Robotics in Education eJournal

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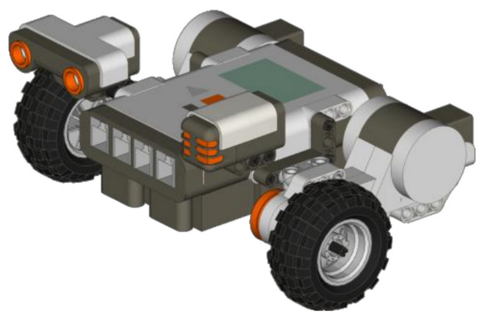
Compiled by Damien Kee – Domabotics



Robotics in education is fast becoming a popular way to engage students in the fundamental STEM concepts (Science, Technology, Engineering and Math). This eJournal brings together articles from teachers from all over the world who are using Robotics in different and exciting ways. Please join us on the *Robotic in Education* mailing list, and let us know how you have been using robotics in your classroom.

Contents:

Damien Kee – *Robotics in Education* mailing list coordinator and moderator.

Dr Damien Kee holds a PhD in Robotics and Bachelor of Electrical Engineering from the University of Queensland. Damien has been heavily involved with the RoboCup Junior competition since 2001, currently serving as Chairman of RoboCup Junior Australia.

He has been running robotics workshops in Queensland, Australia and Internationally for students and teachers since 2002 and has worked with over 1000 teachers and countless more students.

A week of Legos

Ed Chapin - Chattanooga Engineers Club

For several years, Chattanooga Robotics, an education project of the Chattanooga Engineers Club, has developed a five day (fifteen hour) introduction to the Lego robot. This is our eighth year sponsoring and mentoring First Lego League competition, but a short and fast introduction to the Lego NXT was developed to use during the spring and summer (FLL off-season) to stir interest in the FLL program (11 teams last year and 16 to 18 for 2009).

We have used these techniques at "summer camp" sessions at the Chattanooga State Community College for three years and at the Creative Discovery Museum Science Theater for two years. We use the same robots assigned to teams for the FLL season (August through December), with cleaning, sorting and testing on the standard 9797 NXT robot. After the first year, the bill of materials was changed to eliminate the "minifig" pieces (too much incentive for horseplay) and add a "skid" (2 X 2 dish) and a "disassembly tool" to the basic components. This way, each robot is used by three or four groups each year, both reducing capital costs and keeping the rechargeable battery in good condition.

The next major issue was portability and the realization that the 4 X 8 First Lego League table was simply too large to move from place to place and limited the number of robots that could run at the same time. We developed the "BOT-BOX" so that teams of 2, 3, or 4 could each test a robot at the same time, without mingling the parts from the basic set. Each team has its own construction area, programming area, and challenge area that is easily moved from one location to another. I can easily load eight BOT-BOXes, eight robot kits, and two boxes of challenge parts and supplies into the rear of a pickup or SUV and convert a computer lab into a robot lab in minutes. For details on the BOT-BOX, see http://chattabot.org/botbox.html.

Our curriculum is quite simple. See http://chattabot.org/resources.html. Each team consists of 2, 3, or 4 students (depending on space and computers available). Each team has a robot kit (9797), a BOT-BOX (with challenge inserts), a computer, and chairs. Each team has a standard banquet table (6 foot or 8 Foot) OR shares a table with another team (8 Foot). As the teams move from one challenge to another challenge, the robot is stripped to a "brick" with two motors and all parts returned to the kit box. The robot, parts kit, and challenge box do not move from their original table location.This makes it MUCH easier to clean, recount and resort each box at the end of the week.

During the first day we discuss the origin and current uses of robots. See http://chattabot.org/resources.html for Power Point slides. We then have each team build a robot (currently the Damien Kee DomaBot) and use the brick pushbuttons to program it, without the use of a computer. The programs are tested in the BOT-BOX. The robots are then stripped of sensors and put on the chargers. A quick review and the first day ends.

The second day, new teams are chosen and we equip each BOT-BOX with a challenge. Some of these come from previous years of FLL challenges, some are simple parts (pick up ball, drop ball into plastic box, etc) used over the years. Most of these challenges require only motor control and each team completes two or three, moving from one table to another at the end of forty five minutes. Strip down to motors, put on charger and a quick review. The challenges are mounted on 30 X 40 inch foamcore (a standard US size) which fits the BOT-BOX. Difficulty of the challenge is related to group experience. For photos of a BOT-BOX holding a challenge, visit http://chattabot.org/botbox3.pdf.

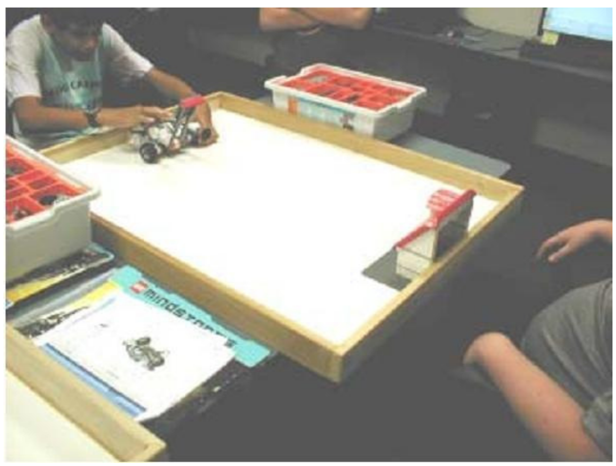
The third day begins with a discussion of sensors and how they can be used in the challenge. Teams change again. Some programming tips on sensors. The challenge parts remain the same, but now a sensor MUST be used and the challenges become tougher (additional task, more precision, etc.). Two one hour sessions, a longer discussion and "success stories" are again followed by "strip down" and charge routines. Blue 3M painter's tape (delicate) makes an excellent light sensor target, when applied to the foamcore. It has an excellent contrast with white board, installs and/or repositions easily and is removed without damage to the foamcore board.

The fourth day, team captains that "GET IT" are chosen and they chose team members. By the fourth day, those with skills are easily identified. Making them captains both spreads the success and makes each one of them "assistant teachers". The sensors are discussed again, success stories are repeated and the day is like day three, but with a faster pace and more success and either two or three challenges, depending on group skills.

The last day is the contest. Teams are chosen at random (I use paper slips in a plastic coffee can) and the teams are given the "Final Challenge", the Firefighter. Each team must build a robot, using two sensors and program "loops", that will enter a "smoke-filled room" that is 20 inches X 30 inches and has a 9 inch door in the middle of the long side. The robot must search the room in a counterclockwise direction, going into each corner and then exit by the same "door" that it entered. As a retired fire chief, I can say that this is essentially the same technique taught to firemen to search a room with limited visibility. The first team to succeed three times wins the prize (usually a $5 Burger King card, or similar) for each member. We then discuss the practical uses of robots, put up the robot kits and dismiss.

I have used this routine many times, with “gifted” students, “typical” students, and groups that include “special ed.” students. It has never failed, but there is a lot of dexterity required on the part of the teacher, particularly for “atypical” students. Both “gifted” and “special ed.” require some creative supervision and, often, more than one “assistant”. Successful assistants are rising coaches that want some experience, successful team members from previous FLL teams, and technology students with robot experience.

No two sessions are ever the same, and I also learn something every session, which becomes a small change in the plans for tomorrow, or next year. For details of some of our programs and experience, visit http://chattabot.org and see what we did recently.



BOT-BOX in use

Introducing Lego Robotics for talented students in middle schools: small start-up projects

Roberto Catanuto, Ph. D.
Robotics Projects Coordinator
Middle and High Schools

1. Introduction

The italian way of teaching has suffered a long-term, slow pace towards technologies in regular curricula. Teachers are used to pursue traditional classes in traditional ways, as an heritage from their teachers in decades ago, and so on.
On the other hand, it is a matter of fact that students gain a day-by-day growing practice with modern tools, changing their way of life but, especially, changing their way of watching the world, acquire new knowledge, get into relation with one other, etc. Shortly, young kids speak a different language from their teachers, making school activities often tedious and not engaging.
The view of the Italian Ministry for Education is rapidly changing and new pedagogical approaches, mainly based on new technologies, are gaining more and more interest in today schools. Also, a number of robotics activities have taken place in the last few years, and more and more schools are running into this field.
Following this world-wide experience, the author started a collaboration with a little number of middle schools, to enrich their curricula by adding Lego based robotics activities.
This paper is intended as a report of the experience done and lessons learned.

