ROBOTEKA: Robotics projects in secondary school

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Abstract

Brazil is undergoing a period of great economic development, and education has been tracking this trend. According to the IBGE (Brazilian Institute of Geography and Statistics), the literacy rate reached 90% of the population in 2007. But, contrary to what one would expect, it is having a shortage of engineers and technical professionals. Only 22% of the population completes high school, and 11% graduate in universities. This results in about 30 thousand students concluding engineering courses every year, not to mention that about a third of them end up working in an unrelated area. This lack of motivation for the area is a major concern, and may end up preventing national growth.

The ROBOTEKA project aims to close the gap between basic education and superior education in technology, using educational robots. It was developed jointly at UFRGS (Federal University of Rio Grande do Sul) and Brazils Department of Education, and it's being held in the state of Goiania, using its network of NTEs (Centers for Technological Education for School Teachers) and the support of CRECIEM (Reference Center for Teaching Science and Mathematics).

Through the presentation of programming concepts, mechanics and projects design (focusing on robotics), it is expected that the students involved will have a better understanding for engineering, and might developing interest in it. Their experiences should be propagated by the college, through informal talks and works exhibitions.

The group is working with the LEGO Mindstorms platform a Moodle system for distance learning. Since the schools and the university are in different states, the work platforms must use simplified, so that teachers could work without technical expertise.

During 2010, the nine schools involved in the project received courses and monthly visits to inspect their progress in understanding the kits. Each has developed a prototype robot to master its use, and made its presentation. Now, in 2011, they are going to participate in a municipal exhibition of robotics, where their projects will be presented for the general public and will be evaluated by a panel of university teachers.

1. Introduction

During the last decade, Brazil’s economy has been growing steadily, and in the face of events such as the ascension of a new consumer class, the real estate market boom, the 2014 FIFA World Cup and the 2016 Olympics Games, innumerous industrial opportunities appear.

But, while Brazil has the potential to improve its economy, a great deficiency has been the theme of studies and cause of concern: the lack of qualified engineers at the most diverse specialties. The demand for engineers is so high that the mean salary for newly graduates has tripled in just four years. This deficit is not only due to the lack of already graduated professionals in engineering, but also to the proportional low number of candidates, if compared to developed or developing countries, such as India or China. Even so, according to researches run by the Institute of Applied Economics Research (IPEA), in 2009 38% of the workers with a degree of engineering were not employed at subject related areas, featuring an aggravating factor at the already deficient offering of specialized workers in one of the most important and relevant areas of economy.

During the last decades, Brazil’s main goal in education was to have a strong higher education, investing mostly in its universities, and today the public universities are praised by their quality.

Boesing (2009) made a compilation of statistic data about universities in Brazil during the 2000s. We can observe a big expansion of higher education courses and, in 2009; there were 3.164.379 vacancies in universities, a growth of 160% from the 1.200.000 vacancies in the year 2000. This growth can also be noticed in the undergraduate courses offer, which jumped from 10.585 to 27.827 in the same time.

This number might be deceiving, if we look at the distribution of courses. About 30% of them are courses on administration, law and business; 20% are related to education and only 10% for engineering, which is divided in more than 200 different types (including courses such as clothing and road engineering).

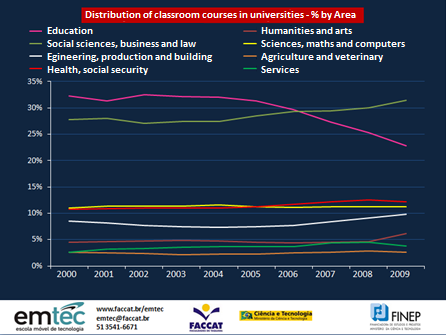


FIGURE 1: Evolution of university courses in Brazil from 2000 to 2009 (modified Ivan, 2009)

Another relevant factor is the filling of the university places. When we look at the number of enrollments for places in the university grew 90% in the same period, from 2.694.245 to 5.115.896. The demand for undergraduate courses is not fulfilling the offer. Adding to this is the fact that university courses in Brazil have high rate of evasion, up to 40% of the candidates does not graduate in its course.

