Science, Education and Technology: Robotics in the curriculum at schools in Brazil

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Abstract

This paper describes, taking a PhD thesis defended in 2011, some results about the integration of robotics as a technological resource in the curriculum of a private school in Brazil. It's emphasized the pedagogical and didactical aspects and brings a discussion about teaching science and the perspective of using robotics and the relation between curriculum, science and technologies. The results indicate the integration of robotics as a technological resource in basics education in Brazil has complex aspects, such as relation between time/space, the preparation of the educators and the relation between robotics and other subjects. Therefore, the comprehension of these aspects could indicate some steps that we should think when integrate robotics into curriculum, that the technology is not going to keep the prescribed curriculum hegemony, but amplified the perspectives of education for science and technology significant and motivated for students.

Keywords

Constructionism and the curriculum; Educational Robotics; Constructionist approach; Education and Technology

Introduction

As a technological resource in education, we could say robotics has been one of the most technologies innovated nowadays. Therefore, schools in Brazil have difficulties to integrate this technology into their curriculum.

The robotics projects in basics Education in Brazil show themselves as an isolated practice in different development projects, because these projects are sometimes understand as a specific subject in the curriculum, which means it has been using in professional education in high school or college. Robotics have been seen by educators and the population as a sophisticated toy, in which people that loves robotics find themselves in championships and conferences around the world.

The research about robotics is reaching the university context – engineering and mechanics – and industries. The interest for the subject is growing, and we can see the investments from the government in education technology. Even with all the investments, only a few schools in basics education integrate educational technology subjects (as robotics) in curriculum. The more significant projects are limited in professional education and college.

Despite all that, sometimes we find educators interested in explore robotics and constructionism concepts into their practice. Influenced by researchers and primary projects using robotics in schools, by cinema and media, or by simply like technology, teachers and students mobilize themselves to construct their projects. Make the design, build, program and analyze the results of robotics become a motivated activity for the learning process and helps cognitive process

(D´ABREU, 1993), as well as provides creative activities (RESNICK, BERG e EISENBERG, 2000; RESNICK, 2006).

Today, the use of robotics in education in Brazil (from kindergarten to High school) as a technological resource receives the name of "pedagogical or educational robotics". We ask, is this the right denomination? Is it possible to determine what´s the right denomination?

The fact is we don´t want to say these nominations are wrong, but we realize educators and researchers that use this resource (robotics) with different names. We find out that even in the internet and scientific articles talk about robotics with a diversity of denominations. Because of that, we find the robotics in education researches related to the following topics:

- **Robotic object** – the concept has a direct relation with robotics hardware;
- **Physical space/laboratory** – Relation to the robotic learning environment at schools;
- **Learning environment** – Its seems to be the same as the topic before, but emphasizes the cognitive process that the environment creates, involving the space, the activities and the relations between students and the teacher;
- **Specific Project** – The characteristic is fundamental about developing projects like Summer programs, outside the school class;
- **Methodology** – This topic emphasizes the use of robotics as a methodology, in other words, pedagogical practice.

We could say that is not easy to describe correctly the name of robotics in education, if it's pedagogical or educational. But still, we don´t have pretention to defend a concept or say that one term is better than other, but we prefer to use the expression "robotics in education", because we believe robotics is a technological resource used in basics education for develop projects related to the following topics:

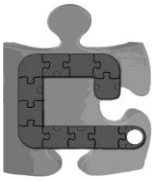
- Learning robotics;
- Robotics as a technological resource used in learning process of different subjects and concepts;
- Integration of both categories.

The first category corresponds to projects with purpose in learning robotics concepts, the students develop projects and learn how to program a robot, how to use a sensor and all the technology involved, and giving attention to robotics itself. At schools in Brazil, this category appears with more evidence in after school programs.

The second category, robotics are used to develop projects that holds in evidence the learning of different concepts, such as mathematics, physics, art, etc. So, this technological resource allows the school to create a different environment to the learning process, in which by creating and programming the robot, the student can learn physics, mathematics, science, arts, for example.

Although the use of robotics in the last category has a direct relation with science and mathematics, projects involved are integrated with knowledge like arts, geography, history and others, and could more interdisciplinary, in special involving the last ones.

In this point of view, the schools in Brazil work with robotics in after schools programs, specific projects such as championships during the school year and in a few institutions the projects using robotics are directly in the curriculum, in other words, are into curriculum as a subject (like mathematics, arts, history) or are used in different subjects as a technological resource, depending on the teacher.



The last category – integration – involves the other two categories, that is, the projects developed include both, learning robotics and specific topics and interdisciplinary subjects. An example of this are activities that provides learning of science concepts, and at the same time the student can construct his/her learning how to program a robot, how to use sensors and motors in the construction of the device.