2. How it all started.

The author is involved in the management of the *MiniRobot* (www.minirobotics.org)[1] competition for high school students of Catania (ITALY) school district. The competition began as a natural evolvement of the robotics courses the author and his colleagues pioneered in a number of schools, as volunteers, since 2003. Its first edition was in 2006, as a joint event of the larger Eurobot 2006 (www.eurobot.dees.unict.it/)[2] robotics competition, for university students, held in Catania in that year.
Then, following the suggestions from the Italian Ministry for Education and the experience gained during these last years, the author proposed a collaboration with some middle schools in the district, in order to get feedback from headmasters and teachers.
The answer was positive in almost all cases: irrespective of their background, principals soon understood the real value of a robotic course in their school setting, as an invaluable tool to help students gain better competencies in logical and critical thinking, mathematics, collaboration among peers, communication, etc. More exactely, none of the first three schools accepting the project had a principal expert in math, science or technologies in general. One of them is a pedagogical expert, the second is a literature expert, and the third is an art and painting expert.
Based on this good first step, the joint project began, and the first phase took place: how to choose students fitting well in the activitiy ?

1 the english version of the site will be available on the early October, 2009
2 the competition changes its location every year

3. Courses general set-up

The author firmly believes that each student can gain good learning via robotics, especially to strenghten his/her abilities in mathematics and related fields. Anyway, each school staff decided to start the experience gathering only a little number of students with outstanding proficiency in mathematics. This decision has two motivations:

- as a general wide experience, it is better to enroll not more than 3 – 4 students per group (i.e. per kit); on the other hand, schools' financial resources were not large, so we jointly decided to gather only one group, composed of 5 students
- robotics has a deep impact on the common experience of life the youngsters, hence most of them misunderstood the activitiy, thinking its aim was to build famous commercial robots in short time and no effort: that's why we chose to accept only students with great mathematics scores and who had a clear view of the intended work to be done, with a strong accent on math and science related topics. Our choices were wrong.

	First school	**Second school**
no. of students	5	10
grade/age	second middle school year / 12	second middle school year / 12
no. of students per kit	5	5
no. of groups	1	2
gender distribution	3 male, 2 female	5 male, 5 female
hours per week (average)	2	2
no. of weeks	10	12
staff	the author as main coordinator, plus a technologies teacher as collaborator	the author as main coordinator, plus a technologies teacher as collaborator

3.1 First school: important remarks

Part 1 – Introduction

The course took a gentle start, since students involved had no previous experience in robotics. The author introduced them to general concepts in the field, especially driving attention to concepts such:

- automation and control: what makes a machine a robot ? can you identify robots in your daily environment ? can you state three characteristics that let a machine be a robot ?
- main pieces of a Lego robot: brick, motors, sensors
- how to tell a robot to accomplish one or more tasks: this has been the core of the project since it lays on a fundamental concept in mathematics (and computer science in general), i.e. the design of an algorithm. First, students were invited to focus their attention to algorithms they use in their daily lives, even if not consciously. They were told to reproduce on a flow diagram all the actions they perform in daily activities like dressing, going to school, eating and so on.

Kids had a good response to this approach, it attracted their attention to concepts which were understandable by them (using their already possessed ideas) but were all the same new and engaging. The author intended aim was to increase the ability of the participants to structure their way of thinking in a rigorous and sequential way, which is a previous step necessary to introduce them to programming, with as few hard steps as possible.

Part 2 – Construction

Students were called to build a simple wheeled robot, no sensors at the beginning, very similar to the famous Lego Tribot. They build it rapidly and then the group started to explore the capabilities of the robot, programmed by the NXT-G language *motor* block. Examples of the challenges given are:

- measure and compare the distance covered by the robot when you choose 90 degrees in the options menu or you choose 0.25 rotations in the same menu
- can you predict how far will it reach if you choose 3 rotations in the above menu ?
- how many degrees you have to choose in order to let the robot performing a complete turn, going in the backward direction ?
- can you let the robot make a 90 degrees steering ? can you use this result to let it perform a square like trip ?

The author decided to stress repeatedly two logical aspects in this work:

- the need to *predict* results well before measuring them experimentally or trying to obtain them via a trial–and–error approach: this requirement compells the students to critically analyze the situation, using all mathematical tools they have, hence optimizing the setup of the simple experiment;
- the need to *build* new results and concepts, making clever use of the previously gained results: more in detail, students were told to move the robot in a square like path, after they learned how to let it perform a 90 degrees steering; this approach is intended to drive students towards the concept of *loop,* which was not a part of this course curriculum but will be in future follow up

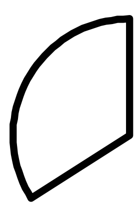
Part 3 – The robot

After the participants increased their knowledge about the fundamentals of the motor block usage, they were told to design and setup their own project. This school is affiliated with an High School of Arts, so it was clear the best choice was to design a drawing robot. Due to lack of time, it was not possible to build a robot able to move up and down a pen, hence we tried to draw simple figures with a fixed marker attached in front of the brick.

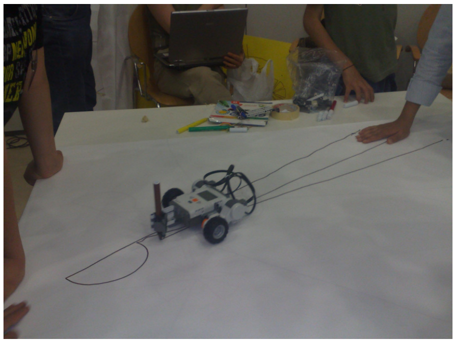
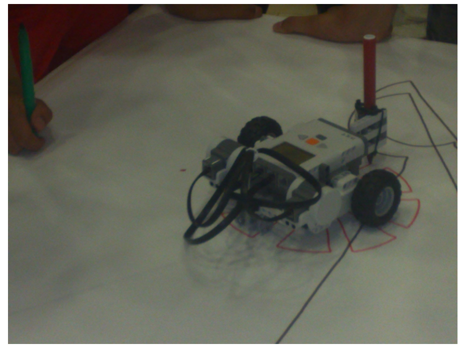
The results were very nice: the first intended paint was a simple representation of “Etna” volcano (first picture), a famous characteristic of this zone of Italy. The second one was even smarter since it reproduced with great care the shape of a flower, in almost all its parts. The last drawing was interesting since students understood they may draw things made up of only some basic shapes:

- straight lines:

- arcs of circumference



So, their work was to recognize these two basic shapes in the intended drawing and program the robot to move according to the desired output. The flower was drawn elegantly using only straight lines and arcs.

Part 4 – Outcomes
Kids learned how to reconstruct different shapes, taken from real world, using hard constraints in the drawing, since the robot was built in such a way that it kept its pen attachment always down, writing on the paper, whatever the movements were. This means it may create mainly the two different basic shapes described in the previous paragraph.
They also learned how to tackle problems together, how to discuss solutions proposed and how to propose their own solutions to their mates. The group were well composed, and there have been no problem in terms of collaboration among them and with the author.

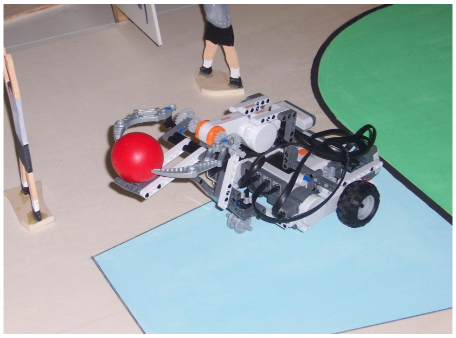
3.2 Second school: important remarks

Part 1 – Introduction
The school proposed an higher number of kids, 10, but, at the same time, the kit was only one. So we split the group in two parts, which would have worked separately on the same core part of the robot, implementing different arms, tools and movements. We created the two groups in the following way: we wanted top students to be evenly distributed among the two teams, so the rest of the students were randomly chosen in order to fill the 5 places in each group. It was a chance, but the first group was composed only by males and the other only by females.
After a short general introduction to the course, students were exposed to the same topics used in the first school (as above mentioned).

Part 2 – Construction
Students were asked to build the same robot as in the first school, and to explore its movement characteristics. They undergone the same set of exercises and tests, also to make comparisons between the two sets of participants.
The two groups in this school were more engaged in the activity. 4 out of 5 of the male students were really enthusiastic about the work: they repeatedly proposed new approaches to the problems, new projects to design and so on. 3 out of 5 of the female students were at the same level of the first group, and worked actively in the tasks. In both cases, the response of the group were really higher than in the first school, hence we decided also to introduce the participants to the use of Lego sensors, which was a good choice to realize the final robots.

