CITA: Promoting Technological Talent Through Robotics

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***Abstract*—Educational robotics gives us a creative way to use technology to implement solutions based on our wit and skills, and not become just consumers of technology. Educational robotics creates learning situations and environments to the application of skills and technological processes, preparing students to live and improve their environment. This article introduces a range of activities - both informal and formal education - developed by the International Centre for Advanced Technologies that allows us the proposal of a new approach of educational robotics as a support tool to explore, identify and develop the technological talent of children and young students.**

***Index Terms*—Educational Robotics, CITA, Technological Talent, Education, NXT Workshop.**

I. MOTIVATION

Nowadays, many difficulties at education of sciences can be observed at most countries. This situation is mainly due to the fact that the current teaching methods at subjects such as Mathematics, Physics or Computing, makes them uninteresting and difficult to overcome. A negative attitude toward science, engineering and technology appear at an early school age so students tend to avoid the obtention of related degrees and to become professionals related to these areas.

However, the studies conducted by the International Foundation of Conceptual Education "Alberto Merani" show that each person has one or more areas where his/her learning potential is outstanding. This one is called the potential talent area [1], [2]. Among these talents we can find the potential technological talent. This talent will be developed only if passion for work exists where the cognitive attitudes and expressive skills can be applied. It will also catalyze in valuable, innovative or exceptional contributions, in the specific field of technological and technical knowledge of the real tangible objects. People that owns this talent has the exceptional ability to detect problems in the relationship between humans and physical world objects and they can propose solutions which will improve living conditions [1].

Technological talent requires motor and manipulative skills to properly handle objects and tools of the physical world. The technological talent involves a divergent thinking behaviour, because when facing a problematic situation, different alternatives and search directions must be explored. Creativity at technology plays an important role because it provides a permanent potential for development. Last research works have proven that anyone can develop creativity through an intended educational process. That is, creativity behaviour can be induced, encouraged, strengthened and developed [3]. However, current educational system does not seem to encourage it, but just the opposite [2], [4].

In this regard, Educational Robotics is an excellent tool that helps us to explore, identify and develop the technological talent of all children and youth. It seeks the student's adaptation through processes in order to learn science and technology topics. Exploration strategies that use tools such as inquiry are considered. The learning environments focused on the student activity and the prototypes manipulation in controlled environments are key elements. The aim is that the student develops a structured thinking, that will develop its logical thinking when he is confronted to a problem that must solve.

Regarding education, Educational Robotics aims to arouse the students' interest on traditional subjects that are mainly related with technology. So these topics will be more attractive and inclusive for them, by creating conducive learning environments, that recreates daily problems [5]. Most importantly, Robotics provides the students with an opportunity to discover if their best learning potential [2], flow by Csikszentmihalyi [6], or his element as he called Sir Ken Robinson [4], is related to science and technology.

But the challenge goes further. We need to achieve that psychological conditions match the social and educational conditions [7] to deploy the technological talent (otherwise lost [2]) so in the future these people can bring wealth to society, because the talent and human creativity are the raw material of science and technology, art and business.

In order to generate an appropriate environment that enables to deploy the technological talent through the integration of robotics into the classroom, we consider important the need for different scenarios to overcome certain

barriers, such as the lack of vision and leadership for its implementation. Many educational robots need management expertise and specific qualifications from the teachers. Most robotic platforms are prohibitively expensive and difficult to maintain in schools due to their complexity, integration into the curriculum and school evaluation.

Every time, a greater number of initiatives to promote robotics in different contexts, museums [8], international projects [9] or educational institutions [10] are developed. They are always a valuable resource for those ones that are interested in disseminating and improving this discipline and educational technology.

This article introduces, in an organized manner, the work carried out by the *International Centre for Advanced Technologies* (CITA) related to Educational Robotics. It describes the experiences implemented (both curricular and extra-curricular) and the future work. It also highlights the importance of sharing lessons learned to promote the construction of knowledge and enrich our repertoire of activities.

II. Robot Educational Activities Developed in CITA

The International Centre for Advanced Technologies (CITA http://www.citafgsr.org/cita/) belongs to the Foundation Ruipérez Germán Sánchez, located in Peñaranda de Bracamonte (Salamanca, Spain), was opened in October 2006 and has since then promoted among their activities, Educational Robotics NXT projects.

