

# A Study About Materials For Use In Educational Robotics

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**Abstract.** *This paper presents a discussion on materials for robotics use in education known as educational robotics kits, these kits show up as the most viable alternative for schools wishing to use technology as a tool to aid learning. There are numerous advantages of using robotics in education: students are challenged to build solutions based on concepts presented in the classroom, while assimilating new knowledge as programming logic. Despite the advantages offered by the kits, these materials are not yet available to all Brazilian institutions, much due to their costs. Therefore, this article offers suggestions of available kits, pointing out their features and observing their suitability to the different levels of education.*

## 1. Introduction

Gradually, robotics has been implemented in public and private educational institutions in Brazil. To Siebra and Lino (2010), the use of this resource allows students to develop logical reasoning through practice with the objects created by them. Robotics also provides a better assimilation of more complex themes such as the concepts of physics and mathematics, besides encouraging creativity and cooperation among students.

To work on robotics in educational environments is necessary to acquire Kits. There is a wide variety of kits produced by different companies that can be used for educational purposes. According to Telles (2010), due to their high cost, these kits are not yet available to some schools. Thus, the present study aims at conducting a study using six robotics kits available in the market, analyzing the features offered, the acquiring cost and verifying their suitability to the different levels of education.

This paper is organized as follows. Section 2 provides the theoretical foundation that underlies the discussion of the following sections through some related works, this section describes the components coming with most kits. Section 3 presents the kits studied (Lego Mindstorms, Arduino, Lynxmotion, Robokit, Modelix, Maxwell Bohr). Section 4 makes a comparison among the kits studied. Section 5 provides the conclusion of the comparison data analysis of the previous section and describes the future direction in which we intend to develop in later works.

## 2. Theoretical Referential

### 2.1. Materials for use in Educational Robotics

Educational Robotics emerges as one of the most effective ways to use technology for education. The student is challenged to develop solutions to the questions proposed

through the analysis, planning, and questioning [Telles 2010]. The playfulness provided by educational robotics makes learning more fluent and dynamic, its use has as main objective the development process and construction of student thinking, and as discussed by Castilho (2002), the final product does not become so important, but the solution found by students to solve a particular problem.

The educational potential offered by the robotics is directly linked to the tools used at work in educational environments, as exposed by Azevedo et al (2010), the use of kits facilitates the process of building robots, especially for a beginner audience, thus these materials are the best alternative for schools that wish to deploy robotics as a teaching tool.

Thus, it is necessary to know how the kits are constituted so as to provide paths for using this resource. As discussed by Azevedo et al (2010), the robots are composed of parts such as: controller, sensor, actuator, gears, shafts, manipulators, power supply, wiring and structure. Also according to Azevedo et al (2010), a proprietary language developed for the kit or the use of traditional languages such as C can be used for robots programming. With respect to the proprietary languages these can be based on graphs and icons or based on text [Azevedo et al, 2010]. In addition to these criteria, it is necessary to verify the existence of printed materials that support the use of the product, such as user manual, technical documentation and supporting materials for pedagogical support of teachers, these are some advantages from the use of educational kits [Miranda and Suanno 2009].

For a better understanding and in order to establish criteria for evaluating the suitability of each pedagogical model, the kits components will be classified into the following sets:

#### **Hardware Pieces:**

- **Structural components:** These are the parts that make up the physical structure of the kits, this set includes manipulators (arms and claws), wheels and mounting bases to other parts
- **Electronics:** They allow the addition of motion features (motors) and allow the robot interaction with the environment (sound devices, visual devices and sensors).
- **Programmable Unit:** Microcontrollers are included in this category; this is the central part of a robot, which allows incorporating a program to be run.

#### **Software:**

- **Text Programming language:** This type of language covers traditional (Delphi, Java or C) and proprietary languages used in products such as Arduino [Arduino 2012].
- **Graphical Programming Language:** Languages, whose building programs are based on drag and drop icons and other graphic elements, as example there is the interface of Lego Mindstorms [LEGO Mindstorms 2012].

### **Support Material:**

- **Teaching Support Material:** teaching support material, traditionally containing examples of projects that can be developed with each kit.
- **User Manual:** Traditional material that shows the relationship of parts available in the kit, as well as the instructions for installation and software manipulation.
- **Datasheet:** Material that covers technical data, generally designed to allow the construction of extra components or insert more advanced implementations such as creating libraries.