Part 3 – The robots
The first group (first and second picture) decided to build a robot able to hold a ball, moving in a straight way until it reached a black line. After that it threw the ball towards a goalkeeper, eventually scoring a goal. Kids were really engaged also in the construction of the scenario around the robot, probably because it belonged to their daily world of experiences, where sports are always present.
The second group, decided to undertake the construction of a robot able to move in a very simple

maze, hence making use of ultrasonic sensor. The greatest problem was to let the robot make correct steerings, since it changed frequently its behavior.



Part 4 – Outcomes

The results were really good, especially as far as regards the first group of students. The plans were to let them study only the move block and tasks related, but they learned almost alone also how to use and program the sensors, especially the light sensor.

As for the first school, they also learned how to tackle problems together, how to discuss solutions proposed and how to propose their own solutions to their mates. There have been minor problems in terms of collaboration among them in the male group only: they did not agreed always on how to solve programming and construction problems. The author had frequently to help them in order to divide tasks and let them work correctly.

3.3 Future plans

Both schools demonstrated an increasing interest in this kind of activities. Also, they soon introduced robotics in regular morning hours, not in after school periods. This was allowed by the internal rules of the schools.

The first school plans to repeat the project, increase the number of students involved, maybe also buying one or two kits more. Moreover, it plans to start robotics well before January, as it was in this project, in order to let more groups be involved.

The second school plans to repeat the project, maybe moving it in afterschool hours.

Both principals, teachers, students and also parents were satisfied with the outcomes gained by this project, and plans to collaborate in the near future.

Acknowledgments

The author would like to thank principals, teachers, and administrative staff from both schools involved, who supported the activity with great efforts and patience[3]:

- Art High and Middle School, Giarre (CT) – Italy
- “S. Domenico Savio” Elementary and Middle School, S. Gregorio (CT) – Italy

3 Permissions for using pictures are granted from schools staff or directly to teachers involved in projects reported here.

NXT Acidity Tester (aka. The pH Screaming Robot)

Michele Perrin
Marian Middle School – St Louis, MO

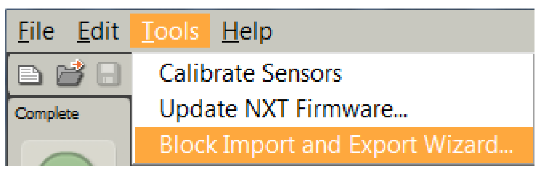
Most of us learned about acids and bases by sticking a scrap of litmus paper into a cup of soapy water. When the paper turned blue, we knew we had a base – easy to remember since they both started with "B." But in our digital electronic world, it is no surprise that students tend to equate the litmus paper test with Crayola's Color Wonder papers. Why not build a robot with your NXT kit to test the pH of a variety of liquids using an inexpensive pH sensor? As a math teacher I like using the pH sensor, because it gives numbers taking the guesswork out of comparing color intensities. As an engineer, I like the way a sensor-based robot combines science, technology, engineering, and math into one easy lesson.

Engineers use robots to do tasks that might be harmful to humans. One common example is working with hazardous chemicals. A hazardous chemical is one that could cause a negative health effect, such as cancer, lung damage, skin irritation, or even death. If a mixture contains at least 1% of a known hazardous chemical, it is classified as a hazardous material. Consequently, many common household solutions, such as paints, cleaners, inks, and dyes can be considered hazardous. Acid is sometimes considered a hazardous chemical, because it can cause severe burns if it gets in your eyes, nose, or skin. Not all acids are hazardous, however. Some acids, such as vinegar and lemon juice, are used in cooking to give foods their distinctive flavor. The acidity of a solution can be expressed using the pH scale. The acronym pH stands for the "power of H," or the concentration of hydrogen ions in a solution. Acidic solutions have pH values between 1 and 7; basic or alkaline solutions have pH values between 7 and 14; and neutral solutions, such as pure water, have pH values right around 7.

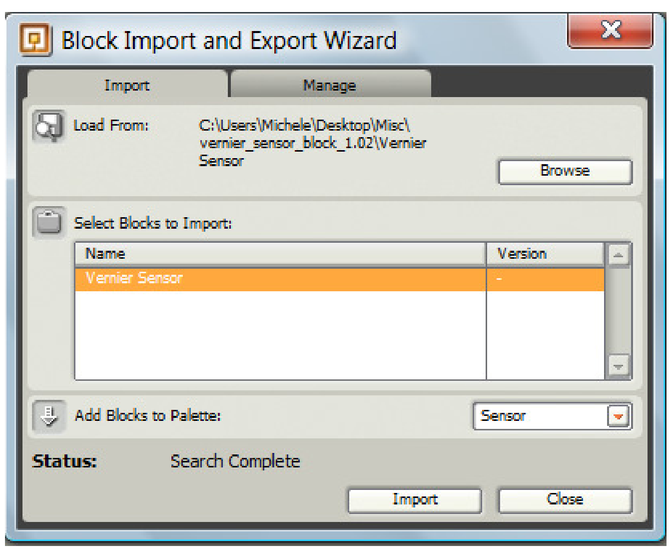
To give credit where it belongs, I first saw this activity on YouTube, traced it back to the Vernier website, and worked with the owner Dave Vernier to turn this idea into a class project. This robot will sort a group of liquids into acids and bases based on their pH values. The robot will be mobile, so that "hazardous" chemicals can be kept away from human operators. If the liquid has a pH greater than 7, the robot will assume the liquid is safe and push it off to one side of the storage area. However, if the liquid is acidic with a pH less than 7, the robot will scream and push it off into the hazardous material section. This gives an auditory as well as visual indicator of the liquid's pH. To build this robot, you'll need a Vernier pH sensor and an NXT sensor adapter. I've found that many high schools already use pH sensors in their chemistry classes; so if you can borrow one, all you'll need are Vernier's NXT sensor adapter and your LEGO® MINDSTORMS® NXT kit.

You'll have greater success with your students if you tackle this activity in two stages: first, teach your students to determine the pH of a liquid using the pH sensor; then build a robot to find and reposition a set of cups. We'll start with learning to use the pH sensor. The Vernier pH sensor is a wand-shaped device with a glass sensing bulb on one end and a BTA cable on the other. The BTA cable is slightly wider than the NXT cable, so you will need to use a Vernier Sensor Adapter. The adapter is about the size of the LEGO Sound Sensor, and includes a LEGO NXT cable socket on one end and a Vernier BTA sensor socket on the other end. You can attach the adapter to the side of your NXT with two black connector pegs, the same way you would attach any of the other LEGO sensors. Plug the pH sensor into the BTA end of the adapter; then use one of your NXT cables to connect the other end of the adapter to any of the sensor ports. For this activity, we will use Port 1.

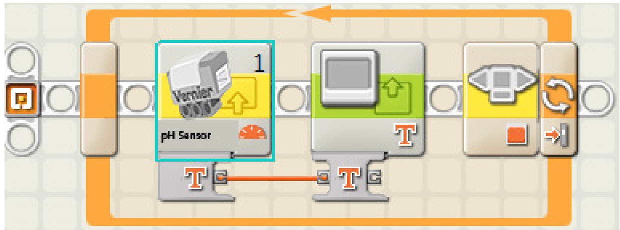
To use any of the Vernier sensors (they have over 30) you will need to import a custom sensor block into your Mindstorms software. This is a free download from the Vernier website, and will support either the original Mindstorms 1.1 software or the new data logging feature in Mindstorms 2. Since we are using it in a program, the directions that follow are basically the same for either version. After you download the Vernier Sensor block, use the *Block Import and Export Wizard* located under the Tools menu to import it.



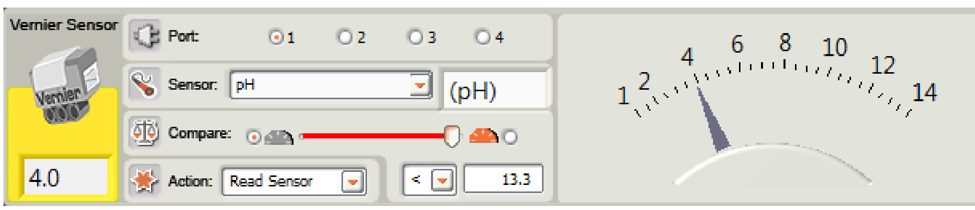
Click on the Browse button, navigate to the Vernier Sensor folder, select "Vernier Sensor," and click OK. In the *Select Block to Import* window, be sure to click and highlight the "Vernier Sensor" name or the Import button will not appear. From the *Add Blocks to Palette* drop-down list, select Sensor. The default is the Advanced palette, but it makes more sense to store this block in the Sensor palette along with the other sensors. Finally click on the Import button.