The aim of CITA is the introduction of the Information Society and Knowledge in rural areas through the qualification of human resources, access to information flows and the generation of technological services applied to education, local government, culture, equality and democracy.

For the CITA, when it comes to learning, Educational Robotics is a versatile, multidisciplinary and inclusive activity. It is equally suitable for children, youth and adults, who by solving problems in a collaborative work environment, will generate their own knowledge.

CITA, mindful of its commitment to the development of individuals and society through TIC and education, used the Educational Robotics as an innovative teaching resource.

Here are the activities undertaken in CITA to achieve this goal, its development and description. These examples are a sample of the variety of learning environments that can be generated from the same area (university, foundation, ONG, school...) and illustrate how we can use different strategies in order to excite, detect and enhance the technological talents through robotics.

A. NXT Workshops

The first initiative developed is the NXT workshops [11], [12]. Its name comes from a teaching resource used: the latest model for the construction of LEGO Mindstorms robots called NXT. This model includes the typical parts that allow building different robotic structures: sensors for the perception of the outside, motors to get the movement of the robot and a microcomputer for programming NXT actions.

NXT Workshops consist of extracurricular activities with duration of approximately 20 hours over five or six sessions. The methodological structure of the sessions is shown in Table I. One reason for the attractiveness of NXT workshops [13] is that they involve multiple design possibilities because of the versatility of the Lego Mindstorms NXT kit. Each workshop has a different subject and we have designed many different prototypes (robots that compete in the traditional scarf game, formula 1 cars, robots that play basket, humanoids, animals, robots with drawing skills, sumo, space explorers, NXT vehicle). As a picture is worth a thousand words, http://www.flickr.com/photos/citafgsr/collections/72157629051949945/

TABLE I
Methodology Workshop Structure NXT

Session	Activities
1	Introduction of the course Team building Getting to the Lego kit parts
2	Design and selection of the desired model Start of the Assembly
3	Assembly Construction (either fully guided, free or mixed)
4	Programming (using graphical language NXT-G or textual language NXC, depending on the difficulty)
5	Pre-testing Assembly of the track Fitting-out of the classroom (morning) Competition / exhibition final with family and friends (afternoon)

Workshops based on specific topics offer participants opportunities to develop skills both to find out and to solve problems, in contrast with the school activities in which students are given a fully structured problem [14]. This is important because one of the most critical parts in the design of projects in the real world is to identify and refine the problem to be solved. This aspect has been considered by including the methodology and data of the benefits gained by participants in these publications NXT Workshops [11], [12].

However, we consider relevant to show the example of the last workshop held NXT called "NXT Vehicles", whose objective was to build robots-cars. A total of seven teams were formed with a maximum of three members of 8 to 15 years. Four teams (the smallest and rookies ones) chose to build vehicles step by step, while the veteran guys first decided to design their own vehicle.

When making free designs, their first task was to define the model building by using the Internet: a tank, a caterpillar and a monster truck were the selected cases. The complexity level of design a robot without an outline is great, but these teams managed the decision taking problems as they arose to take concerted decisions.

The team "Nydea", that built the tank, decided to implement 5 engines so they needed two NXT modules to control the

robot . The team "Monster Truck" used pneumatic and gear items for the vehicle control. The final results, that were surprising, can be seen in this link:
http://linoit.com/users/tallernxt/canvases/E-infocenter%20Vehicles%20NXT

These activities allow us to identify, by observation (see section III), the participants that show a greater potential to be a technological talent and, in the following, guide them in their training.

One thing to note was the attendance of young people from neighboring towns, from other cities (Salamanca-45 km, Bejar-90 km), from other provinces (Zamora-115 km) and possibly another region (Madrid-170 km.) Their parents support and encourage their interests, regardless of distance traveled. This reveals the lack of activities for this kind of talent in Spain.

B. Competitions with robots: First Lego League

The constancy of some participants of the Workshops NXT takes the CITA to participate -since 2009- in robotic tournaments, specifically in the First Lego League (FLL), a very popular competition with LEGO robots that takes place worldwide and is addressed to children up to 16 years old. Each competition, a different subject. Each time, a different test. Each year a different challenge.