The components listed above are the basis of most kits available in the market, these materials differ in the number and type of pieces that came with the kit, having a proprietary or traditional language, the type of programming (visual or textual), and support material that accompanies it. According to Miranda (2006), another determining factor in the choice of kits is the cost. Since, imported models have high cost compared to most national kits; on the other hand some Brazilian kits possess certain limitations of hardware and software.

## **2.2. Educational Use of Robotics**

Educational Robotics is an activity that has become very common in recent years, especially with the advent of educational kits, which as exposed by Brum (2011), these products are designed to facilitate and enable the construction and programming of robots for beginners. According to Chella (2002), the kits are also designed to stimulate learning of concepts and methods related to education in various fields.

In school environments, Robotics allows finding solutions through computational, physical and mechanical concepts [Telles 2010], in addition to facilitating the planning, construction and reconstruction [Guedes and Kerber 2010]. The use of robotics can focus on assembling devices, programming and concepts related to subjects such as physics and mathematics, which according to Siebra and Lino (2010), causes the maturation of these concepts, because students interact with them in a practical way.

Working the concept of programming, robotics becomes a powerful tool in building the logical reasoning of students. For Castilho (2002), the robot programming is supported by the students need for formalizing a solution to a problem they diagnosed. This strand of use of robotics is very useful for introducing computational concepts, such as creation of algorithms. According to Lopes and Fagundes, cited by Gonçalves and Filho (2008), studies confirm that debugging activities, programming and design cause the enrichment of significant schemes with new schemes of logical-mathematical representation.

Furthermore, when working on the assembling of structures with the kits, fields such as physics and mathematics are clearly favored, since during assembly of a structure, these concepts are required for students [Siebra and Lino 2010], so that the

robot acts as a facilitator of the educational process and promotes the interdisciplinary in carrying out educational activities.

### 3. Survey of educational kits

A survey was conducted with six educational robotics kits aiming at pointing out the feasibility of deployment and appropriateness of these products to the pedagogical needs of schools that aim at inserting the robotics into their curriculum activities. The choice of kits was due to the educational proposal submitted by the manufacturer as well as the fact of some kits already being used by schools and being proposed by previous works.

#### 3.1. Lego Mindstorms

The Lego Mindstorms (Fig. 1b) are products that have structural components like LEGO TECHNIC, sensors (color, touch, ultrasound and others) and three servo motors, in addition to cables for connections [LEGO Mindstorms 2012], this kit brings the user guide as support material with instructions for assembly of robots, and an introduction to hardware and software [Brum 2011], a CD containing software for programming NXT robots [LEGO Mindstorms 2012].

According to [LEGO Mindstorms 2012], the kit can be mounted in four different ways, but this does not preclude the students to build their own structures and program their robots with the NXT 2.0 programmable controller (Fig. 1a). The Mindstorms pieces are plastic and dockable, the NXT programming interface is based on drag-and-drop visual blocks [LEGO Mindstorms 2012], (The Mindstorms also enables textual mode programming by NQC language). What makes a product that can be used both for teaching children, as in fundamental level, and even in technical education. One of the factors that may hinder its implementation is cost, (Lego Mindstorms costs around R\$ 1,999.99 in the Brazilian market). Lego Mindstorms is represented in Brazil by the group M CASSAB [MCASSAB 2012].



Figure 1. NXT 2.0 (a), Lego Mindstorms (b).

#### 3.2. Arduino

The Arduino is an open source hardware platform, designed for physics computation [Arduino 2012], based on a board with digital and analogical inputs and outputs [Fonseca et al 2010], which through its Atmega microcontroller allows the creation of

independent models or controlled by a computer. According to the official website, the Arduino has a programming environment that uses its own language based on Wiring, resembling C/C++.

UNO is the current version (Fig. 2a), the Arduino does not have structural parts, electronic components and printed material; however, the site contains technical information about its functioning and also programming examples, allowing the integration of items such as direct current engines (DC), stepper motors and servo motors; the Arduino has libraries that facilitate the handling of a good part of these components as seen in [Arduino 2012], Arduino platform is also compatible with a number of sensors, which can also be purchased separately. The Arduino is a very powerful tool, but it becomes complex to certain contexts, such as basic education, by requiring knowledge of electronics [Fonseca et al 2010].

A major advantage of the Arduino is its use flexibility, which can range from simple prototypes to professional-level projects [Arduino 2012], the Arduino costs on average R\$75.00, one of their representatives in Brazil cited on its website is the Robocore [Robocore 2012].

### 3.3. Lynxmotion

The Lynxmotion produces educational robotics kits since 1995, with a varied catalog where all models have pre-assembled electronics as described by the company website [Lynxmotion 2012]. Some models are controlled by the BASIC language [Lynxmotion 2012].