When looking to the elementary education, since 2007, 90% of Brazil’s population is literate according to IBGE (Brazilian Institute of Geography and Statistics). Unfortunately, the number of high school graduates is just 22%, and only 11% of the population enters universities, a really small portion. From these 11%, just 4% end up graduating, summing 826.928 students every year. Comparing with the 30.000 engineering students graduating every year, we can see how little the interest in the area is.

The question arise: How can we attract more talents for engineering? How can we create more interest and reduce evasion?

With the presentation of such reality and difficulties the Roboteka project sets as objectives the insertion of young high or elementary school students in the technological and scientific context of the engineering courses, hoping for an increase in the search for and interest by the engineering courses. It also hopes to promote familiarity with the subjects of study and actuation of technical professionals, probably reducing the chances of future university withdraws due to students unmet expectations.

1.1. Robotics and education

Robots are becoming a commonplace in all areas of our knowledge. They are also becoming a promising idea for education. Besides holding the student’s attention, robots, today, may become a practical, cheap and relatively easy to use platform for teaching of many kinds of subjects to students of all ages. They can also be the platform for students to develop their own projects or solve complex problems.

They are a powerful learning tool because even physics or geography lectures can use them at classes. You can program them to perform a certain movement or install sensors in it and watch it analyses the soil chemical composition. Robots are definitely the most interdisciplinary technology.

While robots projects are complex, require a lot of technical knowledge and are not very cheap, there are platforms that abstract these innate characteristics. One example is the LEGO Mindstorms NXT, which is a kit with parts, sensors and electric motors ready to be combined to create many kinds of mobile robots or static machines to perform lots of movements and tasks which are defined using a program that comes with the kit, where the commands are showed with images that represents the chosen orders or movements. These programs are really easy to be used by kids and teenage students.

These kits can also be a tool for digital inclusion. Brazil is a land full of contrasts, while it’s the seventh world economy; it is also has one of the greatest economic inequality. When looking at ONU’s 2009 Human Development Reports, Brazil’s Gini coefficient (which measures economic inequality) is the world’s tenth bigger. It’s not surprising to see in rural areas people that don’t even know what is a DVD player, separated by just a few kilometers from areas where technology is used in a massive way; where precision agriculture is made with large machines, sensors and telemetry.

Brazil is the right place to use educational robots; if schools create groups of students to work with technology; this will make a greater part of the population being digitally include, and may motivate more students to search for engineering courses. The promotion of group and interdisciplinary activities has also its own benefits, making the students aware of the problems being currently faced by the country and the world, helping them with their research, administration and teamwork abilities and the shaping them into responsible and dedicated citizens.

2. The Roboteka project

The project Roboteka was conducted by UFRGS’s PET (Tutorial Teaching Program in the Federal University of Rio Grande do Sul State) Computation group, composed by of 12 graduate students from both Computers Science and Computers Engineering courses at the university, coordinated by professor Dante Barone. The group’s main goal is to develop actions in Research, Teaching and University Extension. This project aims to create a group of schools working with educational robots, closing the gap that exists between basic and superior education in technology. It is the sequel of another project that the group conducted for three years, the RoboEdu.

2.1 History

Since the year 2000, the PET Computation group has been working with robot soccer. In 2006, after the fourth team built, came a question: what can be done with the older hardware?

The RoboEdu project was a spinoff project that aimed to use those robots to aid teaching. Initially, the group worked with Municipal School Tubino Sampaio, in Porto Alegre, using robots and computer simulations to give physics classes for students. Some classes on robotics were also organized in the UFRGS technical school, in order to give students a different perspective in programming and electronics.

The project ran for more two years, giving courses on robotics and programming to school teachers and workshops for students. In these years, the group also helped schools involved with the LEGO FIRST competitions that were held in these years. Negotiations for a broader group in the prefecture, called First Sciences Center, started, but were not developed since the discontinuity of the competitions.

2.2 Objectives

Since robots in education were well accepted by teachers in the prior years, and most students that took part on the workshops remarked that they were missing this contact with engineering, a sequel for the RoboEdu was proposed, called Roboteka. In order to make it more effective, this project should aim to give the knowledge on robots and engineering to schools, so it would reach more students than the workshops. This would also give the project independency from external partners, and the schools would be able to keep the activities without them.

