A Methodology of Contextualized Educational Robotics

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***Abstract*—Just as in educational robotics the students solve problems in order to build their own knowledge, so too in contextualized learning the students learn by solving problems. The difference is that the former works with interdisciplinary problems that are solved by the construction and use of a robotic model, and the later approaches cultural or socioeconomic problems related to the students reality. Therefore both approaches are based in constructivism and problem based learning, but each one has specific characteristics and benefits. Thus, a teaching and learning approach that combines the two could have different or perhaps more promising results than with just one of the individual methodologies. In this work we propose a teaching and learning methodology that combines educational robotics and contextualized learning. This methodology is described in order to be replicated by other teachers or research groups. After that, we present as an example a course planned and executed with such methodology for a school located in a small town in the semiarid area of Brazil. Finally, we discuss the methodology and some of the outcomes from the course at short and long terms. Although new experiments are necessary to achieve conclusive results, the partial results are promising.**

***Keywords*—constructionism; contextualized learning; educational robotics; teaching and learning methodology.**

I. Introduction

Information and Communication Technologies (ICTs) have exercised a great impact in the society's way of life, creating new manners of social relations and interactions [1]. In this context, both educational robotics and contextualized learning can play important roles for the social and economic transformations necessary for communities under development [2],[6]. In addition, both approach constructivism and problem based learning methods. Therefore, some questions arise: Is it possible to combine the characteristics of both theories to a new teaching and learning methodology? What are the benefits that this combination may bring? In this work we propose a teaching and learning methodology that combines educational robotics and contextualized learning.

Dias et al. [6] highlight that the main success factors for initiatives that approach ICT for education, such as educational robotics, are: the community participation in planning the interventions according to local problems and needs; knowledge transfer and empowerment; sharing resources with others in order to achieve better affordability and profitability of such resources; local partnerships for the execution of the initiatives; and global partnerships for sharing resources and to bring new perspectives and opportunities; sustainability; and evaluation metrics for short and long term. We can notice that the first component for success for such initiatives is intrinsically related to contextualized learning, which refers to contextualize the contents to the local reality of students.

Educational robotics, sometimes called pedagogical robotics, was based on Seymour Papert's Constructionism [13]. It makes use of robots or robotic models approaching the use of building and programming kits, or the assembly and programing of electronic components or even using scrap material; this last approach is called "free pedagogical robotics" [16]. It can be seen as a learning environment where the student learns while building (or assembling) and programming (or controlling) robotic models with his colleagues in order to solve a problem [17]. The problem approached at each class or workshop is interdisciplinary and may involve curricular contents of one or more disciplines in conjunction with specific robotics and computer content. Such an approach has, among other characteristics, playful learning, teamwork, learning from mistakes, problem-based learning, and the construction of knowledge through experience and the palpable action and interest of the learner, characteristics of constructionism. However, constructionism was presented as a methodology that happened through the use of the computer, the language Logo [3] [4] [5] and a robotic (or virtual) turtle. Over the years the concept became broader and embraced more complex activities as the act of mounting robots with initiatives as the LEGO MindStorms robotic kit [19], what culminated to what is now known as educational robotics [18].

Constructionism was also based in constructivism, a theory that seeks to explain how learning happens through a process of knowledge construction based on the learner's previous knowledge through transformations in his worldview [14].

Contextualized Education takes place through the political, economic, social and cultural contextualization of curricular subjects [7]. Such contextualization also meets the pedagogy proposed by Paulo Freire [15], that says that curriculum content must be correlated to the problems that the student experiences at home, in his or hers neighborhood, community or culture. In Brazil, many studies on contextualized education have focused on the semi-arid region [7]. And one of the major obstacles found to achieve effective implementation of this

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methodology in schools is school management at several levels [11].

An initiative related indirectly to educational robotics and contextualized education has already happened in Brazil, in the work of Schlunzen [12], which sought to unite constructionism to contextualized education. The cited work [12] made use of computers and Logo language for solving problems in the context of the students. The indirect relation with the focus of this work is given because educational robotics is based on constructionism. In this way, we find an indication of what results we can expect. Therefore, some of the results enlisted in the paper were "a more pleasant way to teach, to give meaning to learning, to contemplate the curriculum, to evaluate the child's development, to integrate and contextualize the concepts, and to value the students' potential and abilities".

