Arduino Etoys

A programming platform for Arduino on Physical Etoys

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Abstract— **In the last fifteen years, the technological education has been essentially based on digital technology, leaving aside the use of concrete material. Still having excellent simulators of the physical world, working with concrete material allows the development of cognitive structures that digital doesn't offer. Moreover, these didactic resources allow highly participative group dynamics that have not been yet reached by the existing computers at schools.**

Unfortunately, in our view there are two major difficulties for the presence of these resources in the classroom. The physical technology is expensive and suffers from constant wear. On the other hand, teachers are not accustomed to working in a dynamic classroom with a methodology of work in a participative group, and have fears about the use of specific technological equipment.

Physical Etoys is a development that aims to overcome these difficulties. Physical Etoys facilitates the interaction between inexperienced users and concrete material such as open hardware devices or popular toys by providing a powerful and intuitive visual programming system in order to explore and learn science in an enjoyable way. The objective of this paper is to introduce a new module of Physical Etoys which aims to persuade kids to do different electronic projects with an Arduino Board.

Keywords— educational robotics; Etoys; technology education; Arduino

I. Reasons for the development of the project

Next we present the reasons that we have to manage with for the development of the project.

A. Fluidity in the use of technology

First of all, in the last fifty years the technology has taken a relevance in our lives that makes it difficult to think life without the integral use of them. It is for this reason that different analysts of the current school, as David Perkins [8] among others, considers that the presence of technology in classrooms and the necessity of a change of perspective keeping in mind the student more than its environment in its educational process are fundamental. That is to say, the student is no longer only the student: it is him plus his technological resources. It no longer cares where the knowledge is but how you access it. The problem is that, in spite of the exponential decrease of the costs of these resources, we are still in front of a considerable digital divide among those included and those excluded of the system. Gap that is not given by the access but for the significant use of technology. The more disadvantaged social classes are away from the metaphors that propose the current technologies. It is for that reason that the use of concrete material for the learning of technology allows to leave this framework and open conceptual and learning new opportunities. In synthesis, the children of all the social classes in their first years of life play with concrete material, and this game has a very deep load of technological learning. If we maintain this profile in the formal learning of technology, we will be able to reach a bigger number of students.

B. Technology with concrete material

Besides from a social greater reach, the concrete material allows us not only to develop intellectual activities but also sensory, that diminishes the problems of the passage from the concrete thought to the abstract one. In the physical experimentation, the student takes the error like a factor of his learning. and allows him to operate and control a group of continuous variables that no computer simulator provides. It is the real same world the one that defines the results reached by the boy's experiences.

However, the solution of problems with this material, allows the development of the systemic, structured, logical thought, but not starting from premises or abstract situations but from the solution of concrete problems.

Linda Williams [10] suggest the realization of activities with concrete material that generates processes not only in the left hemisphere of the brain (highly developed by the daily activities of the school) but also of the right hemisphere, what will allow to integrate components in a whole, with a simultaneous and parallel process, space and visual space.

C. Cross-curricular thematic and without gender difference

As we comment previously, technology is present in all the activities of our life. It is not in particular a privilege of any science or discipline, neither of any workspace especially. Therefore, it is fundamental that our students integrate the use of technology in all their subjects, and not simply in those where it seems "more natural" its presence. For it, we should leave the traditional framework of the technology teaching, where we develop devices with an end in itself, like the robot that follows lines. We should carry out significant projects for each child, to model devices that the man uses in his daily life, and that serve as excuse as a starting point, analysis or pursuit of diverse topics of the curricula. It is habitual that the technological activities of this type attract more boys than girls, for cultural diverse reasons that escape to this article. If we are able to propose the design of daily-life devices (for example, a table to create ceramic vessels, a microwave, a washing-machine, the dancer of a music's box, a turnstile), we will open the game to the cultural diversity that we have inside our classrooms.

D. Motivation for the learning

On the other hand, diverse studies that demonstrate the motivational impact that generates the use of these materials in the students, habituated to a not very participatory activity in the classrooms, exist. The possibility to build significant devices of concrete utility and the growing cycle in the learning that offers the test and error, generates in the student a deep interest not only in the construction but also in the contents linked to the carried out activity. That is, the use of these materials allows giving to the curricular content, even in cases of being less related with technology, a more significant framework reference for the student.