Development

Our research sought, from a qualitative analysis, identify the characteristics of robotics (constructionist concepts) integration in the curriculum of a private school in Brazil, from kindergarten to high school, especially about pedagogical and administrative aspects.

When we use the term "integration in curriculum", we refer to relation between curriculum and robotics as a technological resource, in other words, not only the use to "knowledge transmission" and the consequence adaptation of this technology to learning process, but a real rethink of pedagogical practice and other aspects that involves the integration of this resource (robotics) in curriculum.

Although we can find robotics at schools around Brazil, considering the researches produced until 2011 in Brazil, the proposes of companies that sell robotics materials and the Brazilian school system, we could say that our work has an impact in point some elements of curriculum integration of this resource and the constructionist concepts in the curriculum.

The research considered the focus group as a methodology, having sixteen students in eighth grade (13 years old). We use the data to analyze the impact of robotics and constructionist concepts in the curriculum, as the students face the subject with one class per week, studying components, sensors, engineering, math, science and others.

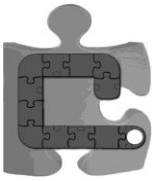
We accentuate that our research considered the perspective of robotics in the curriculum as an amplified form, in other words, its integration permeates the curriculum of everyday class and after school programs. However, this research prioritizes the integration of robotics in curriculum because after school programs have specific characteristics, allowing more flexibility during development. Although, this projects seems to be a part of the curriculum, with few activities during the school year.

In fact, we observe that integration of robotics in curriculum of basic education is complex, involving pedagogical and administrative aspects in relation to objectives and purpose.

It is important to point that this technological resource has characteristics that influenced directly the integration in curriculum. Robotics materials (Lego, tetrix, and picocricket) are not like computers that condense a wide range of media in one physical device, the items that define robotics demand specific knowledge (program, building, motors, sensors, etc.), which makes more difficult for teachers to know how to use in classroom for example.

There so, one important issue that interferes directly the integration of robotics and constructionist concepts is the necessity of the educational institutions to have in its staff, educators who know robotics and constructionist approach in all characteristics, such as: robotics materials available in the market, building pieces and the computer program language.

When we say educators, we are not referring to professionals specialized in computer science or robotics, which by their degree they have knowledge in program a robot and building the device, but we talk about history, arts and other subject teachers, coordinators and educational managers.



In this way we understand that education institutions, most of them, doesn´t have exclusive teachers to develop projects to integrate robotics in the curriculum, so make this process even more complex, considering the most of the teachers responsible for use robotics (constructionist approach) have their degree in science (Mathematics, physics and others).

Besides, the personnel responsible to the management (principals, advisors, coordinators) don´t have specific knowledge like teachers, which means they need to learn in service. Therefore, a few companies are specialized in courses that involve learning robotics (how to program a robot and how to use sensors, motors and a sort of pieces), so it´s more difficult to integrate robotics in curriculum.

The integration of robotics in curriculum is different from a simple specific training, demanding from teachers a continuous learning about robotics itself (sensors, motors, language program) and a pedagogical approach about using robotics in learning situations.

We can add the fact that exists in the educational market in Brazil robotics projects that seems "easy and ready" solutions for schools, with books and activities that tells everything students and teachers should do, limiting their creativity and the possibilities of knowledge construction by students. That is, robotics and constructionist concepts have been incorporated in the curriculum at schools in Brazil without a real reflection and preparation.

Another important question of robotics integration is the relation between continuous teachers learning and pedagogical planning for robotics classes, including the content and activities to be done during school year.

A relevant element of this aspect is the fact most institutions doesn´t have a consistent conceptual basis about what to teach in robotic subject, in other words, they don´t know what or how to relate any content to this technology that has been incorporated in curriculum tables, and the consequences are different ways to choose books and didactic instructions to robotic as a subject.

Indeed, this is a fundamental data when we talk about integration of robotics in curriculum. Differently from other subjects such as mathematics, history, geography, culture studies and others, those have been historically constituted in schools curriculum with defined content for all grades, robotics don´t have this structure, and for this we can see a wide range of content that is not helping the real need of robotics integration in the curriculum.

To exemplify this, we could think in schools that have an annual planning for content in robotics subject related to technology concepts directly attached to sensors, motors, cables, pieces and program, as an example, learning how to program an electronic device (robotic) and use of sensors and motors. In this case, schools cannot get together interdisciplinary subjects that compose school curriculum and either construction of scientific concepts.

Other example are institutions that gives privilege in content related to subjects in general (science, mathematics, physics), which can reach learning of technology that we mentioned before.

Well, in fact when we think in integrate robotics in the curriculum is consider the basis to choose content to work in robotic subject. Considering the results of interviews and the observation of activities during school year of 2011, we believed that integrate robotics in curriculum as a subject should be sustained in three basis: education for **science**, **technology** and **interdisciplinary**. In this particularly research, we observe physics subjects and during the activities the students amplified science and other concepts.