However, by combining educational robotics and contextual education we also hope to gain some of the claimed benefits of educational robotics, such as motivation for learning, improved logical and mathematical reasoning, increased student self-esteem, development of teamwork skills, improved learning of sciences, and mastery of a scientific method of learning.

In this way, an education methodology that uses educational robotics and contextualized education can bring pedagogical and socioeconomic benefits, applying robotics to solve problems of the locality of the students.

This article is organized as follows: Section II presents the proposed methodology; Section III presents the results of the application of this methodology in real teaching environment; Section IV discusses the results; and Section V concludes the article.

II. Proposed Methodology

As the methodology presented here envelops contextualized learning, it is necessary to start working by performing a diagnosis at the school, the students and their community. Next, the course planning must be discussed with the teachers so they can suggest which curricula contents are most necessary to be worked with the students who have been selected to participate of the course, and what local problems they suggest to be approached in an interdisciplinary way. So, each class plan is detailed.

In order to do all that, this methodology is presented in five steps (Fig. 1):

i. **Initial diagnosis:** Collect data about the school, the students and their community.

ii. **Survey of contextualized problems:** With the school´s teachers.

iii. **Course Planning:** The duration and frequency of the classes must be decided with the school pedagogue or schools' director.

iv. **Classes:** Execution of the course planning, where the contextualized educational robotics classes may occur as workshops. Three hours per meeting is recommended, especially if the workshops make use of reusable robotic kits that are shared with other classes. The three hours are the time needed for the entire class including assembling and using the robotic model. These meetings can be held weekly or at each two weeks.

v. **Robotics Fair:** At the end of the course, a small robotics fair is performed where students exhibit interdisciplinary projects that approach local issues for the school community.

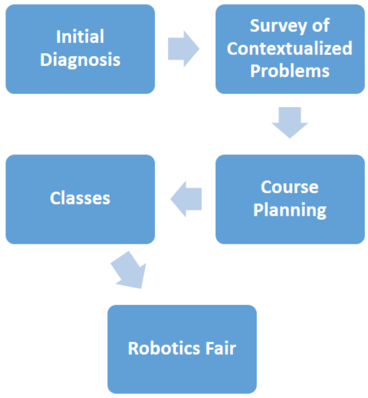

Fig. 1. Steps of the proposed methodology.

II.A. Initial Diagnosis

In this step, it is necessary to collect the following data:

a. **School's characterization**: data on the infrastructure, available spaces, number of teachers and students, digital or analog equipment, and student statistics (grade, income range, evasion rates, history of external and internal evaluations).

b. **Data from the schools' community**: history, statistics, socioeconomic indexes, environmental data, main sources of income etc.

c. **Students' profile**: trace the profile of the group that will receive the course, searching for information on previous knowledge, average grades in each discipline, difficulties, and background about information technology and robotics.

With this data, one can get the first ideas about the students' needs and the specific topics of robotics/informatics or the curricular contents that need to be explored the most.

II.B. Survey of Contextualized Problems

This can be achieved by meeting with the schools' teachers to discuss or brainstorm about initial ideas of possible classroom themes addressing contextual problems. The data collected in the prior step also can be helpful. For instance, if the statistics about the community show that wood crafting is an important source of income, issues related to this craft can be discussed to select one of the contextualized problems for the course. A contextualized problem is any issue related to the reality of where the students live, that could be approached with curricular contents and robotics.

II.C. Course Planning

The planning of the course can take place in the same meeting where the problems were raised, or in later meetings.

The classes or workshop should preferably be planned in modules or courses of ten to fifteen meetings by semester. And the last three meetings can be held for preparation and realization a the robotic fair. The purpose of this fair is to motivate the students and the community, who will attend the presentations of the projects, and to instigate the students to participate in science fairs.