E. Teamwork

Work in classroom with these physical tools becomes impossible individually. Teamwork is necessary, beyond the economic limits in the purchase of equipment. It is important to order this teamwork with differentiated roles so that each participant has a specific and concrete work in the activity. Each of these roles enables the student to develop a skill set. Therefore, these activities allow us to introduce learning about teamwork and roles, conflict resolution, respect for differences and the need to listen to all members of the team. Each participant has its own point of view that enriches the work of the team. The proposed roles are related with the organization of working materials, the construction process, the communication with the teacher and the others teams, the development of written reports, and other activities.

F. Use of free or low cost hardware

The main cost of these projects is not the software, but the hardware platform used. For this reason, we decided to make the platform to program open or low- cost hardware, or robotics kits with presence in the schools of the world. Then, schools still have no equipment can purchase low-cost material as Arduino board. Schools that have some robotic kit or robotic toy can enrich their use, programming them with Physical Etoys.

II. TECHNOLOGICAL CHARACTERISTICS OF THE PROJECT

A. Cross-platform

One of the goals we define in the development of this project is the possibility that works both on Linux and Windows. In addition, the works developed in it should be cross-platform too. During the development, we were also requested that the software worked on Sugar, the operating system of the XO, the computers of the OLPC project. Nowadays it runs on 90% in the three systems.

B. Extensible

The experience we have lived in the education technology community suggested us that the development would not only be open but also easily extensible. The hardware proposals for the teaching of technology emerge every day, and we want to provide the possibility that each technology developer can build their tools on our platform. This is the reason we developed an easily extensible framework with basic knowledge of Etoys.

C. Why we use Etoys?

Etoys, the new educational version of Squeak, is an education tool to create multimedia and interactive projects. It has a long tradition of open development, because it was made by the Smalltalk team: Alan Kay, Dan Ingalls and other researchers. Furthermore, their educational criteria have been defined by great educational thinkers, such as Jerome Bruner and Seymour Papert [7]. Etoys is a highly effective tool for teaching math, science and arts, in a context of play and experimentation. Moreover, it’s cross-platform and has become the most important software on the OLPC netbooks, since it comes integrated with Sugar, from the outset. A large academic community is present behind its development, as MIT, Viewpoints Research Institute, University of Illinois, etc.

III. PHYSICAL ETOYS: OVERVIEW

Physical Etoys is a visual programming tool that connects the virtual world of computers with the real world in which we live in. With Physical Etoys it is possible to program real world objects (such as robots) to perform interesting tasks, or sense the world and use that information to control virtual objects (such as drawings on the screen).

It does not require any programming skills, and its consistency across the entire system makes it easy to accomplish some reasonably complex tasks that would be almost impossible in a different one.

Physical Etoys is an “extension” to Etoys. This is a wonderful software that helps children explore their own creativity in fun and educational ways, but it lacks communication with the outside world. Physical Etoys aims to overcome this necessity.

In outline, Physical Etoys is divided into a set of independent modules. Each module is responsible for controlling one robotic kit. Even though these modules can work independently from each other, the connection between them produces the most interesting results.

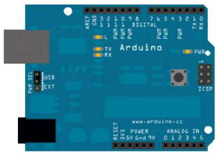
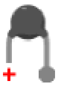
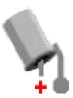
IV. WHAT IS ARDUINO?

Arduino is an open hardware platform based on a simple microcontroller board with digital and analog I/O pins. Due to its open philosophy, every teacher can access to different designs and build his own board (it is also possible to buy a prebuilt board). In addition, there is a great variety of examples of Arduino and a very collaborative community that is fond of helping people.

