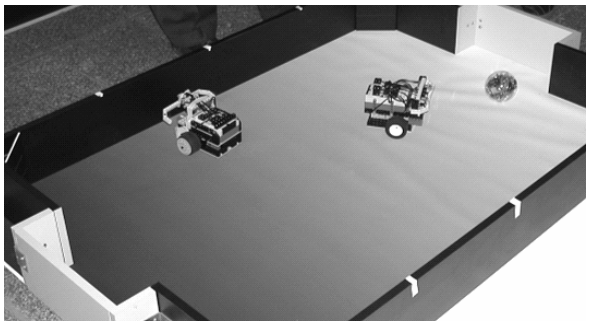

Figure 3. Ball found?… lets kick it towards the goal! The opponent's one… of course!

3.1.1. Soccer rules

Team.

For the 1-on-1 League, a team shall consist of one and only one (1) robot.

For the 2-on-2 League, a team shall consist of no more than two (2) robots.

Playing Field.

Size.

The playing field for the 1-on-1 League is 87 cm by 119 cm

The playing field for the 2-on-2 League is 122 cm by 183 cm

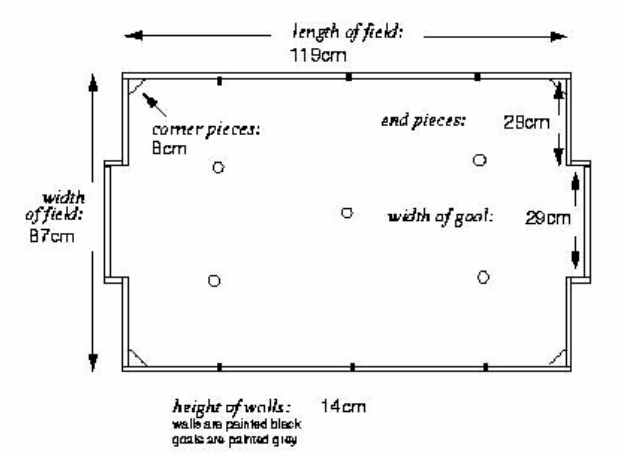

Figure 2. Diagram of a robotic' football playing field for the 1-on-1 league.

Floor. The floor of the playing field is covered with a printed, matte greyscale. The playing field should be placed so that it is flat and level. The field may be placed on a table or on the floor.

Walls. Walls are placed all around the field, including behind the goals. The walls are 14 cm high and are painted matte black.

Goals.

The width of each goal for the 1-on-1 League is 29 cm, centred on the shorter end of the field.

The width of each goal for the 2-on-2 League is 45 cm, centred on the shorter end of the field.

The back and sides and floor of the goal (inside the field) are painted matte grey: 75% matte white and 25% matte black.

Lighting. Teams must come prepared to calibrate their robots based on the lighting conditions at the venue.

Robot:

Diameter.

For the 1-on-1 League, the upright robot must fit inside an upright 18cm diameter cylinder.

For the 2-on-2 League, the upright robot must fit inside an upright 22cm diameter cylinder.

Robots will be measured with all parts fully extended.

Height. The robot height must be 22cm or less.

Control. Robots must be controlled autonomously but must be started manually by humans.

Length of the Game.

The game will consist of two 10-minute halves. There will be a 5-minute break in between the halves. The game clock will run for the duration of the game (two 10-minutes halves), without stopping (except when robots are damaged).

Ball.

A well-balanced electronic ball shall be used. The ball will transmit infra-red (IR) light.

Ball Movement. A robot cannot hold a ball. The ball must be visible at all times. Other players must be able to access the ball.

Ball Capturing Zones. Ball capturing zones are defined as any internal space created when a straight edge is placed on the protruding points of a robot. The ball cannot penetrate the Ball Capturing Zone by more than 2cm.

3.2. Robotic Dance Junior

One or more robots perform to music, in a display that emphasizes creativity of costume and movement.

As there is no mandatory use of sensors, and thus a somewhat simplified approach to robotics, the focus of the activities dealing to the setting up of the kind of teams will be both the dynamical control of the machine and design and creativity.

Figure 4. Some of the dance robots that participated at the Robotica'2003 National Robotics Festival in Lisbon.

3.2.1. Dance' rules:

Stage:

Size: The dance stage will be a flat area of 10m x 5m.

Lighting: There will not be any direct spotlight on the stage.

Scenery: Teams are permitted to provide their own scenery.

Robots:

Size: Robots may be of any size.

Team: There may be any number of robots on a team. Each team may perform one and only one routine.

Control: Robots must be controlled autonomously. Humans may start robots, either manually or with remote control.

Costumes: Costumes are encouraged.

Routine:

Duration: The duration of a routine is no more than two (2) minutes.

Music: Teams must provide their own audio source.

Humans: Human team members may perform along with their robots. However, human team members must not touch the robots (except to start them).

Start of Routine. An official will start the music for the routine. One human team member will start each robot, either by hand or remote control. Teams are allowed to repeat their routine, at the discretion of the officials.

Judging.

Routines will be judged by a panel of five officials. The five officials will be designated prior to the tournament. The officials shall not have any relationship with any of the teams entered in the tournament.

Routines will be judged according in the following categories:

1. Programming.
2. Construction.
3. Costume.
4. Choreography.
5. Creativity.
6. Originality.
7. Entertainment Value.

Scores from 1 to 10 (best) will be assigned to each team for each category.

Winners.

A winner will be chosen for each category, as the team with highest total score for that category.

Figure 5. The sweet flavour of victory.

More information concerning these projects can be found in the websites created by the project students: http://robos.no.sapo.pt

4. Conclusion

In-class hands-on experimental activities have a very positive impact in the large majority of the students involved. The construction of robots and robots' teams is a challenging activity that students irregardless of their age level, take in a very responsible and committed way.

The fact that the large majority of our teams were chosen in the Portuguese selection' competition for participation in the world robotics championship Robocup'2004, (representing over 40% of the Portuguese teams in the competitions they will participate), is important.

However, by far, the most important outcome of the project is the self-confidence and responsibility our students developed and that it is in a very positive way replicating among their colleagues.

4. Acknowledgements

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5. References

[1] Piaget, J. & Inhelder, B. (1966) La psychologie de L'enfant. Paris: P.U.F.

[2] D. A. Kolb, "Experimental learning: Experience as source of learning and development", Prentice Hall, Upper Saddle River, N.J. 1984).

[3] Manuel F.M. Costa, "The importance of experimentation on teaching the basics of optics at elementary and high schools", Proc. Soc. Photo-Opt. Instrum. Eng., vol. 3190, p. 228-232 (1997).

[4] Harel, I. & Papert, S. (1991). Constructionism. N J: Ablex Publishing Corp.

[5] Papert, S. (1980). Mindstorms: Children, Computers, and Powerful Ideas. NY, New York: Basic Books

[6] Kafai, Y. & Resnick, M., (1996). Constructionism in Practice: Designing, Thinking, and Learning in a Digital World. Mahwah, NJ: Lawrence Erlbaum.

[7] Pagliarini, L., Lund, H. H., Miglino, O., & Parisi, D. (1996). Artificial Life: A New Way to Build Educational and Therapeutic Games. In Proceedings of Artificial Life V. Cambridge, MA: MIT Press/Bradford Books.

[8] www.robocup2004.pt

[9] www.cienciaviva.pt

[10] robos.no.sapo.pt