The classes will be planned in workshop format, and each lesson plan should contain the following topics:

i. Contextualized problem.

ii. Subjects or curricular content.

iii. Specific subject of robotics/ICT.

iv. Activities and evaluation - for example, challenges and questionnaires, involving the problem and issues addressed. The questionnaires should propose the reflection so that the students discuss how they would solve a real problem of their daily life using the knowledge of the class. The challenges must be active and dynamic tasks performed with the robots.

v. Robotic model (a tutorial that can serve as a model to assemble and program the robotic model, step by step; especially helpful if the group does not yet master the technology or cannot find a solution after some time).

vi. Materials - for the robots, models, posters or other class activities.

Each class should introduce a robotic or ICT concept alongside the interdisciplinary curriculum subjects. And all of these subjects should be discussed with the contextualized problem in focus. The choice of these interdisciplinary subjects should regard the profile of the class, curricular components the class has difficulty, or what the teachers of the school wish to work in the workshops.

In developing communities, digital literacy is also an issue and need. So, both educational robotics and contextualized education can be used for digital literacy, as can be seen in the literature [8][9][10]. In order to choose the subjects specific to robotics/informatics in the workshops, the following questions should be answered: What is the prior knowledge in robotics and informatics in the class? Is digital literacy needed, or the topics could be more advanced in these areas?

We should also plan what activity students will do: build a robotic model, build and control, build and program, or just program the robot. And also what will be the form of evaluation: observation, objectives achieved in order to solving the problem, robot design, programmed code, written questions involving the interdisciplinary subjects etc.

General planning should respect the order of prerequisites for presentation of robotics/informatics subjects and curricular components. Therefore, at the same time, the contextualized problems must be chosen so that they fit the interdisciplinary themes of each workshop, and these themes must also be chosen with these problems in mind.

The robotic model of each class should be chosen according to the knowledge of robotics presented at the respective class. In addition, the models should be progressively more complex throughout the classes.

For example, let’s say that in a class we are planning has to address some issue about Agriculture. In the last class, the introductory robotics content has already been worked on. So in this class we can work detailing sensors. We must think of a situation involving agriculture in which we can use sensors, and what curricular knowledge can be addressed.

A Geography teacher might suggest working about types of farming and soil conservation, an English teacher might suggest a lesson on words and terms involving agriculture, and so on. After choosing the curricular subjects that will be approached in an interdisciplinary way, we must plan the class activities together with the teachers. So it could be decided for example what the students should build and program a robot that uses the sensors to navigate in a sandbox and plow the soil. Students should program the robot to make the curve whenever the sensor indicates one of the bounding walls of the box. At the end of the class the students should answer a questionnaire about the subjects seen in the initial presentation and what conclusions the student took at the end of the activity.

So we could think of a robot model that prepares the soil and uses sensors to navigate while reproducing one of the plantation models. If the class is already at an advanced level and is able to create the models themselves, we only choose one robot building tutorial fitting this scenario as Plan B that will be presented if the class does not reach the goal within the stipulated time. Finally, we should list and provide the materials for this class.

The informatics subjects of each workshop will depend on the knowledge of the class, can be from the introduction of the computer parts and use of the mouse, browsing the Internet to do research, and creating presentations. However, we can also explore the creation of media for the publication of robots in social networks, or even the creation of videos with some didactic purpose. It is up to the course developers to discuss what the objectives are. If Internet use is chosen for the course, it is important to remember the issue of information security so that students do not expose themselves to Internet threats. Also, informatics subjects may not be required if the students’ background about the subject is considered enough.

The basic subjects of robotics that can be addressed are: general concepts about robots, robotics, sensors, motors and energy; History and applications of robotics; Types of sensors and their use, like following lines and deviate obstacles; Types of motors and actuators; Principles of electronics; Control and programming. However, the content that will be taught to each class, which may even be more advanced than this, should be planned based on the previous knowledge of the class and the course objectives.