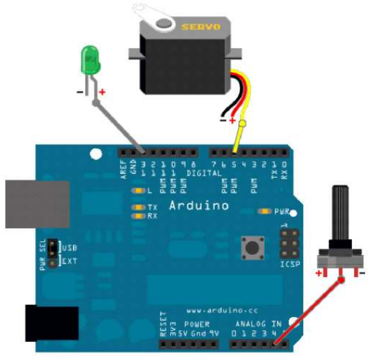
These characteristics are suitable for people who want to start using physical technology. Although the Arduino's official software is intuitive, it is still a low-level language like C and it looks cryptic for the average user.

V. USING ARDUINO WITH PHYSICAL ETOYS

All Physical Etoys modules are composed by a few objects that try to resemble the real objects of their respective kit. The Arduino module is not an exception. You can see in the table below some of the Physical Etoys' objects and their correspondence in reality.

Name	Virtual object	Real object
Arduino board		
Buzzer		
Led/Pwm Led		
Photoresistor		
Potentiometer		
Pushbutton		
Servo		
Switch		
Thermistor		
Tilt switch		

The "Arduino board" is the main object of the Arduino kit. It contains pins on which other electronic devices can be attached using wires. All these interactions between real objects have been represented in Physical Etoys as you can see in the picture below.



1 – Components attached on a virtual Arduino

Every object has its own set of properties and commands that are accessible using the same interface. For instance, the "Led" object has an "is on" boolean property, the "Servo" has a "degrees" property, the "Photoresistor" has a "light value" property, the "Thermistor" a temperature value property, and so on.

This interface is also shared with all the graphical objects in Physical Etoys. Texts, sliders, pictures, buttons and every user interface widget that composes Physical Etoys is accessible and programmable in the exact same way (although they contain a different set of properties and commands). This extreme consistency across the entire system makes it really easy to use and explore.

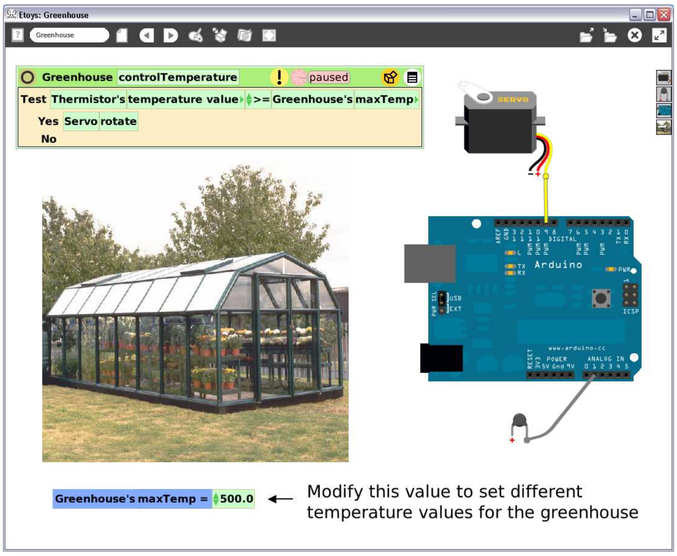
VI. EDUCATIONAL EXAMPLES

This section will describe a few exercises that can be implemented in a classroom.

A. Building a greenhouse

It is possible to build a miniature model of a greenhouse by using a servomotor and a thermistor. The motor will be used as a fan that keeps the greenhouse cool and the thermistor will sense the temperature of the air and it will activate the motor when its value exceeds a certain number.

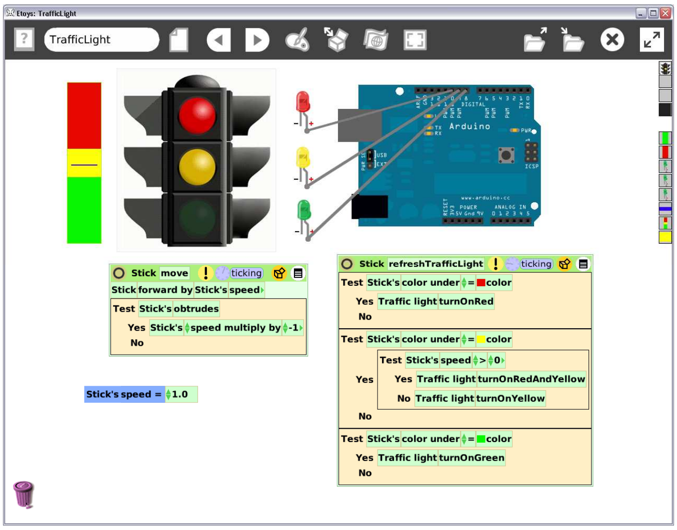
The picture below shows a simple implementation of the greenhouse project. The script "controlTemperature" at the top of the picture is the responsible of the behavior described above.