The first team was called "Tuercas Locas". In 2011, due to the number of young people interested in this activity a second team was created: "Locas Tuercas". For three months they work hard to participate in the FLL. If anything is striking watching the kids' work is their excitement, and this is only possible if there is enthusiasm. We know there are other ways to learn, but they are definitely more boring.

What is the secret? The seductiveness of an activity that uses a methodology based on *learning by doing*, which is capable of stimulating the eight intelligences defined by Howard Gardner [15] in his *Theory of multiple intelligences*: linguistic (presentation of their projects), logical-mathematical (robot programming), the visual-spatial (building of the robot), the musical and Bodily-kinesthetic (theatre play), intrapersonal (self-knowledge), interpersonal (knowledge of others, teamwork) and naturalistic (research project). It also gives us the ability to recognize and develop the talents of each participant. With this conviction, CITA promote and supports this activity.

C. NXT Christmas Workshops

The robots are also key players in the Christmas activities in CITA. Each year, we invite the local *children with their parents* to a free workshop, to discover the NXT Educational Robotics (three hours) with designs done step by step in a Christmas atmosphere. They are the students of CITA, along with their coaches, who are in charge of guiding the participants of the workshop in this wonderful family activity (show in Fig 1).

Fig. 1- Christmas workshop in CITA

D. Videoconference with robotics groups of Latin American countries

Due to the facilities and technologies available in CITA, we have carried out videoconferences with American robotic students, including St. Jude Tadeo College (Santo Domingo, Dominican Republic), Science Club *Electronic World* (Ushuaia, Argentina) and a group from the Technological University of Panama - *Chiriqui Regional Centre* (Panama). During the videoconference, each country introduces their designs and performs a short demonstration of their robots. This is usually done in the closing activity of the NXT workshops, or while preparing for the FLL competition.

For many of us, the experiences with remote control are limited to change the television channel from our sofa and, for the most experienced, drive a toy car down the hall at home. But what would you say if we propose to control a robot from the other side of the Atlantic? What if they were two robots which, controlled from different parts of the world simultaneously, compete with each other?

This kind of activities -the Lego NXT robot teleoperation through the Internet- has been highly valued, and we have made it with the three countries mentioned before in several stages: 'exploration of Mars', 'sumo wrestling', 'challenge ecological' (educational track manufactured by Lego) or FLL competition. These activities show the participants different technological possibilities such as:

- Videoconference (Skype software application) to see the stage and talk.
- Remote access through the Internet to a computer in another country using LogMeIn software.
- Bluetooth Communication to handle the robot using the NXT-remote application.

For example, in the sumo match, two Lego NXT robots physically located in CITA, were controlled remotely from across the Atlantic and from different countries: Argentina and the Dominican Republic. The 'struggle of prototypes' was took place in real time and all those attending the event, (the ones in Peñaranda and the ones in America) could see live the evolution of robots and live, at the same time, the emotions of the competition (show in Fig. 2).

Fig. 2 - Teleoperation Sumo robot from the CITA

E. Training for Teachers

Given the experience of CITA in the field of robotics and education, in May 2011 teachers from the Technological University of Panama -who participated in the project "*Development of scenarios which facilitate and encourage science learning and technology, making available educational robotics to students and school teachers*"- were instructed in this methodology in order to share its benefits.

In this experiment, we used the Kit 9797 educational robotics of Lego Mindstorms NXT. The invited teachers learned how to motivate students through several imaginative designs of robots, incorporating their key elements (sensors, motors, …), and how to program the robots to give them intelligence and autonomy.

Thus, these teachers acquired an overview of educational robotics and experienced how to use a robot as an educational tool in teaching Mathematics, Physics and Technology.

In order to know a set of recommendations related to project development and their integration into the classroom, we need:

- The material: the guide for each session, a student portfolio and a team guide where the proposed activities are developed in each lesson and a reflection that allows them to analyze what they made that day. In addition, project staff must have their own observation and reflection guide to what has been done in each session, as a means to to reach a continuous improvement.

- The teachers and students training that participate in the project on different days, based on their background and their respective roles.

- The scheduling of the teachers gradual training process. That is, during the first phase both teachers and students receive the same lessons, as suggested by [16] "teachers teach as they are taught, not as they are told to teach". In a second phase, the constructivist/constructionist methodology and a project-based learning approach [9], [17], are explained. A set of examples of proposals in their subjects is given. Finally, after these sessions, the teachers would plan and implement a lesson, which includes robots, in their respective classes.