II.D. Classes

In general, the classes or workshops should follow this order:

i. The teacher presents the contextualized problem.

ii. The teacher presents the interdisciplinary curricular subjects.

iii. The teacher promotes a reflection about the relation of the problem to the subjects.

iv. The teacher presents the specific subjects of robotics (and informatics).

v. The teacher proposes to the students to organize themselves into groups of up to five or six students in order to solve a problem with a robot by planning, building, controlling or programming and applying the robot to a task.

vi. Assessment - questionnaires, teacher notes, and/or homework. This step can be done in parallel or intercalated with the others.

vii. Organization - at the end, the students must organize all the electronic components, tools or parts used in class. If using robotic kits that should be shared with other classes, it is necessary to also disassemble the robots and organize the kits. If using electronics or free pedagogical robotics (with pieces of scrap) it may not be necessary to disassemble the robot - unless it is needed for reusing components. If disassemble is not needed, may be the case that students can keep the robots.

In its turn, the process of using a robot, automated model, or robotic device described in item (v) must go through four steps:

1. Planning: Each group should discuss the design of the robot or model and how it will act to solve the problem. Even when a building tutorial is offered, each group can add parts and customize their robot.
2. Building or Assembling: Students should assemble the robot or model. If the time stipulated for planning has passed and the group does not have a model, or if the lesson has been planned for using a building tutorial, one is offered. Alternatively, the teacher may present a built robot and ask the students to try to build by observation or to disassemble and assemble a new one. Note: this step is optional if the activity involves only programming.
3. Control/Programming: The students must test the robotic model with a remote control or they must program the robot to perform a task autonomously.
4. Application - the activity is performed with the built model using the remote control or program, and in case of failures, one must go back to previous steps to analyze the error and correct it.

II.E. Robotic Fair

As stated before, the last three classes should be reserved for a robotics fair. The two first of those classes are for proposing and preparing the projects, and the last one is for presentation.

In first of these three meetings, the teacher presents the group with the proposal of the fair and asks the students to organize themselves into groups and choose the problem that each group will address. The teacher can advise on the themes and provide reflection on how they could be approached in an interdisciplinary way. In the rest of this meeting, the students can plan the robotic models and can Internet research or go research at the library about the curricular subjects that will be the basis for each project.

In next class, students should prepare models, posters, slides or other media, and robots (hardware and software), also in this meeting they rehearse and test their presentations. If the classes have very young students (first school years), it is possible to make a more feasible project such as a small play or dance presentation with robots.

In the last class, the robotics fair is realized. Other students, teachers, parents and the community should be invited to watch the presentations. Therefore, each group should present a problem, explain it with curricular knowledge (through a poster or slide show), and present their solution with a robotic model performing a task. There should be a closing ceremony. Besides a speech from the robotics teacher, we suggest a display of photographs of the course, delivery of certificates and optionally awards to the most rated or voted works.

III. Results

In order to apply this methodology, we chose the Maria Alina Pinheiro State School, in the small city of Afonso Bezerra, located in the countryside of Rio Grande do Norte, Brazil. The school was chosen to meet the wishes of the community, which expressed the desire to participate in research or extension projects of Universidade Federal Rural do Semi-Árido (UFERSA), a university with a campus located in Angicos (neighbor city). Such aspirations were transmitted to the professors mainly through university students who lived in Afonso Bezerra, and also through teachers from the local schools. In this way, the application of this methodology would begin in a place where there was a good receptivity.

III.A. Initial Diagnosis

With the initial diagnosis, it was found among other data that the school was overcrowded of students, since the cafeteria/patio area and even the secretariat were used as classrooms. The school is located at the address that serves the majority of low-income students of its city and at the time of this experiment it had 16 teachers and 369 students enrolled in elementary school in 2015.

The school's ICT structure was scarce. The school had only eight computers for students' use, with very slow and intermittent Internet access, as well as two TVs attached to a parabolic antenna and a DVD player, three stereo sets and a single multimedia projector for the whole school. The faculty only had two computers and three printers besides these resources.

According to the Brazilian Institute of Geography and Statistics (IBGE)'s population census of 2010 [21], the population of Afonso Bezerra was 10,844 inhabitants, with only 6,797 people literate. That is, it has an illiteracy rate of 30.29%. The main sources of income in the municipality are public administration (66.14%), services (20.42%), agriculture (5.68%), taxes (4.66%) and industry (3.09%).