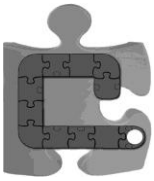
As an example, an 8th grade group of students had an idea to a project (The theme was about robotics and special human needs) that teacher asked them to get involved. Instead of just research and present something press, they decided to build a model of a wheel chair with lego mindstorms and also construct a small example of a street to represent a real attempt of the device they were building.

For that, they spent two months to design all. What made that possible was because they had one lego mindstorms exclusive for them, and so they could experience the whole project building and also learning the concepts involved.

Figure 1. Image of students building the street reference for the Lego model.

To compare, the same group had weekly robotic classes, in which they worked in projects design for only 50 minutes. On that, all students should build the models and at the end of the classes they get all the pieces back in the box for other students. That is different from the project we described above, because in this case they couldn't use the same Lego material for a long time. Instead, they constructed some device and had to take all the pieces apart to other students that were going after them.

Therefore, these aspects need to guide the content insert in pedagogical projects in educational institutions and the integration of this technological resource in curriculum in a significant way (Thinking about constructionist approach), having as a reference the construction of knowledge and the student's freedom in the learning process.



The education for **science** expresses elements such as investigation process and concepts like force, motion and energy. About education for **technology**, we need to consider the knowledge of pieces functions like sensors, motors, computer science and all involving this theme.

Lastly, we have education in relation to interdisciplinary, in which involves concepts such as working team, creativity and even those that are not directly attached to robotics or science. We want to say that interdisciplinary is something inevitable and goes beyond different subjects, amplifying their boundaries.

Integrate robotics in curriculum is fundamental, because it's not only a technological resource that allows students to participate directly in their learning process, but has a potential to contribute in the development of projects that aim to emancipate the students in their thinking.

Besides, contributes not only to build a multiple referenced curriculum, that considered both historically content and specific context in each institution to develop pedagogical projects, but also to enrich a culture of use of technology in education that has sustained by emancipation and autonomy of students in learning process.

It is not, therefore, simply add a subject "robotic" in curriculum because is interesting, to conquer new students or to be more "visible" with clients (in case we talk about private schools, because in Brazil is more significant in use of robotics), neither to use this technological resource in a few moments during the school year depending on the teacher or the content. (Bers, M., 2007)

Indeed, integrate robotics in curriculum means considerer two sides, articulating the teaching learning about robotics and a school pedagogical approach that has as foundation to the necessary steps to develop an activity using robotics (**challenge/problem, design/solution, test, results and share**), providing to students an active participation in the whole process.

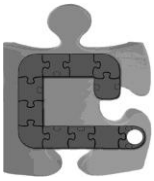
The creativity in the context of robotics integration it is another important element. Projects that give instructions to students to build the devices don't help in knowledge construction and student autonomy, and this is the most usual scenario around the schools in Brazil.

Then, during the class steps described before (**challenge/problem, design/solution, test, results and share**) students need to be creative, in other words, they cannot, for example receive instruction (device model) to build, but instead use imagination and the challenge proposed to build their device. They have to program the device to operate and not get the program from the teacher.

A reference for creativity is the spiral of creative thinking from Resnick (2007). For this, *creativity* must permeate the student action during all steps in robotics activity, with the objective to enrich the use of this technology and constructionist concepts in learning process, and there so, guarantee the significant integration of robotics in curriculum

Another fact that compromised the integration of robotics in curriculum is the relation time/space, related to development of robotics activities in schools. The data from students shows the needs to rethink this matter.

Most of the schools don´t have specific labs to teach robotics, environment that facilitates students to be more engage during the activities, using large tables with computers and different robotics materials. What happen in some schools is that robotics classes usually occurs in small places, with association to computer labs, and students must build their device with small spaces available, interfering significantly in the integration of robotics in curriculum.



We can go further, talking about time. In general, schools have in their curriculum robotics classes with only fifty minutes, or in some institutions with one hour and a half. This context makes difficult to integrate robotics in curriculum because the lessons steps that we described cannot be fully developed. As an example, we could imagine a robotic activity, and during fifty minutes students must design and build the device, write the language program, test and share the solutions.

It is not difficult to understand that time is not sufficient, which makes the integration of robotics limited in all ways and all the steps are compromised. In case of after school programs, even though time seems to not be a problem (because the project could last weeks), the projects have been developed without connection to curriculum.

The relation between time/space is directly attached to management in institutions, because the costs involving teachers, robotics materials, classes' time and adequacy in the curriculum prevent us to reflect about our real needs to integrate robotics in curriculum.

Then we could say, the integration of robotics in curriculum is considering **education** for **science**, **technology** and **interdisciplinary** as fundamental elements to pedagogical planning for teachers and educators, especially about content of robotics.

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