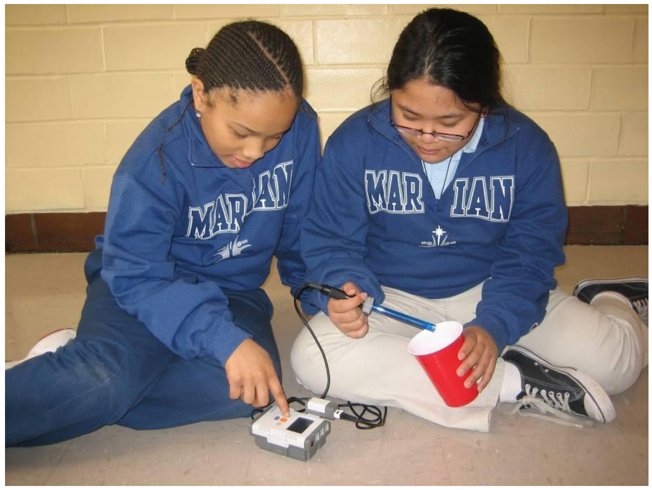
Once you have imported the Vernier Sensor block, you can begin programming with it. To collect pH data, we'll use the Vernier Sensor block and a Display block. We'll put both of those inside a Loop so that we can continuously test liquids without having to rerun the program.



When you click on the Vernier Sensor block, the configuration panel is displayed at the bottom of the screen. Since this one block controls several sensors, you will need to select pH from the drop-down list.



To display a sensor reading on the NXT screen, you can wire the Text output of the Vernier Sensor block directly to the Text input of the Display block without needing to use a Number to Text conversion block. Displaying sensor readings this way has the advantage of displaying the value with appropriate decimals and units. Download the program to your NXT and have your students test several liquids to get the feel of the sensor. One nice feature of this sensor block is that you can also see the sensor readings on your computer in the lower left corner of the configuration panel if the NXT remains connected either through Bluetooth or a USB cable. Make sure when students are lowering the pH sensor into a cup that they don't strike the glass sensing bulb on the bottom of the cup. Also be sure they rinse the pH sensor in between readings to keep stray drops from contaminating other liquids.



The final step in this activity is to build a robot to do the pH testing for you. Remember, we're trying to show that these liquids might be hazardous to humans. There are many ways this project can be tackled, but it's always best to start simple. Since you won't be able to see the NXT display screen, we'll use sound files as an auditory indicator of the liquid's pH. You'll need use two motors to build a mobile robot (Tribot is a good example), and a third motor to build a holder capable of lowering the pH sensor into a cup. Test this carefully to make sure the pH bulb doesn't hit the bottom of the cup. One good idea is to build a robot with a LEGO Touch sensor on the front. The robot will move forward to a cup placed directly in front of it, and lower the pH probe when the cup presses the Touch sensor. If the pH of the liquid is greater than 7, the robot can just say "Good" and back away. If the pH is less than 7, the robot will scream and continue pushing the liquid forward into the hazardous zone. Depending on your students' programming expertise, you can add the LEGO Motion and Light sensors and work towards sorting a small group of cups into acidic and alkaline areas.

Research has shown that students learn best when they are actively involved. What better way to experience chemical engineering than by having a little fun with a real world situation.

Introducing Lego Robotics for differently talented students in middle schools: large start-up projects

Roberto Catanuto, Ph. D.
Robotics Projects Coordinator
Middle and High Schools

1. Introduction

The Italian Ministry for Education interest is rapidly growing towards new pedagogical approaches in learning, mainly based on new technologies, which are gaining more and more interest. Also, a number of robotics activities have taken place in the last few years throughout Italy, and many schools are running into this field.

Because of these considerations and the good success of two small start-up projects in middle schools during the first months of 2009, the author proposed a collaboration with three middle schools more, in order to setup larger robotics projects for first, second and third year students (aged 11 to 13), eventually involving not only gifted students but also a broader audience of kids.

This paper is intended as a report of the experience done and lessons learned.

2. How it all started.

The author is involved in the management of the *MiniRobot* (www.minirobotics.org)[1] competition for high schools of Catania (ITALY) school district. The competition began as a natural evolvement of the robotics courses the author and some of his colleagues pioneered in a number of schools, as volunteers, since 2003. Its first edition started in 2006, as a joint event of the larger Eurobot 2006 competition for university students, (www.eurobot.dees.unict.it/)[2], held in Catania in that year.

Then, following the suggestions from the Italian Ministry for Education and the experience gained during these last years, the author proposed a collaboration with some middle schools in the district, in order to get feedback from headmasters and teachers.

The answers from the first two schools were enthusiastic in almost all cases: irrespective of their background, principals soon understood the real value of a robotic course in their school environment, as an invaluable tool to help students gain better competencies in logical and critical thinking, mathematics, collaboration among peers, communication, etc.

Moreover, schools staff made all efforts necessary to let their projects be co-funded by European Union and they finally succeded. This allowed a larger number of kits in order to fulfill the high request for participation of the students.

Based on this good first step, the joint project began, and the first phase took place: how to choose students fitting well in the activitiy ?

3. Courses general set-up

The author firmly believes that each student can gain good learning via robotics, especially to strenghten his/her abilities in mathematics and related fields. Each school staff decided to start the experience gathering not only students with good or outstanding proficiency in mathematics, but also students with normal skills in these topics. This decision (also shared by the author) has many motivations:

- the talented students may act as little leaders of their groups, since they gain sooner a better understanding of what is going on;
- robotics belong to the cognitive universe of the young students, also via movies, cartoons and videogames, so many of them may desire to get a deeper grasp of what's behind the stage
- finally, a robotics project involves also other abilities as public speaking, communicate your

1 the english version of the site will be available on the early October, 2009

2 the competition changes its location every year

own ideas, time planning and sharing and so on, which are really critical for a young boy or girl of today.

The courses structure is summarized as follows:

	First school	**Second school**	**Third school**
no. of students	16	18	30
grade/age	second and third school year / 12 - 13	second school year / 12	first school year / 11
no. of students per kit	> 4	> 5	5
no. of groups	3	3	6
gender distribution	10 male, 6 female	12 male, 6 female	21 male, 9 female
hours per week (average)	> 4	3	3
no. of weeks	10	10	10
staff	the author as main coordinator, plus a technologies teacher as collaborator	the author as main coordinator, plus an italian teacher as collaborator	the author as main coordinator, plus a technologies teacher as collaborator

3.1 First school: important remarks

Part 1 – Introduction

The course took a gentle start, since students involved had no previous experience in robotics. The author introduced them to general concepts in the field, especially driving attention to concepts such:

- automation and control: what makes a machine a robot ? can you identify robots in your daily environment ? can you state three characteristics that let a machine be a robot ?
- main pieces of a Lego robot: brick, motors, sensors
- how to tell a robot to accomplish one or more tasks: this has been the core of the project since it lays on a fundamental concept in mathematics (and computer science in general), i.e. the design of an algorithm. First, students were invited to focus their attention to algorithms they use in their daily lives, even if not consciously. They were told to reproduce on a flow diagram all the actions they perform in daily activities like dressing, going to school, eating and so on.

Kids had a good response to this approach, it attracted their attention to concepts which were understandable by them (using their already possessed concepts) but all the same new and engaging. The author intended aim was to increase the ability of the participants to structure their way of thinking in a rigorous and sequential way, which is a previous step necessary to introduce them to programming, with as few hard steps as possible.

Part 2 – Construction

First of all, students were divided into groups, in order to assign a kit for each group, hence let them collaborate better. The author shared the decision of the teacher to let the participants be free to create their groups alone. An interesting remark is that all female students decided to gather in the same team, and all male students agreed with this decision. The average level of the female team was higher than the one of the other two teams: they were more coordinated, more able to fulfill the schedule planned, also the communication and collaboration with the author and with the teacher was easier and more productive.

On the other hand, the best student of the project (and also of all the three large project of this paper) was a male, working on another team.