Afonso Bezerra was only decreed as a municipality in 1953, and is located in a region of very hot and semi-arid climate, surrounded by the caatinga biome. Bee honey is also produced in the region and there are other products that can be derived from local flora and fauna that are not economically exploited despite their potential, such as Angico bark; Carnauba wax, fiber and powder; Cashew nut; Mangaba fruit; Oiticica seeds; and Umbu fruit. The city is cut by the rivers Açu, Cabugi, and Serra da Aguda, and the water is stored in dams that are also exploited by the local population for subsistence fishing.

The school indicated nine students for the course and they attended the 8th and 9th years of elementary school.

III.B. Survey of Contextualized Problems

At first we tried to arrange a meeting with the teachers to discuss local problems. But it was difficult to schedule an appointment with the teachers because as they have not good salaries they worked in different schools in the three shifts to supplement the income. So, the survey was done by collecting suggestions in informal conversations with the teachers; and by a brainstorming of the team that would conduct the workshop, based on the data collected in the initial diagnosis and in the experience of one of the members of the group that at the time of the experiment lived in the community of the chosen school.

The problems chosen were: alternative energy sources (solar and wind), use of fishing boats, recycling of wood, cooling the characteristic heat of the semi-arid region, simulation of the most popular sports in the region (jiu-jitsu and soccer), collection and storage of water in the semi-arid region, extraction and processing of the fruit of cacti locally called with the popular name of “Pêlo” (that means Fur, the scientific name is Tacinga inamoena).

III.C. Course Planning

After discussing with the school's director, we ended up scheduling a total of 10 classes in the period from June 26 to August 28 of 2015. It was agreed that the workshops would take place on Fridays in the morning, while the students regular classes were in the afternoon, and that each meeting should last three hours. As there was a budget limit, and the delivery of the robotic kits ordered by the project would be delayed due to bureaucracy, we prioritized for this course the use of free pedagogical robotics.

Here is a condensed list of classes describing: the contextualized problem; curricular subjects; the specific subject of robotics or informatics; activities; assessment; the robotic model; and the required material.

For the first class we chose as contextualized problem and interdisciplinary theme the exploitation of the potential of alternative energies abundant in the region, such as solar and wind energy. Initially the teacher will apply a questionnaire to make the diagnosis of background knowledge about robotics and thus better target the workshops for the profile of the class. In this lesson, in addition to the presentation on the themes above we will work on the introduction to robotics concepts. As a practical activity, students should use the 6-in-1 robotic children's kit with boats that move to solar energy, and they will be offered to make a play using the material. For the activities, besides the "6 in 1 kit" it is necessary basins with water and an open space with direct sunlight. As homework we can ask for an essay on the importance of alternative sources of energy.

For the second lesson, we plan to address the recycling of wasted wood, abundant in the community, for making toys. In this lesson, we will cover the curricular subjects of complete and incomplete combustion, and interaction between water and soot. This class will use a wooden model covered with soot generated by the incomplete combustion of a paraffin candle, causing a drop of water to slide over the model because the soot-covered surface repels the water. In this lesson we will present the concepts and examples of free pedagogical robotics. The theoretical evaluation will consist of: explaining the difference between the types of combustion, explaining why water is repelled by soot, and asking what other toys could be made with the same principle. The homework will be to research about free pedagogic robot models . The free pedagogic robot model for this class is called the "Hydrophobic Labyrinth" (labirinto hidrofóbico), available on the Internet. The material for this class is the video explaining the experiment, pieces of discarded wood, Popsicle sticks, glue, candle and water.

The third lesson approaches the need of cooling due to the characteristic heat of the semiarid. For this purpose, the teachers could explore concepts of physics about engines or heat exchange, but since the class was not so advanced in curricular content, we chose the contents of sciences that relate the climate with the regions of the world and the different latitudes. The specific subject to this class was the knowledge on electronics necessary for building a fan model powered by USB or batteries. The material required to build this model are an engine from a CD/DVD drive, USB cable or battery and vanes. The theoretical activity planned consists of relating geography and temperature.