- The definition of the team's size and the each member role must be done in an anticipated way. Based on our experience, we recommend that teams have a maximum size of three participants, where each can play one of these roles: programmer, engineer, journalist, and these three functions in each session must be rotated. It will allow to each of them an experience at all three roles, the enhancement of their strengths and the overcome of the weaknesses.

- Robot competitions are very popular. A challenge provides additional extrinsic motivation for students, it increases their skills of teamwork and it encourages the student to identify and evaluate a variety of views [18]. So we propose to acquire the educational resource of LEGO "Green City Challenge combo pack" to make an intercollegiate competition as the final event of the project, similar to FLL.

Some details about this Panamanian project and its results just been published [19].

F. A Visit with Mouse

Educational Robotics is also present in an activity called "a visit with mouse". This activity shows students and teachers of schools the importance of technology in the classroom through workshops in our center. The workshops include activities with interactive whiteboards (IWB), computers, tablet PCs, and, since 2011, Educational Robotics (show in Fig. 3). This program was specifically designed for groups of children between 3 to 17 years old and schools teachers from the region (Castilla-Leon) and other Spanish, who are introduced the advanced technologies in a fun and easy way.

Up to 50 people are invited to a session, which last for one hour. We usually divided them into two groups, so they get a better experience. We separate each group of 25 people in 6 teams (3 to 5 members).

We have six kits 9797 educational robotics of Lego Mindstorms NXT and six tablet PC to develop this activity. The methodology is divided into three sections:

1) *Theoretical section* (10 minutes).

- Welcome
- What is a robot and its parts?
- Examples of robots in our daily lives and its importance.
- Introduction to the Lego Mindstorms NXT educational kit.

2) *Construction and programming section* (25 minutes).

Due to time constraints, it was decided to perform the construction and programming simultaneously. That is, while one or two students from each team learn to program, their colleagues built the robot.

In order to build the robot, each team is given a step-by-step guide. After trying several models, we decided to use the model called "*Domabot*" [20]. This design is very easy to build and it also incorporates a light sensor, an ultrasound sensor and the possibility of placing either a touch sensor or a sound sensor. Some teams even tuning their robot.

We used the NXT-G software through the interactive whiteboard (IWB) available in the classroom. This enables us to provide the programmers with a dynamic learning. They are briefly explained the sections of the interface; the blocks

"move", "sound", "wait" and "loop", and how to download the programs into the robot.

We analyze three basic programs in the IWB, and then each team will write this program in his table PC.

- The first program verifies that the communication between the NXT robot and the sensors/motors woks properly.
- The second one involves straight-line motion and turns (motors).
- The third one follows a black line (light sensor) and detects obstacles (ultrasonic sensor).

3) *Practical section* (25 minutes).

By the time the builders have completed the Lego NXT robot, the programmers have the programs ready to be downloaded to the robot. It is amazing to observe the expression of these children watching the robot run the first program, and even more when the robot uses the sensors! Now it is time to try to make their robot perform a sumo match, using previously learned programming blocks. We explain them a simple program and they write it on their computer. They are responsible for calibrate the distances for the ultrasonic sensor which will detect the opponent (a cardboard box in our case) and regulate the powers of the motors used, and the duration of the turn.

Then they put the robot in the ring (dohyō) and fun begins. Trial and error to get your robot meets the objective: getting the opponent out the ring avoiding going off the ring.

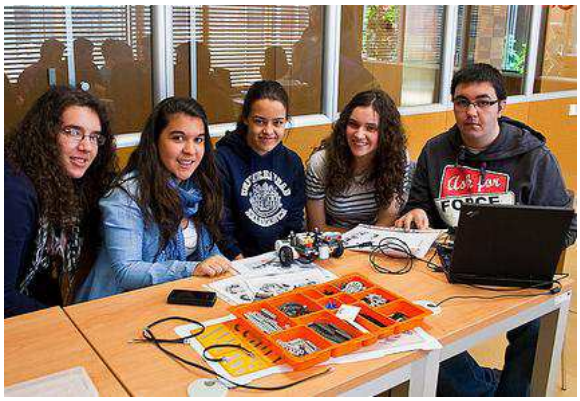

Fig. 3 - Group of students during a visit with Mouse in the CITA

G. Robotics in the Classroom Project

In most countries, the current challenge of educational robotics is being moved from the extracurricular activities and being integrated within the school curriculum on a permanent basis, as a learning resource. Not only in technological subjects, but also in those where it can serve as a support for improve teaching and learning processes, in addition to promoting the development of skills that are so requested in this new millennium.