The company manufactures their kits with focused on high schools, higher education and hobbyists [Aliatron 2012]. According to Lynxmotion (2012), its parts are constructed of anodized aluminum; in addition, the kits do not require mounting screws, rivets and some nylon fasteners are used.

In order to reduce the kit cost, the company provides the support material only in online mode [Lynxmotion 2012]. In Brazil, the products Lynxmotion (Fig. 2b) are distributed by Anacom Eletronica [Anancon 2012]. This kit offers ease for pedagogical work due to their structural parts being fixed, the activities are focused on developing solutions using the kit.



**Figure 2. Arduino UNO (a), Lynxmotion Kits (b).**

### **3.4. Robokit**

Kit created for educational purposes by Impley® in partnership with the Bachelor Course of Computing at the University of Santa Cruz do Sul (UNISC) as described on the company website Impley (2012). The kit is designed so that schools can have access to educational robotics.

According to the blog Robokit Online (2012), this product is focused on basic education, Robokit has an independent controller that does not require a computer to program it, so that students can trigger motors, LEDs and sound through this controller. According to Impley (2012) the Robokit can be used in projects such as the representation of urban areas (models), development of games and other inventions. It is composed of four LEDs, two direct motors (DC), a stepping motor and a sensor. The Robokit (Fig. 3a) allows the use of programming features, such as creating procedures and repetition commands through a colorful keyboard, the kit brings a manual containing a guide of educational activities to be developed. The product sale is made through the company Impley.

### **3.5. Modelix**

The Modelix is a company of the Group Leomar Equipamentos Náuticos, which develops products for individual users and schools [Leomar 2012]. Its materials in educational robotics are based on small metal bars that connect by screws; the kit also has gears, pulleys, wheels, electric motors and sensors pieces. Besides these components, other Modelix pieces can be used for expanding the kit [Modelix 2012]. According to Modelix (2012), its controller Modelixino 2.8 (Fig. 3b) is open source and can be programmed through a visual blocks interface.

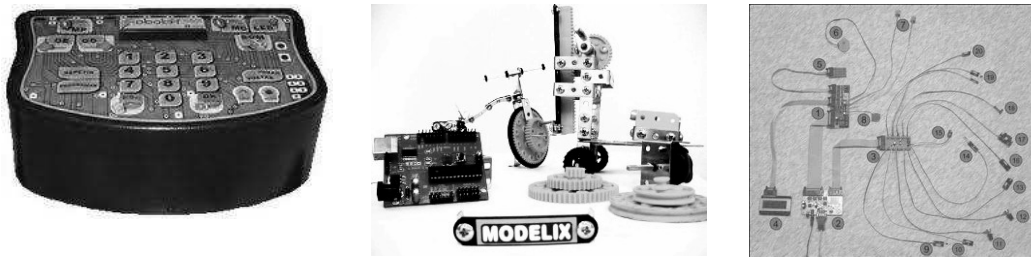
Some Brazilian schools already use the Modelix products (Fig. 3b). On the company website can be accessed a list of schools that adopt these kits. The Modelix products include support material for teachers, containing examples of class and handouts for students make use of the kit. With regard to the cost of their products, there is a variation according to the kit, for example the kit F 1.1, the investment for classes from 1st to 5th grade with 20 students is R\$ 8,980.00 [Modelix 2012] and the acquisition can be made by the e-mail vendas@modelix.com.br.

### **3.6. Maxwell Bohr**

They are products designed for educational purposes. The kits Maxwell Bohr do not bring structural parts [Maxwell Bohr 2012]. The kit KDR5000 brings modules to interact with the environment, such as sensors (temperature, light, touch, vibration, weight and distance), DC motors and stepper motors, LCD display, keypad, Buzzer (audio), among others. The MEC1000 is another product developed for teaching purposes; these devices can be used to practice activities involving electronics, mechanics and programming, as can be seen in the Maxwell Bohr website.

The KDR5000 (Fig. 3c) was designed to be part of the school material, while the MEC1000 is a simpler version of KDR5000 developed to compose the student material. According to the technical manual of the kits, Maxwell Bohr products use a library of

control that is responsible for sending instructions to the Kit, programs can be written in languages Delphi, C ++, C # due to the library have been developed to these languages. Its supporting material consists of a book and the user manual,; the technical manual can easily be found on the company website [Maxwell Bohr 2012]. Regarding the acquisition, there is no record on the company website about suppliers or how to purchase the products Maxwell Bohr.