The problem chosen for the fourth class was fishing, one of the local economic activities for subsistence. For such problem, one can work on the curricular contents on the economic activities involving fishing, and as we chose the robot model "Barquinho Pop Pop" (Little Boat Pop Pop) (available at Internet), what works with steam, we also address the theme of steam energy. The robotics subject for this class will be types of engines, focusing on steam engines. Students will use a carton from juice or milk boxes along with two straws, a soda can and a candle, to mount boats that move with steam. The practical activity can be a boat race or a fishing game, tying hooks to boats so that they catch objects that simulate the fish inside the basins with water. The theoretical activity could be an essay about the importance of preserving the environment where fishing activity occurs, or a research on sustainable ways of fishing.

For the fifth class we chose a robot-fighting sports competition because muay thai and jiu-jitsu are the most popular sports in the region next to football. The theoretical subject was a discussion about the role of sports in education and about respect to others. The specific content of robotics was the knowledge to elaborate the robot and the remote control, made with cardboard, wires, clips, stapler, foil, DVD engine and balloons. The cardboard would be the base (chassis) of the robot, and two engines would play the role of wheels. The wires would link the motors to the batteries and to the control made with paper clips and cardboard. To do this, the clip should contact the positive wire through foil when pressed, so that the engines should run whenever the control is pressed. A balloon is placed on top of each robot, and a clip with thin point at the front, the robot that first burst the balloon of the opponent would be the winner of each round of the competition.

We planned for the sixth class a soccer robots competition, not only because the local importance of this sport, but also for its importance in the Brazilian culture. The interdisciplinary curricular themes worked in this context could be: racism in soccer, violence of the fans, and the risks of biochemical doping. The students must create new robots and controls based in the models used in the prior class, and the same material of that class should be available. The practical activity is a soccer competition played by the robots built in class. The theoretical activity is to produce posters about the interdisciplinary themes.

The seventh meeting was planned to address the problem of extracting spikes from edible cacti, especially from the fruit of the local cactus variety called "Pêlo" (Fur). The interdisciplinary curricular content addressed is the use of cacti for human and animal feeding. The purpose of the lesson is to construct a mechanical device that uses gears and cranks to rotate a pair of shafts covered with rubber, where cactus fruits and palms can pass so that the spikes get stuck in the rubber. Therefore the robotics subject addressed is the use of gears and cranks, and the physics behind them. The required material can be reused bicycle pedals or cranks of old household utensils, gears, metal scrap or wood to make the machine structure, and rubber enough to cover two shafts per appliance. The practical activity is to assemble this device in a group and extract the spikes of some cacti fruits. And the theoretical activity is a questionnaire identifying edible and inedible cacti. A homework activity may be to search for local culinary recipes using this raw material.

The last three classes are planned for the creation of projects and the realization of a robotics fair.

In the eighth lesson, the teacher should suggest a list of contextual problems and indicate reference material for technologies for the semi-arid region. In this same meeting, students should organize themselves in groups and define a theme with a contextualized problem. Then, they should discuss ideas for a solution to that problem using robotics. Next they will receive advises from the teacher on how they should research and use the disciplinary contents to support their works and presentations. The teacher may also point out sources that may be helpful for the construction of the robotic models and the material needed for each project.

Then, in the ninth meeting, the groups will have teacher orientation about how to present the problem, the theoretical subjects, the robot models and the task that the robot should perform in order to approach the problem. They will also have the remaining time of the class to build the robots, models and to work on their posters or slide shows.

The robotics fair occurs at the last meeting, when the projects are presented for relatives and the remaining of the school community. After the presentation, the students will receive certificates and there will be a celebration after the closing ceremony.

III.D. Classes

The classes were executed on the days and times scheduled, except for the seventh meeting that ended up not happening because all school activities that would occur on August 08 of 2015 were canceled, and the academic calendar of the university and the school were incompatible, not being possible to reschedule classes.

The classes happened in a space used as computer lab and library, because it was the only place "available", due to overcrowding and low budget of the school.

In spite these difficulties, the school offered office supplies. And most of the rest of the material used in free pedagogical robotics classes was collected by the students and teachers throughout the week preceding each lesson. Since they could not find many discarded CD/DVD players, the extracted engines were reused in several of the robotic models through the classes.