CITA submitted to the CFIE (Centre for Teacher Training and Educational Innovation) -institution under the Ministry of Education and in charge of teacher training-, a proposal to make available to secondary teachers of Peñaranda de Bracamonte a new educational resource for the teaching of their discipline: the Lego Mindstorms NXT educational kit, in the following ways:

- Type A: technology teachers
- Type B: all kind of teachers

During the academic year 2011-2012 two schools, three teachers in category A and one teacher in the form B took part. The proposed training is divided into two phases:

Phase 1: Training of teachers on the didactic use of these resources (Lego Mindstorms NXT).

Phase 2: Implementation of an educational activity with their students.

For this project we have the same 6 educational kits Lego Mindstorms NXT with their tablet PCs. It is important to highlight certain aspects of this proposal:

- The teachers attended the course in the CITA, one hour per week (20 hours total) between the months of December and May.
- The design of the activity that will be done with students is planned during Phase 1, according to the curricular needs of each teacher. Thus, there were three different experiences (show in Table II):

TABLE II
ACTIVITIES CARRIED OUT

Activity	**Introduction to Robotics**	**Body Forward Challenge**		**Sumo NXT Competition**
Teacher's Subject	Technology	Technology/ Programming		Sport
Content	What is a robot? Why they are important? Components and examples.	What is a robot? Why they are important? Components, mechanism and examples.		Fine motor skill, Team-work, Tactics, Obeying rules, Perseverance
Level	3º ESO	4º ESO		2º ESO
Number of groups	2	1		2
Number of students	35	6		34
Place	CITA	CITA	School	CITA
Number of sessions	4	4	4	5

In the second phase, the robotics instructor leads the class, assisted by the teacher of the subject. We believe that this initial support is key for a teacher to acquire the confidence that will allows him to integrate robotics in the classroom, because he will learn to identify and solve the problems that may arise.

In all the workshops we used programming NXT-G software.

Since the school of some of the teachers who attended the workshops, had already the track for the 'Body Forward challenge' activity, they could develop the activity in the school with the rest of the pupils.

H. Other activities, and a look at the future

We have also take part in three international events:

- European Campus Party in Madrid (2010), with the project 'Red Planet NXT' (show in Fig. 4), whose objective was to show the importance of space research, through a robot inspired in the current 'Mars rovers'.

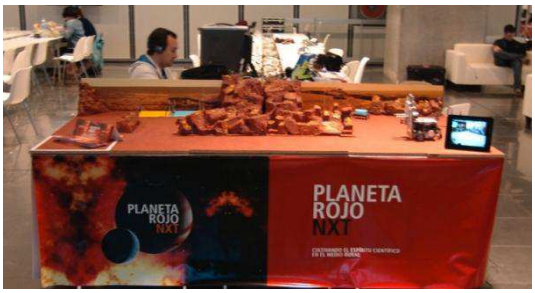

Fig. 4 - Our stand in the European Campus Party 2010 in Madrid

- In Empírika (Iberoamerican Science Technology and Innovation event). CITA decided to raise public awareness about recycling, through a "race" of robots. We emulated a recycling plant with two areas: one for paper (in blue) and one for other waste materials (in red). Visitors would guide the robot to the right place depending on the type of waste material, using a remote control (show in Fig. 5). Afterwards, the robot, in an autonomous way, would repeat the activity using a color sensor. A panel showed the time that took both the robot and the person using the remote control, to place the material in the appropriate container: the robot was faster.

  Allow direct interaction of the participants with the robot in such activities is a key point to consider in the design of activities to promote robotics.

Fig. 5 - Our stand of educational Robotics in Empírika 2010

- European Campus Party 2011 in Granada, with the European project 'Robots in India', whose objective was to show our experience with robots to children in a culture as different as the Indian (show in Fig. 6).