**Figure 5. Robokit (a), Modelix Kit (b) and Maxwell Bohr KDR 500 (c)**

#### 4. Comparative

This section provides an overview of kits and components shown in Table 1. The following notation will be adopted for data demonstration, the character (X) is used to expose the components present in the kit, while the character (-) will be used to demonstrate that the component is not part of the kit.

**Table 1. Summary of Kits and Parts**

		<i>Lego</i>	<i>Arduíno</i>	<i>Lynxmotion</i>	<i>Robokit</i>	<i>Modelix</i>	<i>Maxwell Bohr</i>
<b>Hard ware</b>	structural	X	-	X	-	X	-
	electronics	X	-	X	X	X	X
	programmable	X	X	X	X	X	X
<b>Softw are</b>	Textual	X	X	X	-	-	X
	Graphic	X	-	-	X	X	-
<b>Support Material</b>	User manual	X	X	X	X	X	X
	Technical documentation	X	X	X	-	-	X
	pedagogical support material	-	-	-	X	X	-
	Cost	R\$ 2.000,00	R\$ 75,00	-	-	R\$ 8.980,00	-

Based on the information displayed in section III of this article and in the criteria listed for the classifying the kits, we can infer that the kits presented in this work, despite being designed for use in educational robotics, partially meet the needs of Brazilian schools. In order to obtain results with robotics, it is necessary that kits include the necessary components for installation and programming of robots, also provide material support to both students and teachers and have a better use of this resource.

Through this discussion, it is observed that the products Modelix present the best cost benefit among the kits analyzed; moreover, that its differential in the proposal of pedagogical use, as prepared for F1.1 kit that meets groups of up to 20 elementary students brings full content to an academic year of the course Robotics [Leomar 2012], which explains the seemingly high investment.

The Lego Mindstorms kit costs about a quarter of the Modelix kit, but it does not support the same number of students than F 1.1 of Modelix and has no teaching materials associated with the kit. However, the Lego kits despite the high cost, have good quality in addition to being very versatile products, this kit can be used at the fundamental level due to its parts being easily pluggable and plastic and having a programming interface based on icons, ideal for introducing programming concepts in this level of education, but it can also be used in high school by meeting more complex projects.

The Robokit has better adaptability to the elementary school by being a very simple kit to be programmed, which by using a keyboard with buttons and colorful figures students create and run their algorithms, facilitating the logical understanding of programming. Despite not possessing structural components, the Robokit can be used for example, in projects such as game development and creation of models, as well as the kit Modelix, the Robokit has educational material to assist the development of activities in the classroom.

Maxwell Bohr and Arduino are products with similar use, both programming interfaces use textual language. Arduino has its own language, while Maxwell Bohr kit uses languages such as Delphi, C and C #. The fact that Maxwell Bohr Kits use these languages makes the kit familiar to students of technical and higher education levels. However, the use of these kits is more complex than Modelix, Lego Mindstorms and Robokit, due to requiring knowledge of electronics in some cases, ratifying a better adaptation of these products to secondary, technical and higher education levels.

The Arduino is a platform and very versatile, it can work not only with robotics, but also automation issues. Despite not providing printed material, manuals, guides and tutorials are easily found on the internet; however, only with the Arduino it is not possible to develop all the possibilities of educational robotics, once just programming devices would be explored, making necessary to acquire other components (sensors, motors, chassis, etc.). Furthermore, the kits Maxwell Bohr comprise a set of electronic components, eliminating the need for striking components compatible with the kit.

The Lynxmotion products, as well as Maxwell and Bohr Arduino, are best suited to medium and technical levels, despite not requiring expertise in electronics like the Arduino and having the kits structure fixed, the programming made in some models by the BASIC language, makes complex these products in the context of elementary school.

## **5. Conclusion**

This article presented a research on materials used in educational robotics, which were designed to provide resources to enter this segment of technology in the classroom. The advantages that educational robotics offers are indisputable, not only improving the physical and mathematical skills of students, but also working on the understanding of concepts related to technology.

One difficulty that arises against the inclusion of this feature in schools is the cost of products and adequacy of kits to school needs. Even with all the possibilities of



models available in the market, it is necessary a product that fits the needs of Brazilian schools. To have a material to work on the different levels of education, and thus can exploit the full educational potential that robotics can provide.

### 5.1. Future Studies

The following activities are proposed for future development:

- Prepare an Arduino school kit;
- Development of educational support material and activities guide for students;
- Development of educational support material and activities guide for teachers;
- Development of case studies that offer a definition of methodologies for use of educational robotics.

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