Even though the school had only two multimedia projectors, they were not being widely used by the school teachers, so it was possible to show all the videos and presentations of the classes without problems.

At the beginning of the first class, we applied a questionnaire to verify the prior knowledge of the robotics class.

With the questionnaire, it was possible to identify that although they had not studied robotics before, the students had previous knowledge in the subject, probably constructed by their life experiences. But such knowledge was superficial and still was not clear and elaborate on technical or scientific definitions. Nonetheless, this result served to demystify the subject for the students, giving them more security to explore the subject. The rest of the class proceeded as planned and the students were able to assemble the boat as expected using the 6-in-1 robotic kits borrowed by a university student. The Fig. 2 shows some of the students with the kit, their motivation and excitement was remarkable.

Fig 2. Group studying the 6-in-1 solar energy robotic kit.

Likewise, the second class was held and the students set up the Hydrophobic Labyrinth. The class was divided into four groups, two of the models worked perfectly, and the other two worked with some minor flaws.

In the third class all groups were able to build the fans with pet bottles, DVD motors and USB cables.

The fourth class presented the planned themes, and then a video explaining how to make the steam boats with recycled material. The students were divided into three groups, and just one group managed to make the boat move (even though slowly) because of a failure in the assembly of parts that caused an air leak. The other two groups failed to build properly and their boats did not move due to many air leaks.

Fig 3. A) Wired remote controll. B) Robot fight.

Although the fifth class was simple, it was one of the most exciting because of the fight between robots. After explaining the subjects and a debate about mutual respect, it was time to build the robots. The cardboard was used as the base (chassis) of the robot, and two motors were used as the robot tires. The wires connected the engines, the batteries and the control made by clips and a cardboard (Fig. 3a). And the robot that managed to explode the opponent's balloon first was the winner (Fig. 3b). The class was divided into two groups, thus producing two robots that worked as planned, except they were too slow because the batteries had only 1.5 volts.

In the sixth class, the students had to perfect and adapt the model of the previous class for the construction of the soccer player robots. This time they used a more powerful battery and the robot moved with the proper speed.

The robotics teacher was an undergraduate student who had little experience in the classroom and unfortunately ended up not working well the theoretical exercises (only applied some of the planned exercises and did not give feedback for the students about their responses).

III.E. Robotic Fair

As the workshop scheduled for the seventh class was canceled, the next one happened two weeks later, applying the plan for the eighth class. In this meeting, the robotics fair was proposed, and the students organized themselves into two groups. With the guidance of the teacher, each group developed a project for the educational robotics fair contextualized in the semiarid. As it was a project-planning meeting, there was no practical construction of a robot. In order to help the planning, we provided the following questionnaire: 1) Choose a theme and justify regarding its relation with the region where you live. 2) Explain what is the problem addressed and the objectives of your project to solve this problem. 3) How robotics will be used to approach the solution? 4) Which curricular subjects can help to explain the problem and/or the solution?

At the next meeting the students brought the material and began to build their robots. With the help of the teacher the robotic models were tested and design problems were solved. The fair happened in the afternoon shift.

The projects developed were a small boat and a prototype of a carousel. For the development of the boat, the students used a battery as a power source, instead of the previous models that used solar energy and steam. Besides the battery, the other materials used were wood to build the boat, a switch to activate and deactivate the DVD engine, wires for the transmission of energy, and a CD playing the role of the propeller.

The carousel was made using straws, which served as the support for the pillars of the model; wires, to transmit energy; DVD engine to spin the carousel; a control similar of the used in the sports classes to switch on/off the model; and cardboard for the rest of the model. Both the robotic models worked fine at the presentations.

IV. Discussion

Although combining contextualized learning and problem based learning is not a novelty, we believe that approaching that with educational robotics and its peculiarities is. The mere presence of a robot in the classroom so far seems to be appealing to the this generation of students and it helps bringing their attention. But educational robotics goes beyond that, it seeks to promote learning when students manipulate, build and program robots. It effectiveness compared to conventional problem based learning needs further studies, since educational robotics by its roots approach problem based learning.