The larger amount of hours in this course (~50) let the author give more time to the students to freely explore Lego kits capabilities. They started to interact with sensors, using the "View" Menu of the brick, in order to understand how the robot reacts to its environment.

The author thinks a little amount of project time dedicated to a free interaction with the kit is worth doing, provided that the coordinator pays great attention to what students decide to explore and how.

After that, they were called to build a simple wheeled robot, no sensors at the beginning, very similar to the famous Lego Tribot. They build it rapidly and then the group started to explore its movement capabilities, programmed by the NXT-G language *motor* block. Examples of the challenges given are:

- measure and compare the distance covered by the robot when you choose 90 degrees in the options menu or you choose 0.25 rotations in the same menu
- can you predict how far will it reach if you choose 3 rotations in the above menu ?
- how many degrees you have to choose in order to let the robot performing a complete turn, going in the backward direction ?
- can you let the robot make a 90 degrees steering ? can you use this result to let it perform a square like trip ?

The author decided to stress repeatedly two logical aspects in this work:

- the need to *predict* results well before measuring them experimentally or trying to obtain them via a trial–and–error approach: this requirement compells the students to critically analyze the situation, using all mathematical tools they have, hence optimizing the setup of the simple experiment
- the need to *build* new results and concepts, making clever use of the previously gained results: more in detail, students were told to move the robot in a square like path, after they learned how to let it perform a 90 degrees steering; this approach is intended to drive students towards the concept of *loop,* which was not a part of this course curriculum but will be in future follow up.

Part 3 – The robots

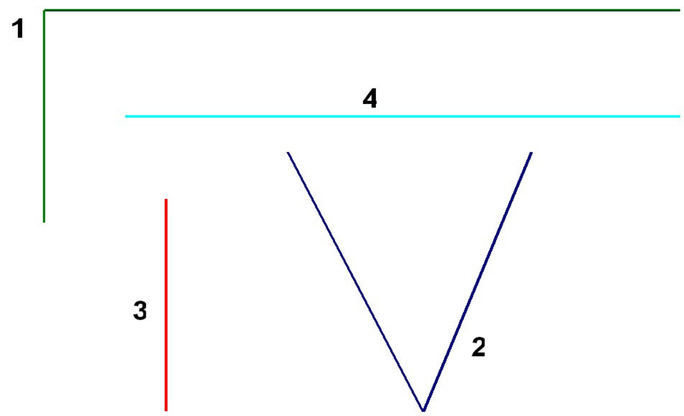
After the participants increased their knowledge about the fundamentals of the motor block usage, they were told to design and setup their own project. The decision came soon only in the female team, where girls decided to build a drawing robot, able to write part of the name of the school ("Dante"), in a over-simplified yet nice way. On the other hand, the decision of the male teams took a longer time: all the kids proposed different ideas and it was not easy to share a common view of the work to be done.

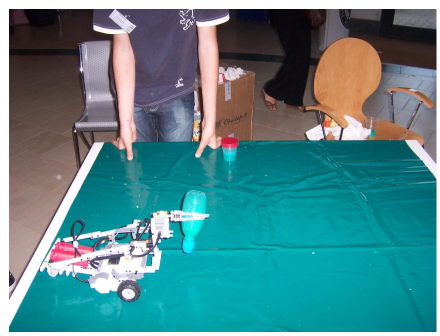
Finally, the second team decided to project and build a robot able to collect little parts of sheets (as if they were garbage) and move them to a large storage area. In this way, their work also acquired an important social motivation. The third team decision was the longest but they finally decided to project a robot able to make and serve a simple cocktail, made up of two different colored liquids.

More in detail:

- *drawing robot*: the most importat task was to let it draw the five letters "DANTE", identifying some "base components" in the letters, hence saving programming time and memory. The girls studied this geometric problem a lot, finally reaching the conclusion (with some hint from the author) that the best approach was not to think in terms of letters but in terms of common base blocks which eventually repeated throughout the word. This approach let a finer and simpler design of the algorithm necessary to get the goal. A graphical scheme reporting 4 base drawing blocks is reported in next page (try it your own !). The drawing was to be improved but the logic behind was good and will be followed again.
- *garbage collecting robot (picture on the left)*: this robot was simpler to build and program. It moved from a zone of the field to another one, collected garbage, moved back and then finally reached the discharging area. The hardest problem in this case was to program fine tuned movements, in order to let the robot not to miss its objectives. An interesting remark is that all students of the group were actively involved in the mission, also constructing the scenario. The

best student of the three schools belonged to this team: it was impressive its ability to discover new and fine solutions to problems, both in programming and in building. On the other hand the collaboration with him was not that easy, since he tried frequently to do everything alone.





- *cocktail robot (previous picture on the right)*: the difficulties in this project was mainly on the building side. Students smartly projected an attachment to hold a little bottle, which received fluids to be mixed together. The robot moved in straight direction towards one of the students, then stop and received water in the bottle. Then it moved towards another student and it received another fluid. After that it moved repeatedly the attachment in order to mix the fluids and, finally, it moved towards the visitors to serve them automatically, filling their glasses.

Part 4 – Outcomes
Broadly speaking, kids learned how to design a simple algorithm in order to fulfill the task assigned to the robot. In all of the three cases they reached the final goal the robot was intended to.
They also learned how to tackle problems together, how to discuss solutions proposed and how to propose their own solutions to their mates. The group were well composed, and there have been no problem in terms of collaboration among them and with the author, except for one of the teams where two of the students were older than their mates and did not succed to integrate themselves well with others.

3.2 Second school: important remarks
Part 1 – Introduction
The main characteristic of this project is the decision of the staff to integrate students coming from social and cultural backgrounds really different. More than 1/3 of the participants live in underserved communities, and they also get to school in a separate building from the main one, for logistic reasons, since it is more easily reacheable by their parents. The integration between these two groups was not that easy, and, as a matter of fact, most of the students decided to belong to groups made up of their social peers. Anyway, the author and the school staff promoted

collaboration whenever possible.
Three groups were constituted, with a mixed gender composition.

Part 2 – Construction
This part was really similar to that of the first school, hence no further details will be given here.

Part 3 – The robots
The first group decided to project a robot able to perform simple tasks and movements. This group came from the poor cultured surroundings of the school. They had strong deficiencies in math. Nonetheless, they struggled to find their way in the project. Most of them (especially girls) constributed enthusiastically in building and painting the scenario. One of the boys did all the programming, another one did not integrate himself at all with the rest of the crew.
An important remark is in order here: at the end of the project, one of the guys of the other two groups decided to help this one to fulfill the programming of the robot. This is a good example of inter-team working, when collaboration happens not only inside a team but also among different teams.
The second group programmed a robot moving in a city like scenario, eventually kicking a ball at the end of its path, and trying to score a goal. No particular difficulties were in this task, the group worked fine together and reached its goals.
Finally, the third group designed the hardest project: the robot moved straight on an imaginary line, while getting near to a row of three balls. An external user could press the touch sensor in order to kick the ball when near the robot, trying to play a simplified version of the bowling game. If the score was satisfying, and no other pressure was done on the sensor in the next 5 seconds, the robot moved on; otherwise, it kicked the ball again. This operation was repeated for three balls. Students were really engaged in this project.
One of them demonstrated outstanding abilities in programming, since he immediately understood an "if" control structure was necessary inside a "while" loop, and all that was to be inserted inside another "while" loop. He reached this conclusion even if the author did never explained none of the above programming controls. This boy clearly needed more attention as wanted to spend a lot of time in the project, more than was allowed.

Part 4 – Outcomes
One of the clear outcomes was that it is difficult to integrate students coming from social and cultural backgrounds too far apart each other. Another lesson learned is that outstanding students do not easily integrate themselves with other peers, hence requiring more specific attention and help from adults. This is one of the future plans in this school.

3.3 Third school: important remarks

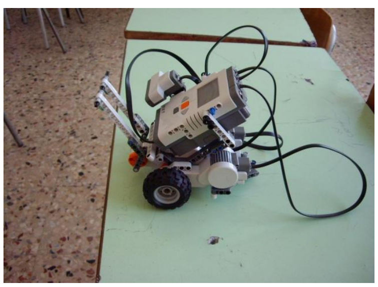
Part 1 – Introduction
This is the school which decided to start the project most enthusiastically. It started with internal funding only in November, 2008, with the 10 best math proficient students of the first year. They reacted to the proposal in an excellent way. After that, the school decided to enlarge the project to 20 students more (thanks to EU co-funding), even if they were less good at math, but their interest was high all the same.