So, Roboteka’s main objective was to organize a group of schools to work with robots, and giving them lectures on engineering and technical issues, so they would be able to develop their own robots and exchange their knowledge. Since these schools will have students working in technical projects, it’s also expected that the students will have a better understanding on the engineering career and will seek them after graduating.

2.3 Organization

The Roboteka Project was launched in 2009, through negotiations with the Brazil Department of Education, by UFRGS professor Dante Barone. The project was held in Goiania, the capital of the state of Goias, 2000 kilometers away from the university. In spite of the distance, Goiania has a strong structure of NTEs (Centers for Technologies Education), groups that gives formation in technology and multimedia for school teachers. Also, the schools have the support of the CRECIEM (Center for Reference in Teaching Sciences and Maths), which not only gives support for school laboratories, but also organizes a municipal science fair. The center is coordinated by professor Lydia Polleck, and was responsible for selecting and coordinating the participant schools and notifying the group on the progress of the activities. The following map shows how far those cities are:



FIGURE 2: Map of Brazil showing Goiania and Porto Alegre cities.

The following municipal schools took part on the project in Goiania:

* Edmundo Rocha
* Heli A. Ferreira
* Hermógens Coelho
* Jardim América
* José de Assis
* José Carlos de Almeida
* Nazir Safatle
* Olavo Bilac
* Pedro Xavier Teixeira

The Lego Mindstorms kits were chosen as the basic platform for the project, since the group had experience with, and the platform is very simple, so it should not be difficult for the teachers and students to learn its use. The physical pieces, the sensors and actuators would also help them to come up with ideas for robots, and would limit the types of problems that could happen.

The MITs GogoBoard was also considered as a possible platform, but dropped since it required some programming skills and knowledge on electronics that most of the participants didn’t had and would require a long to train them.

2.3 Development

The Roboteka Project was developed in three stages. It started in June 2009 when professor Dante Barone and the doctorate student Marcelo Carboni went to Goiania for the project official opening with the Goiania state secretary for education, prof. Milca Severino. Lectures were given to teachers from the public schools network about the use of new technologies in education and how robots can be used in classrooms.

The group also acted in the 10th Congresso e Feira de Educação Pensar (Congress and Exhibition on Education and Thinking, the city’s science fair), in October 7 to 10. This time, the actions were aimed for the high school students, in the form of lectures and workshops on LEGO Mindstorms programming, given by graduate students Felipe Chies and Marcos Cavinato. These activities had a motivational character, so that teachers and their students would be drawn for the project.

The second stage started in 2010, and its goal was to train the teachers on using the platforms during the first half of the year, while buying the LEGO Mindstorms kit. In the year’s start, the CRECIEM choose nine schools to take part on the actions.

Since doctorate student Marcelo Carboni departed from the project, two new staff members were hired in this year, Dhiego Carvalho and Lucas Mizusaki. They helped to set up a distance learning tool (the Moodle, which can be visited in the link [http://moodle.inf.ufrgs.br/course/ view.php?id=364](http://moodle.inf.ufrgs.br/course/%20view.php?id=364)) in order to coordinate the actions with the group. They went to Goiania in April, to give classes for the teachers involved. This meeting started with a formal introduction with a presentation, analysis and discussion of the impact of new technologies in education. There was a Moodle tutorial and a small workshop on how to build and program LEGO robots.

In order to continue the project, the teachers were asked to send ideas for robots before the next meeting. They should describe the robot and it’s functionality, how they would build it (which sensors and actuators had to be used), and how this robot was related to their courses. The main purpose to this was to check how involved the teacher would be, if they could create projects related to their disciplines, and if their students had ideas.

Unfortunately, after two months, only one teacher sent us this project. This shows one of the greatest challenges; most teachers do not have the knowledge or the time to study this technology and will not feel comfortable enough with it, even when using a simple tool the as LEGO Mindstorms.