The evaluation of the results of the application of this methodology is a complex task. Since short term and long term results must be measured in some way. In the short term, examples of what can be measured are school performance, grades, testimonials, behavioral changes of students, and changes in school and community. Some of these data can also be analyzed in the long term, and also, we can see how these students will grow academically or professionally in comparison to their peers who did not participate in the contextualized educational robotics course.

In Brazil, an important official data that could be used is the IDEB - index of development of basic education, which measures the quality of learning and establishes goals for the improvement of teaching [20]. However, the index was not measured for the 8th and 9th years during the period of application of the robotics course, because according to the indicator the number of students was considered insufficient for the statistic in these classes (although the school is overcrowded in other grades).

The school had its first participation in science fairs in the same year of this project, but before the planning period of the course approached here. One of the school groups was qualified in the regionals for the state science fair. After the contextualized robotics course, the students highlighted that the experience would help them with ideas for the next year’s science fair. In the same year, only other school in the city sent another two groups to the state science fair (and that school also had projects with the university). In the following year, seven groups from these two schools participated of the state fair.

During the application of the course, the students displayed motivation and enthusiasm, reflected in improvement of grades and behavior in the classroom in the other classes. One of the students appropriated the knowledge acquired in such a way that he put together pieces of broken appliances and built a mini tuned car with "giant" speakers, emulating something adults do constantly in real cars where he lives.

Seeing the impact of this work in her school, the school’s director planned to continue with the use of educational robotics in the following year, enrolling the school in this modality to the integral education program called “Programa Mais Educação”[22]. However, due to government cuts in the education ministry, caused by the economic and political crisis in Brazil, the program was suspended at the end of 2015.

Even so, contextualized educational robotics has been applied in this school and in others of the same city by initiative of the professors, local undergraduate students and teachers of the public elementary schools.

From the nine students that participated of this first course, three were approved for the state’s most renowned school, which offers high school with technical formation (IFRN) - and they chose the computers course. In 2016, three more of those who were in the eighth year at the beginning of the course finished the ninth year of elementary school and were approved for this same high school in 2017.

One limitation that we had in this first application of the contextualized educational robotics methodology is that we did not use robotic kits with controllers. So, it was not possible to teach programming in that course. This reduced the complexity of what could be taught and learnt in this course. The use of robotic kits was not possible in that year because of the omnipresent bureaucracy in Brazilian public universities, in purchase and import processes. So, the delivery of Lego EV3 robotic kits acquired by the university was delayed until the beginning of 2016. After that, the material and methodology have been used in robotics courses offered by undergraduate students to some schools and rehabilitation centers in the region.

The application of this methodology in other schools and regions should be done with care, always considering the characteristics of the community, school, students and available material. We believe that the methodology proposed here was explained in details enough so that it can be applied in other places. One limitation is the need of a collaborator that understands the robotic technology enough no help searching or planning the robotic models adequate to the classes. Another limitation is the cost related to acquiring the robots (if free pedagogic robotics is not used).

In this session, we discussed some of the results found subjectively, due to the lack of relevant or significant quantitative data for some conclusion. We highlight that a common problem currently in the area of educational robotics is exactly how to effectively measure the results and benefits of an educational robotics methodology in a way that two methodologies can be compared by their results.

V. Conclusion

In this paper we presented a methodology that combines contextualized learning and educational robotics. The methodological steps were detailed so that they can be applied by other researchers so that the results can be compared.

We consider that the application of this methodology had a positive impact on the school and the community where it was implemented. Because, in spite the data on the school’s development index are not clear to conclude if there was an improvement of the school in the classes in which the methodology was applied. neither on the impact of this methodology in relation to the other projects applied in the school; there was an interest of the school management, teachers, students and the community to promote the continuity of the project, either through isolated actions or even other projects and extension programs.

Although much of the work of the contextualized education field in Brazil is directed to the semi-arid region, we believe that the methodology presented here contains sufficient details to be applied and adapted to the context of any region of the world. While applying this methodology, the teachers must decide what curricular contents should be worked and what problems of the students community could be approached with such problems. The main difficulty should be applying that with robotics. So, a teacher that knows educational robotics enough to create, to adapt or to find the adequate robotic models for these classes is necessary at least as a collaborator.

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