Part 2 – Construction
This part was really similar to that of the first school, hence no further details will be given here.

Part 3 – The robots
Due to the great amount of work produced in this school, a short summary of the six robots created is provided here:

- *basket robot* (right picture): the robot moved until it reached a certain distance from the basket set; then it stopped and tried to shot the ball inside; both the programming, the construction and the scenario were built very well from the team, which is the best of all the three schools, both for personal level of participants and for their ability to collaborate

- *cream robot*: the robot plugged a knife inside a famous italian nuts and chocolate cream, then it moved away and reached two slices of bread, where it roughly spread the cream
- *climbing robot*: the robot was a simple tribot-like machine but it was placed on a sloped moving plane whose first inclination was zero and then increased slowly. The students then showed that the robot shifted its movement from going towards, to be stuck on the same point and then moving downwards, yelding a simple and nice physics experiment
- *black and white robot* (center picture): the robot moved in a simple maze, made up of black and white paper walls. Students programmed it to turn around black walls and move over white (or viceversa)
- *garbage robot*: the aim of the robot was the same of the previously explained robot in the second school
- *minesweeper robot* (left picture): this project was nice and original. The robot moved towards little coloured air balloons. Then, using its ultrasonic sensor, it was able to let the balloon explode, using its arm, gifted with a sharp end point. The balloon exploded in almost all the trials. The social meaning of this project is clear



Part 4 – Outcomes
The school is a great supporter of robotics in education. It provided excellent administrative, technical and educational aid to the author in order to complete the project. Students reacted very well to every proposal done. More in detail, the first 10 students were great in math and this helped them very much in doing robotics. The author would like to report an interesting example of what we may call “learning by oneself”. As a matter of fact, the project started with 10 kids. After the first 3 meetings, one of the girls decided not to continue anymore. Hence, she has been replaced by one of her schoolmates, a boy really interested in robotics. The author wondered if it was necessary to repeat for him alone the introductory part of the course, to let him be at the same level of knowledge of his team mates. But this guy reacted independently, payed a lot of attention to the observations done by the other students, studied the problems posed during the meetings, eventually finding solutions well before the other students. When in troubles, he asked his peers to explain stuff needed. He seldom asked teachers for help. Nonetheless, he integrated himself very well with his team mates. This is a simple yet neat demonstration of how much kids are able to understand and learn, even alone, when they are deeply engaged in a topic.

3.3 Future plans

These three schools firmly decided to continue robotics activities during 2010 and on. All of them organized shows at the end of the school year where all projects were presented to external and internal visitors. Robotics stands were extremely visited and students described their projects proudly. This way, they learned also to communicate their work and their knowledge to their peers but also to adults. They learned to receive comments and tell what they did attractively.

Acknowledgments

The author would like to thank principals, teachers, and administrative staff from all the schools involved, who supported the activity with great efforts and patience[3]:

- "G. Macherione" Middle School, Giarre (CT) – Italy
- "G. Parini" Elementary and Middle School, Catania – Italy
- "Dante Alighieri" Middle School, Catania – Italy

The projects belong to European Funding Actions, whose codes are:

- C – 1 – FSE – 2008 – 1806
- C – 1 – FSE – 2008 – 1875
- C – 4 – FSE – 2008 – 510

3 Permissions for using pictures are granted from schools staff or directly to teachers involved in projects reported here.

Integrating Educational Robotics in Elementary Curriculum

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Introduction

The purpose of this paper is to introduce one example of integrating educational robotics into curriculum at The School at Columbia University ("The School"), a private elementary school affiliated with Columbia University. The School has integrated educational robotics in its regular school curriculum; that is, it is taught during regular class periods. It is not difficult to find schools that offer robotics classes, however, the majority of such classes are extracurricular activities. In this light, The School provides a unique learning opportunity to its students.

Background

The School opened in September 2003 with students from Kindergarten through fourth grade. In 2006, The School expanded to the eighth grade with an enrollment of approximately 650 students. The School is sponsored and directed by Columbia University, however, about half of the students are admitted from the local community (New York City School Districts 3 and 5). Students from the local community are selected randomly, which makes its student body unique in terms of their diverse backgrounds in ethnicity, culture, the socio-economic status as well as learning needs.

The mission of The School states that it provides "a place that fosters life-long learning supported by the architecture and design of the classrooms." By following its mission, The School created a learning environment advanced in technology use in its classrooms with a Smartboard. Students start using computer in kindergarten. For kindergarten through second grade students, one laptop computer is provided to a pair of students. From third grade, each student receives a Mac laptop computer and uses it throughout academic year. There are enough digital cameras and camcorders for teachers and students to use for various projects. The whole building has a wireless network for anyone in the building to connect to the Internet.

Uribe first learned about LegoRobotics during a home visit with one of her 3rd grade students in the fall of 2003, the week before The school opened its doors for the very first time. Her student proudly shared stories of his accomplishments in National and International RoboCupJunior. His explanation of the design of his robots and programs showed a degree of sophistication and understanding that was amazing for someone so young. She knew immediately that robots would be the perfect tools for introducing young students to programming and engineering concepts. Through the student, Eguchi joined the initiative. The meeting led to a long and close collaboration on many educational robotics projects, beginning with a one-week project (Integrated Project Week, IPW) for 3rd and 4th graders called "Dancing Robots."

Integrating Educational Robotics into Curriculum Project Rational

Technology is ubiquitous, yet our students rarely stop to think about how it works. Learning with educational robotics gives them this moment to really think about technology. When designing, building, programming and documenting autonomous robots, students not only learn how technology works, but they also apply the skills and content knowledge learned in school in a meaningful and exciting way. Educational robotics is rich with opportunities to integrate many disciplines, including math, literacy, technology, science, social studies, dance, music and art, while giving students the opportunity to find new ways to work together, express themselves, problem-solve, and think innovatively. Robotics gives the students immediate, objective and unequivocal feedback on whether their program works or not. Since the robots are completely autonomous, they rely on programming to start, stop and maneuver, which gives students opportunities to learn logical thinking skills. An important part of the learning experience involves communicating and documenting the process and solutions. Thought must also be given to group organization and project management. The program has been enormously popular with our children and teachers because it provides everyone with a fun and engaging learning environment. In addition, educational robotics can provide a fun learning environment because of its hands-on nature. The engaging learning environment motivates students to learn whatever skills and knowledge are needed for them to accomplish their goals.

Educational robotics also provides a learning environment where students learn collaboratively. Unlike traditional computer instruction, in which typically one student works on one computer or two students share a computer but no collaboration is encouraged, educational robotics can be used to encourage students' collaboration. With educational robotics, while working in groups, students are motivated to share their ideas, engage in collaborative decision-making, provide constructive criticism, and acquire communication skills. Since educational robotics is hands-on, it provides students with the opportunity to explore and solve real-world problems. The main purpose of our project is to integrate educational robotics into The School's curriculum. As several studies show, most of robotics programs are run as extra-curricular activities, not as part of the core curriculum. We feel it is important that all students benefit from the experience of educational robotics, not just the lucky few who are encouraged to join the after school robotics club team. In this light, this project is very unique and successful.

Implementation of the Project

We use LEGO Mindstorms Robotics Invention System (NXT, formerly RCX) at The School because this is the most popular and most accessible robot kit in the US. The Mindstorms kit comes with LEGO pieces for construction, a programmable unit, three motors, several different sensors including two touch sensors, a light sensor, a rotation sensor, an ultra sonic sensor and a sound sensor (last three sensors are for NXT only). There is the additional advantage that many more sensors are also available separately from the kit, from third party vendors. For programming, we use RoboLab programming software. RoboLab is a graphic-based programming language used to control the robots. Using LEGO Mindstorms gives an opportunity for students to explore more at home if they are interested. It is easy for parents to purchase the kit from toy stores or LEGO Education website. RoboLab is also available for purchase online through LEGO Education. This gives the project an opportunity to plant some seeds for future exploration by students at home.

It was extremely important that we integrate robotics into our daily curriculum rather than offer it as an after school club as that was the only way to ensure that all the children would benefit from such a great learning experience.