The third was intended to take place in June 2010, with the delivery of the kits to the schools. Unfortunately, the deliver was delayed to August. So, during the second week of June, Cristiano Dalbem, Dhiego Carvalho, Felipe Micco and Igor Schmidt went to Goiania, in order to give a workshop on how to build robots for classrooms. The group also took part on the 11th Congresso e Feira de Educação Pensar, giving new workshops and lectures on robotics for the whole school network. The following is a picture of the group in the fair:



FIGURE 3: The group in the the 11th Congress and Exhibition on Education and Thinking

In Augusts second week, the group went once again to Goiania, this time to give the LEGO kits to the schools. They also visited every school to give the kits and a lecture on robots and on university courses. The term of commitment that every school signed aimed for the continuity of the project; the following aspects were observed:

* The LEGO Mindstorms kit is to be used for projects with the school students;
* The school will show its projects to the other schools every year, through a science fair.
* If the kit is not being used by the school, it will return to the CRECIEM and will be assigned for a new school.

There were two other visits to Goiania during 2010s second semester, in order to keep up the schools progress and help with problems that could arise. The first took place in September 30, when 5 schools met took questions to the group in the NTE. The second visit happened in November 3, when the group visited every school individually to see how their groups were organized and how they worked with the robots.

The project concluded in December 13, when the schools met in the NTE to discuss the year and show their projects to each other. They were also evaluated by the group. The results are discussed in the next section.

3. Conclusions

The fact that every school brought a robot to the presentation at the end of the year is not a measure of the projects’ success. In order to see how these robots affected the students and teachers, we must look at the technical aspects of the robots the schools prepared and how they developed their works during the semester.

The 9 groups created automated cars, with two motors for steering and one for a claw or crane, and most of them justified the build as a robot for cleaning roads from rubble. This was the basic design taught during the training. Looking closely, 3 schools developed good projects, going beyond what was taught in the training, experimenting with different builds (levers, for example) and one school even built a small contraption to simulate a rotating brush. These schools also created multiple programs with the basic functionalities, and experimented with sensors. Their robots performed some simple works, such as grabbing an object and moving it.

There were 3 schools with average projects, building a really simple robot with a very basic programming, without sensors or replicating one of the example programs given to them during the training. The last 3 schools built a robot “on the fly”, just to present something to the group. The following picture was taken from the schools robots:



FIGURE 4: Eight of the robots created by Goiania schools.

During the semester, we noticed that most schools had a very slow development. Most teachers still had fear to work with the kit, even after the training, and could not help their students to develop projects. They also had little time to research, since most of them work in two different schools in order to have a higher pay grade. This time constraint is one of the greatest problems for this project, the teachers had little time even to take part on the training.

It was also difficult to organize the large groups of students interested in working with the kits with the small time constraint, and most groups did not work more than one hour every week. The 3 best schools were those who had smaller groups and whose students overcame the time limit by going in their time off classes to school.

Most teachers also remarked that they could not think on interesting projects for their students. Technological insertion is not easy since, without previous experience and little time to research, the subject cannot develop familiarity. This is why we could not see the expected creativity from the students and teachers alike in their projects. For 2011, every school created a robotics course in their syllabus, so that they will have more time to work on the kits.

In spite of these problems, the schools not only built robots, but also used them in their own context. As noticed in the introduction, Brazil has a high evasion rate, and the teachers told that by creating a robotics group in the school and showing their activities inside the school (visiting classes and in their science fairs), the overall interest of the students on their classes was renewed, even those who were not working with the kits.

In order to check if the involvement in this project created interest for engineering and technical areas, we also gave the students questionnaires to fill.

3.1 Questionnaire

To measure the projects impact on the students, they received a questionnaire on their thoughts on the whole experience. They answered, anonymously, the following six questions:

* How would you rate the experience you had in the project?
* What were the positive and negative aspects? Do you have any suggestions?
* Would you say that the experience was positive? Why?
* The experience with robots helped you in the classroom? How?
* With what you'd like to work, and how to achieve your professional career? Experience with robotics helped you decide on a career?
* Do you use or would like to use some educational tool in their classes (chemistry kits, notebooks, models, etc.)? Which and why?

40 questionnaires were answered, and the following points were observed:

The students unanimously considered the project a good experience. They praised the contact with technology as something important, and that they received an insight in questions they didn’t know existed. The following were the most iconic of the answers:

“It was quite enjoyable, as it opened my field of interests and research, giving me knowledge about robotics, something that is unfamiliar to us, students”.