Fig. 6 - Exhibition Robots NXT in India

The interest in robots grows more and more in Peñaranda de Bracamonte (Spain). For this reason, CITA includes, among its summer activities, robotic workshops, for kids over 10 years old.

III. Some Reflections to Recognize and to Guide the Technology Talent

After knowing the range of activities that CITA makes to promote technological talent, one of the questions that arises is how to recognize the potential in our students?. In the following, some simple but very valuable guidance will be shown [1]. They will help in the task of exploring the interests and skills related with technology talent.

How to explore the interest?

1.- Look to recognize the students interests by observing their activities, habits, games, trivia and concerns.

Technological talent likes "tinkering" with machines, computers and technology in general, as well as individual sports or team activities related. They are usually disordered with their spaces. Its curiosity is always directed to the way of how the apparatus, machines or any type of process works, and they want to know and manipulate objects and their mechanisms.

2.- Seek to identify the students interests, by analyzing their performance and inclinations at school and extracurricular activities.

This kind of talent usually has good performance in technical drawing, physical education and sports, technical areas (mechanical, electrical, electronics) and construction. Enthusiastically they can participate in team sports, technology fairs, modeling, prototypes or machines in science fairs.

How to explore the skills?

1.- Recognize the skills of its students by analyzing what is it easier to learn.

A technical talented person easily understands and interprets manuals, plans or rules of games and sports. He easily understands a toy mechanism, a machine or device, as well as the related software tools.

2.- Seek to identify the students skills by inquiring what things are considered difficult in school:

People with this kind of talent tend to be somewhat abrupt, so that social activities are often not his forte. They have a hard time understanding the art language and creativity activity, so they tend to be more specific, linear and pragmatic ones.

We now understand better why robotics is so important to identify this type of talent, as it brings together most of the above mentioned requirements. Moreover, the reality is that this kind of talent does not have enough activities to help you promote it, as it occurs with other talents (sports, arts, etc.). Therefore, the CITA seeks to promote technological talent by creating situations and learning environments that will be conducive for the application of technological skills and processes that allow exploring further.

If a student shows that he has this potential, Table III gives some recommendations to help the teacher guide the formation and deepening of his talent.

TABLE III
ACKNOWLEDGMENT TRAINING STAGES OF TALENT

Stages	***To study in depth:***	**For this:**
1st childhood (0-5 years old)	*Interest recognition*	- Encourage curiosity. - Encourage the achievement of goals increasingly sophisticated.
2nd childhood (6-12 years old)	*Aptitude recognition*	- Probe learning potential. - Teach planning, implementation and evaluation of goals - Pose challenges to seek that the achievement and improvement will be the goals. - Encourage the development of the skills through healthy competition with yourself and other ones.
Youth	*Projection of vocations*	- Channel their interests and skills to specific domains - Guide the formulation of the life project

IV. SHARING ENRICHES US ALL

Sharing experiences is an important factor to meet the challenges that the education system is currently experiencing.

- Web: http://robotica.citafgsr.org/
- Blog: http://www.citafgsr.org/educacion/robotica/
- Twitter: #roboticacita

There you can consult its workshops, activities, photos, videos and comments on the evolution of all these initiatives described.

V. CONCLUSIONS

In this paper, we have introduced the range of educational robotics activities implemented by CITA. These activities can explore, identify and develop the technological talent of the participants, that is, the potential to have outstanding performance when facing real-world problems, using tools and manipulative skills.

Thus, CITA helps to complete, enhance, maintain and meet certain educational tasks. Therefore the education system finds a good ally in CITA to enhance the technological talents using educational robots Lego Mindstorms NXT. This kit, as has been seen in the activities presented, due to its flexibility facilitates the construction of different designs of robots, according to the didactic objectives to be achieved.

Perhaps, in the future, new partnerships will be form between education centers and foundations or non-formal sector institutions. This partnership will arouse new ways to find and share solutions. In the future, we will be able to find the way to better educate our children, whatever their needs are.

Finally, we consider it essential to know and train talent in order to guide decisions on the academic future. It also requires joint efforts of academic and family in identifying and potentiating of the passions, skills and performance of the children, guiding them to build a successful life plan.

ACKNOWLEDGMENT TRAINING STAGES OF TALENT

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