Our project started out with "Dancing Robots (IPW)". As part of the project, the students were required to maintain a journal of their work and ideas, construct robots with sensors, create programs to control the robots by drawing their ideas on paper, and then on computer. They created original music, choreography, sets and costumes. Finally, the students' robots performed before the school on the last day of the IPW. The final performance explored the ideas of iteration, repetition and patterns in dance. When writing in their journals, students were (and are still) encouraged to describe in as much detail as possible the process they went through to solve problems. Robotics is a student- and group-centered problem solving based approach to learning. The "Dancing Robots" project helped us to recognized the amazing learning possibilities that can be achieved through educational robotics.

The decision was made to integrate educational robotics in 2nd grade in Spring 2004, as part of the science curriculum. At that time the students were studying the concept "Expression" in the context of their yearlong theme, "Community". The groundwork laid by Mishler for 2nd grade was continued by numerous educators at The School, each bringing fresh ideas and approaches to the curriculum. Most recently, in Spring 2008, Howland and Benedis-Grab collaborated with specialist teachers and classroom teachers to develop an excited project for the 2nd graders. Through educational robots, the students practiced measurement skills by tackling programming tasks that required them to measure specific distances for the robots to travel, as well as calculating ratios between time and distance. They soon became adept at making predictions for time based on established distance/time ratios. In art, the students created elaborate costumes for their robots' final performance piece.

The task of teaching an integrated robotics curriculum to incoming 3rd graders the following year became the responsibility of the science teacher and technology educator, working in collaboration with other specialist teachers. In the third grade, students study the concept "Movement" in the context of their yearlong theme, "City." Last year the students decided their final project would be a city-inspired dance, with robot pedestrians and vehicles performing to music of their own creation. The students learned to use iterative loops and conditional jumps and also fine-tuned their control of the robots by adjusting motor speeds. With the help of their music teacher, the students composed music to accompany their robot performances. In dance, they learned to plan, diagram and describe the choreography. The next logical step in the robotics program occurs in 4th grade when sensors are introduced.

In the 4th grade, students study the concept "Exploration" in the context of their yearlong theme, "Country." The students learn to program robots to use sensors (temperature, touch, light and rotation) to explore characteristics of imagined deep-sea environments that are inaccessible to humans. Since the students have been learning about life in the marine environment, they already have background information upon which to build. After viewing video clips of automated underwater vehicles, we begin the unit by brainstorming ways robots can help us explore oceans. Examples of suggestions made by students include exploring hydrothermal vents, shipwrecks, looking for sunken treasure, finding new species, placing equipment such as earthquake detectors on the ocean floor, mapping the ocean floor, rescuing people and/or animals, cleaning up oil spills, and finding and observing sea life in very cold environments. Subsequent lessons cover the use of the sensors to accomplish specific tasks set by the children, such as backing up after bumping into an unknown object. For their final project, the students work in pairs to design and program exploration robots. They also describe in a report where the robot will be used and what the robot can do. Students are asked to add information about potential difficulties that face the robots, e.g. water pressure can crush the hull, hot temperatures can melt the arms, and total darkness makes it difficult to locate obstacles.

Challenges and Future Plan

One of the challenges that we as educators often face is how to best encourage girls to pursue studies in traditionally male dominated fields. When integrated with other disciplines, such as arts, dance, music and literacy, teachers have motivated our girls to continue to learn about robotics in the after school robotics clubs. This is also the case with minority students who may be shy and not motivated in science and/or mathematics classes because they may lack role models in the field. We have witnessed minority students excel through educational robotics program in class as well as in the after school club.

The biggest challenge that we faced was, perhaps, to make all teachers involved excited about educational robotics. Teachers tend to think that educational robotics does not fit in their curriculum because it is not a traditional subject or discipline. Making sure that teachers understand the learning experience that educational robotics brings to the classroom without their having experienced it themselves was quite a challenge. In addition, teachers tend to have some fear of using technology in general. Addressing their comfort level was another challenge. Children are eager to dive into new technologies including robotics, but adults sometimes have some difficulties. Overcoming the fear of something so nontraditional would be a challenge for all schools/programs willing to implement educational robotics.

Another possible challenge for other schools/programs, which was not so much of an issue for us, might be administrative and technical support on educational robotics. Thanks to our administrative team including Annette Raphel, the Head of the School, from the launching of the project until now, we have received continuous support with the educational robotics project including the after school program. In addition, our Tech Support team, headed by Don Buckley, has been a crucial resource since the beginning. They always think outside of the box and help us find funding sources to provide the necessary equipment. Without support from the administrative team and Technology team as well as innovative and continuous contributions from our teachers, this project would never have been successful.

We strongly believe that educational robotics provides a great learning environment in any grade level including college~~s~~ and university. Because of this belief, we are currently exploring the possibility of expanding the program to include Grade 5 and Middle School students as well. Many studies report that hands-on learning opportunities are less available in higher grade levels than lower grade levels. We hope that future curricula will continue to provide students with the opportunity to gain valuable knowledge and skills when applying scientific principles to real-world problems. Educational robotics can provide the hands-on learning environment to link the principals and the real-world problems.

Teachers at The School contributed to the project:
Shawn Mishler (former Director of Technology), Jenny Howland (former Technology Educator), Greg Benedis-Grab (current Science Teacher), Nancy Wong (current Mathematics Teacher), Yoshiko Maruiwa (current Visual Arts Teacher), Andrew Gardner (current Technology Educator), Pamela Bernstein (former Dance Teacher), David Gordon (current Music Teacher)

Movies of our Educational Robotics Projects:
Robotics documentary from IPW

http://titan.bloomfield.edu/facstaff/eeguchi/robotics/IPW robotic documentary.mov

Robotics Parade

http://titan.bloomfield.edu/facstaff/eeguchi/robotics/robot parade.mov

Second grade robotics 1

http://titan.bloomfield.edu/facstaff/eeguchi/robotics/SecondGradeRobotics1.mov

Second grade robotics 2

http://titan.bloomfield.edu/facstaff/eeguchi/robotics/SecondGradeRobotics2.mov

Second grade robotics 3

http://titan.bloomfield.edu/facstaff/eeguchi/robotics/SecondGradeRobotics3.mov

Second grade robotics 4

http://titan.bloomfield.edu/facstaff/eeguchi/robotics2/SecondGradeRobotics4.mov

Robotics activities for underserved communities:
a short summer course

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Middle and High Schools

1. Introduction

Many ongoing projects worldwide demonstrate the help provided by robotics like activities in underserved communities. As a matter of fact, a clever use of technologies may lead young kids to a better development of their abilities, better school outcomes and personal success throughout their life.

2. How it all started.

The author is involved in the management of the *MiniRobot* (www.minirobotics.org)[1] competition for high schools of Catania (ITALY) school district. The competition began as a natural evolvement of the robotics courses the author and some of his colleagues pioneered in a number of schools, as volunteers, since 2003. Its first edition started in 2006, as a joint event of the larger Eurobot 2006 competition for university students, (www.eurobot.dees.unict.it/)[2], held in Catania in that year.
Following the good results obtained in robotics high and middle school projects, the author decided to propose a similar activitiy, to be held during summer, for young kids terminating their middle school three year period. These students attended a school placed in a region of their city, poor in cultural and social inputs for youngsters. Most of their peer aged guys do not attend school anymore, since years ago.
The author cooperated with the local district government to submit the project to the school, which in turn received well the idea and immediately proposed it to its 18 best students, passing the final middle school examination.
The students were received by the local district government along with their families, in order to talk to them and explain carefully the project and its possible benefits. Parents totally agreed and encouraged their children to take part.
As a result, 16 out of the starting 18 students accepted to participate[3].

3. Course general set-up

The following table summarizes the course general data:

no. of students	13
grade/age	third middle school year (finished)/ 13
no. of students per kit	4
no. of groups	3
gender distribution	6 male, 7 female
total no. of hours	8
staff	the author as main coordinator, along with four young tutors

1 The english version of the site will be available on the early October, 2009.
2 The competition changes its location every year.
3 3 students out of the 16 accepting the course could not participate because of sudden illness.

- participants of *MiniRobot* volunteering as tutors for younger kids:
First of all, an interesting new feature was added with respect to the course the author taught in middle schools: he asked for the help of young tutors, mainly from high schools, who had already participated in the *MiniRobot* competition during the last 2 or 3 years. These guys were very smart in Lego robotics usage (one of them belongs to the winner team of the 2009 *MiniRobot* edition), they were 4 or 5 years older than the participants, so they fitted perfectly in their role.
As a matter of fact, they agreed to the proposal and trained themselves carefully.