"The experience was good to gain experience and knowledge on mechanics and technology."

The students mentioned experience and knowledge gained through building and the partnership between colleagues as the mains strong points in their activities. While the majority of the weak points are: missing parts, lack of time, schools technical limitations (lack of computers and internet) and eventual disagreements amongst students.

Every student remarked that the experience was positive, especially since they learned about something unknown before, robotics. It was also said that the project gave them interest in research and gave them a good overview on technical courses.

From the 40 questionnaires, only 5 students said that the experience did not help them in the classroom. The others remarked unanimously that the experience gave them interest and aroused their curiosity on the class’s subjects, mainly in physics and math’s. 18 students also remarked that the project helped them to decide their career, with 6 students choosing computation, 1 mechanical engineering and 2 mentioned “engineering”, while the rest did not answer the question or were indecisive. The following table lists all the cited professions.

TABLE 1: Reported course preferences

|  |  |
| --- | --- |
| Biology | 1 |
| Human Sciences | 1 |
| Computers | 9 |
| Education | 1 |
| Engineering | 2 |
| Civil Engineering | 4 |
| Mechanics Engineering | 2 |
| Journalism | 2 |
| Medicine | 6 |
| Military | 1 |
| Chemistry | 1 |
| Undecided | 5 |
| Not Answered | 5 |

Also, almost every student replied that they would like the use of educational tools in their classes, 18 of them saying that these tools could illustrate the subjects and would make the classes more interesting. The other 22 only remarked that an educational notebook would be very interesting for them.

So, it’s correct to say that technical projects have a place in schools, and they can be of great service to the students, since most of them have no contact with research and development. Also, robots give great visibility to these areas, and will inspire other students to look after more information on engineering.

3.2 Next Steps

After six months with the kits, the schools did create their projects, but with some limitations. As observed, teachers did not have the time to study the kit by themselves and develop familiarity with it. The group went once again to Goiania in April this year, to give again training on programming. It was noticed that only 5 schools sent their teachers, and that most of them still had the same problems to think on projects to build with their students. The bi-monthly visits to Goiania are not helping much, since the schools couldn’t come up with questions for the group. Since the schools have their robot groups organized and most teachers created disciplines to have more time with their students, we can take a step forward and rally the schools and give

The most effective way to organize schools to work with robots is to give them the material needed and a goal to accomplish. Without a goal, most of them will consider this a secondary project. While the existence of a robotics project in the school is benefic, the students may end up just build the same robots for fun; this will not generate knowledge and will turn the kits into educational toys.

The group is writing a booklet on the kit, teaching basic programming and building skills with some exercises, a manual for the project. Also, in order to create more compromise from the schools, a cooperative challenge is being proposed to the schools. Following the lines of other competitions, such as LEGO FIRST and OBR (Brazilian Olympics for Robots), the schools will build robots to accomplish five trials about the nuclear accident that happened in Japan this year. Their robots will have works on map to clean the rubble created by a tsunami, rescue the population, map radioactive hotspots, repair the nuclear facility and rebuild the area after. The performance in these trials will not be the only evaluation method; they will have to write down their projects, make a research and will have their behaviors rated during the competition day.

In order to help the schools with their technical problems, the project conducted some negotiations with the IF-GO (Goiania’s technical school). Two kits were donated to create a group of students to give technical support and develop projects with them to show in fairs. This partnership will also serve to close the gap between basic and superior education.

In order to evaluate the efficiency of these actions, two surveys should be done by the end of the next year. One with the students of the schools, to see how these challenges affect them; and the other to see if there was any influence in the inscriptions for engineering courses on the university.

Brazil is investing in these new technologies for education. Not only the country is inserted robotics as a programmatic line in its Mais Educação project (More Education project, that aims to finance extra-curricular groups in the most diverse areas in public schools), but it is also buying educational notebooks (with the Um Computador por Aluno project). Roboteka group is already taking part in these programs, helping as a reference for training teachers and choosing the kits, and is aiming now for an expansion.

In the future, this project aims to work with FIRST to organize an annual competition amongst technical schools, with the creation of a specific league, which will lead to the development of a national open source robot kit.

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