2. Greenhouse project implementation.

B. *Building a traffic light*

This exercise is a little more complicated. It uses three leds of different colors to represent a traffic light. Each led is turned on/off depending on the color behind a little “Stick” that moves across three different backgrounds: red, yellow and green.



3. Traffic light project implementation

These examples show two essential aspects of Etoys programming. On the one hand, it shows how abstract information such as the traffic light state and its behavior become concrete. On the other hand, it shows how the information of the world such as the temperature of the air can be conceptualized as numbers which can be used in any arithmetic or logical operation.

VII. Other Hardware Platforms Supported by Physical Etoys

The other modules composing Physical Etoys are listed below:

- *Nintendo Wiimote:*

  The famous Nintendo Wii’s Joystick which detects the gesture of a hand, enabling the user to make scripts with a non-conventional way of communication with the computer.

- *Parallel port:*

  A type of interface for connecting various peripherals to the computer.

- *Lego Mindstorms Nxt:*

  A programmable robotics kit released by Lego. It allows the user to build almost anything without any knowledge of electronics. Considering that a lot of schools around the world already utilize the Lego Nxt to teach robotics, using Physical Etoys to program it is ideal for children that are just starting on the subject.

- *RoboSapien V2, Roboquad and I-Sobot:*

  These robots can be controlled by using an infrared transmitter. They are prefabricated and although their capabilities are limited, they are very attractive to the general public.

VIII. Physical Etoys in the World

Different educative communities have shown interest in using Physical Etoys on their own classes and workshops after the publication of its modules:

The SqueakNxt module, responsible of controlling Lego Mindstorms Nxt robots, has been used by an educative organization called Planète Science which took place in a workshop of Introduction to Robotics given at the Japan Expo Paris in France 2009. This non-profit organization intends to spread the science on the youth by organizing multiple activities including workshops at festivals and national contests such as the Final Eurobot, the French Robotics Cup and the First Lego League of France among others. During the Japan Expo Paris 2009 they used the SqueakNxt module to do different projects including:

- A drawing robot (similar to Logo).
- A robot that reacts to the environmental noise (its arms moved when somebody shouted).
- A robot that navigates through the exposition avoiding people.
- A robot that navigates through the exposition in order to lift plastic glasses using its clamps.

Planète Sciences has also shown interest in the Arduino Project, which has also been included in a software pack called SqueakBot, similar to Physical Etoys. Educational robotics has become mandatory in the French official curricula so there was a special class oriented to teachers in the region of Toulouse about the basic concepts of electronics and programming with Physical Etoys.

In Colombia a company called HYPER Neurotek which develops and integrates new technologies with education (preferably open-source projects) has shown interest in using Arduino to teach children how to use microcontrollers for building robots with an OLPC laptop.

In Spain, Citilab, an institute for the formation and the spreading of the ICT in Barcelona, decided to use SqueakNxt and Arduino for its Introduction to Robotics talks.

Finally, in Brazil, a consulting company called O3 Tecnologia that works in the area of educational technology used the Parallel Port project with Physical Etoys in robotic classes in high school.

IX. Conclusion and future work

The recognition that Physical Etoys has received in this short time is fills us with pride. This invites us to new challenges. The first one is to fully support the use of all hardware platforms on the three operating systems. We also have requested to add MacOs to them. The next challenge is to incorporate the microphone and camera of the netbooks as sensors to our project. In the case of video, we must think how to provide students with an easy programming mode, removing the complexity that the image processing has. And finally, we will propose a simple physical structure with motors and sensors, allowing to locate the netbook on it for using as an autonomous robot. Physical Etoys has a long way to go. We invite you to do this together.

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