- diverse background and future school plans of participants:
Kids participating had different backgrounds: about half of them really liked math and technologies and had already gained a good knowledge about these topics in their life. The rest were not so engaged, but did accepted all the same, even because they received a strong push from their parents and their schoolmates. Also their future plans are very different, as far as regards high school studies: half of them chose technical schools, the rest chose to pursue humanistic flavoured studies.
Nonetheless, the diverse background of participants was a challenge for the author, since he was used to have a large majority of attendees really motivated in robotics. But this was an advantage in the course since it helped to demonstrate that robotics is a topic which may gain interest from a larger range of students than it may be thought. Also, the author is strongly conviced the help math and science related activities may give to increase and strenghten logical and critical thinking in young students, irrespective of their future jobs and areas of interest.

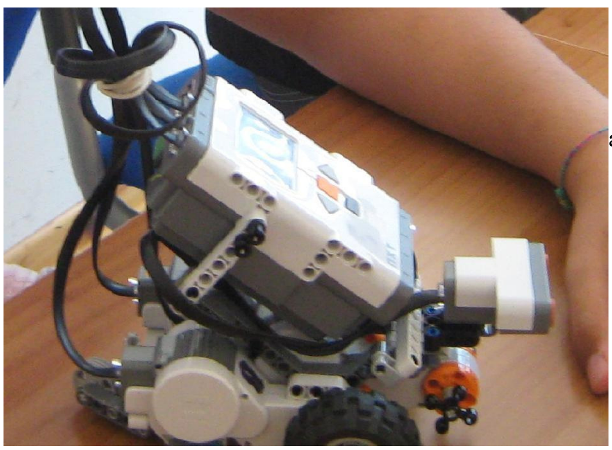
- learning method:
The author chose a different approach in this case, with respect to courses he taught in other middle schools. The students were not introduced gently to robotics, with a previously explained view of the topic, examples taken from their real life etc. Because of the very short number of hours, they were diretcly exposed to little tasks the robots could accomplish.
First of all, tutors let them see a couple of simple wheeled models already built. After that they explained them the basic use of motor blocks of NXT-G language. Finally they asked the member of each group to disassemble the robot, build it again and try to program it to accomplish a simple task: drive in square, 90 degrees steering, etc.
One of the tutors autonomously stressed the algorithmic side of the work, explaining the students how to sketch the behavior of the robot generally but rigorously. Only after that, he invited his students to write down the program and test it again and again.
The rest of the tutors decided to follow a reverse path, explaining the algorithmic side of the game only at the end of the construction and programming phases.
The author let the tutors be somehow free about these decisions, also to gain self-confidence and increase a sense of responsibility. Nonetheless, frequent meetings between tutors and the author took place, in order to check periodically the way of the course.

- final presentation:
All the participants presented their group work to their parents in the final day of the course. They were able to explain rather well the topics studied and learned to their parents, who had no previous experience in robotics. The presentation is a good tool to help students gain more self-confidence, and to demonstrate others the quality of their work done. Also parents were really interested in the constructions and eventually asked for mor informations to the author.

3. Conclusions and future plans

Half of the participants were already engaged in technologies, broadly speaking. They gained even more interest in this field and desired to dive more thoroughly in robotics. They asked also for a more advanced course in robotics during next September.
The rest of the crew gained a finer approach to logical thinking and technologies in general. It was not easy to engage them but the help of their schoolmates and tutors was successful.

Kids exploring their model. They will disassemble and reassemble it multiple times in order to understand its internal sturcture.



A tribot like robot, used to learn first simple movements and programming.

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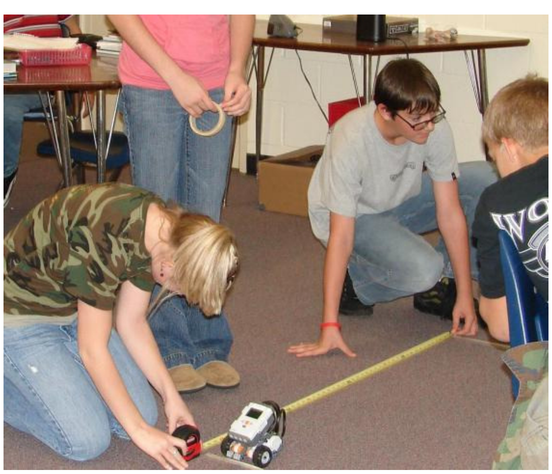
Adventures in Middle School Robotics

By Patti Davis, Math teacher

East Richland Middle School in Olney, Illinois

Reading a newspaper article in December of 2006 began my journey with Mindstorm NXT Robots. I was a math teacher who, knew very little about programming, robots, or legos; but I knew my students would love the opportunity to use them. My first hurdle was acquisition, how would I ever find the funding for the robots? I determined that if I could get a robot on loan from Lego that I could hold a "Robotics College" after school for my eighth graders. I contacted Steffanie Forbes from Lego Education and she was more than willing to allow me to examine the NXT and its software for 8 weeks. I then created an application process and found 12 participants. I divided the team into three groups: engineers (builders), programmers, and public relations. Our job was to familiarize ourselves with the technologies then "sell" it to the community. We played with the robots until we could create lessons for the second and fourth graders in our district. We took the lessons to the elementary school and took pictures of our interactions. The pictures, interviews, and data was then used in the presentation that the team of twelve took to the Educational Foundation to request funding for 12 robots, software, and site licenses.

In the fall of 2007, we had our robots on campus. Our technology staff created an electronic robotic request form so that the elementary teachers could request robots built and programmed to specification to be used in their classrooms. First grade teachers used the ultrasonic sensor to demonstrate bat sonar, second grade teachers used them to practice linear measurement and estimation, and fourth grade collected data, and so on. In addition, the robots were used in the math classes at the middle school to emphasize circumference, distance-rate-time formula, and linear functions with headwinds and tailwinds being simulated with a battery-operated leaf blower. Below is a picture of eighth graders measuring the distance travelled by the NXT to determine it's rate before we use the distributive property to determine the unknown rate of the wind created by the leaf blower. The idea was to show the effect of head wind and tail wind on a moving object. This was used to illustrate a difficult concept in a pre-algebra/algebra setting to demonstrate how head winds and tail winds impact rate of a moving object.



Students at East Richland Middle School are measuring the distance traveled by the NXT to determine its rate of speed. The class was learning about headwinds and tailwinds and their impact on rate.

In the fall of 2008, East Richland School District decided to offer Robotics as an 8th grade elective. During this class, students were taught about the program platform, various builds, and sensors. I was employed to teach this class. It was quite enjoyable. The class lasted 21 days for 84 each day. Class size varied from 14 – 18 8^{th} graders. Because this was an elective class, all students, regardless of their intellectual ability were placed into the class. Inquiry and investigation were the modes used for teaching the class. Children were encouraged to share ideas and work together to conquer challenges. The initial challenges were done without sensors and required the students to collect data and record measurements to conquer the challenges. One such challenge was a cardboard maze that I constructed and asked them to navigate. Below is a picture of my students working on the maze.

East Richland Middle School Students participate in Robotics as an Elective Course. Here they are programming NXT to navigate a home-made maze.

By the end of the course the students were creating robots that placed the ultrasonic senor on a rotating gear so that the robot could “turn his head” at an intersection. The robot would then use the logic block and compare the measurements of the two directions. Based upon the length of the corridor the robot would decide which direction to turn. My students not only became aware of the complications of programming; but the efficiency it affords when mastered. In the last maze assignment the maze would be made into any configuration and the robot would navigate it correctly; however in the initial maze challenge placement of the robot on the maze impacted the outcome and easily frustrated the students.

I observed many interesting things during my teaching of the robotics class. Those labeled academically talented did not necessarily exceed at robotics because they did not have perseverance with regard to problem solving and because the class was inquiry-based many of the gifted students were frustrated. They wanted me to “tell them what to do”. They did not enjoy the struggle of investigations. On the other hand, many of the students that are labeled “learning disabled/challenged” did much better than I or their classmates expected. Often times it was the less motivated, average, or learning-disabled child that would find the needed information to solve the challenge for the entire class. For this reason, I found teaching robotics quite rewarding.

Next year I will be back in the math classroom because of budget issues. My adventures with NXT Mindstorms have been exciting and interesting. Although I will be teaching math this year, I intend to use the robots to illustrate concepts being taught. I am also going to use the robots for a 2-3 week unit in the late spring focused on robots and programming. Each year I am seeking new ideas and ways to utilize this technology to enhance and enrich education for the students of East Richland School District.