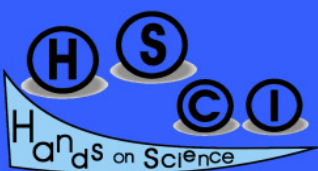


Hands-on Science

Brightening our Future

Edited by
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The Hands-on Science Network

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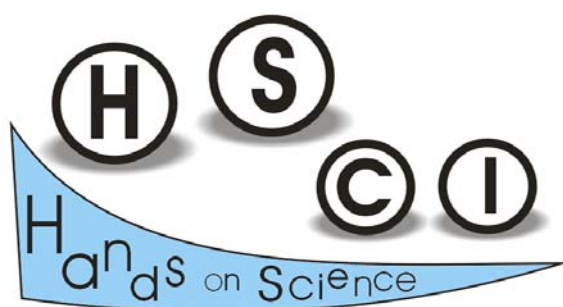


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Hands-on Mathematics with Lego Robots

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Abstract. In the research related in this paper it was designed and implemented a learning scenario, with two primary school classes (40 students), working together with Lego robots (NXT and RCX models). In this paper we intend to discuss and to reflect how the use of robots can contribute to mathematical learning in primary school students and to develop their mathematical competence.

Keywords. Mathematics, Robots, Situated Learning.

1. Introduction

Due to the on-going technological change we are witnessing, the created learning scenarios are increasingly different, making use of educational technological resources. Taking this into account, there have been a growing number of researchers interested in analysing the learning phenomena when students interact with those tools.

The use of Lego robots as a tool for learning basic science and mathematics concepts and also for developing scientific inquiry skills for students has recently drawn the attention of many researchers. However, few studies are focusing on how robots support primary school students to learn when they participate in project work activities.

Using ideas of situated learning from Lave and Wenger [1], [2], we intend in this paper to discuss and reflect how the use of robots can contribute to increase mathematical learning in primary school students and to develop their mathematical competence. The developed activities followed a project work methodology. The nature of the research is qualitative and it was given particular relevance to the process and not to the product of the developed activities.

2. About Learning

One of the most significant developments in educational approaches suggests that learning is taken as a process that emerges from specific situations and contexts.

Lave and Wenger [1], argue that learning is a social and cultural process, where it is relevant to shift "(...) the analytic focus from the individual as learner to learning as participating in the social world" (p. 43).

From this point of view, it is central the idea that learning is closely connected with participation in communities of practice, that are not only groups of persons but, are also communities of knowledge. According to Wenger [2], practice exists because there are people who participate in actions whose significance is mutually negotiated. It does not reside in a structure that precedes it, but "(...) resides in a community of people and the relations of mutual engagement by which they can do whatever they do" (p. 73).

Participation refers to a process of being active participant in the practices of social communities. Because of that, participation shapes not only what we do but also what we are and the way we understand what we do. Participation also shapes the communities in which we participate. In fact, "(...) our ability (or inability) to shape the practice of our communities is an important aspect of our experience of participation" ([2], p. 57).

Thus, a community of practice involves much more than the technical knowledge or skills associated with undertaking some task or activity. Members are involved in a set of relationships over time and communities develop around things that matter to individuals [2]. The fact that they are organized around some particular area of knowledge and activity gives members a sense of joint enterprise [1], [2]. This very specific aspect congeals the essence of the model of situated learning proposed by Lave and Wenger [1]. Learning and knowing involves a process of engagement in a community, thus, learning and knowing are social and comes largely from our experience of participating in daily life.

3. The Learning Scenario

The learning scenario was designed involving two primary school classes (2nd and 3rd grade, 24 and 16 students, respectively) from a school in Funchal – Madeira island – Portugal, working together with robots. This learning scenario was constructed all together by the research team, by teachers from both classes and by their students. The scenario's implementation was developed in two moments: the first between May and June 2011 and the second between April and July 2012.

We started the scenario's implementation with two primary school classes – Year 2 and Year 3. The second phase of scenario's implementation was in the following school year. The students were, at that time, in years three and four, respectively.

At this project students have worked with Lego robots: RCX and NXT. In both RCX and NXT models the programming environment is an icon-based drag-and-drop programming language, designed for an intuitive introduction to programming. By choosing program blocks that work with the motors and make the sensors react to inputs, students simply build up their program block by block, and they created programs that range from simple to complex. Students and teachers had never worked with Lego robots before.



Figure 1. Students building robots

Both classes have worked in heterogeneous working groups. Teachers had to support students in their work and the researchers sought to support students and teachers and to take advantage of situations that could contribute to the emergence of mathematical concepts. With that in mind, researchers assumed a questioning attitude towards students' work in the practice with robots.

In the first moment of scenario's implementation, students had to construct robots and define their physical and emotional features. Their creations will become

characters in a play-story written by them all. After writing the story students had to program their robots in order to perform their roles in the play. The initial goal was to accomplish those tasks in order to make a play with the robots as characters. The play was not done in this first moment of scenario's implementation.

In the second moment of scenario's implementation, students, teachers and researchers decided to make a film, using the produced play and followed the storyline.

Students established new tasks to produce the film and they created teams to accomplish those tasks. Each student has chosen in which team(s) they wanted to work in.



Figure 2. Students programming and testing



Figure 3. Students filming

Two teams were created to program the robots and one team for each one of the robots' models. The voices team was constituted by 10 students who gave voices to the 10 constructed robots. The voice team recorded the voices using the Microsoft Audio Recorder and chose the film's soundtrack. The film was edited, using the Windows Live Movie Maker, by the editing team. Some students were responsible for the filming and others were in charge of the lights. Based on the story written previously, the direction team wrote the script for the film and this team was also responsible for making the communication between all the involved

teams.

According to the created storyboard, students from both classes decided to build, in the art classes, the 'scenarios' needed for filming the movie.

All students decided that Year 3 class would construct the 'floor' in which filming will be made, and Year 4 class would be responsible for the 'vertical' scenarios. In order to accomplish those tasks, students explained to arts teachers from both classes how the robots will perform the scenes in the film, how they will move on the filming scenario and which environments would be necessary to create (a restaurant, a park, a castle, ...). The researcher followed and participated in the arts classes.

4. Hands-on Mathematics with robots

When teachers and researchers designed with students the learning scenario they didn't specified what mathematical contents would be specifically worked with scenario's implementation.

The idea was to design a project with robots based on a big theme: the construction of robots that were to be characters in a play-story written by them all (students from both classes). Both, teachers and researchers, believed that, this will provide students with opportunities to develop their ability to find as well as solve problems where mathematical contents (and others) will emerge in the ongoing practice.

Although mathematical contents have not been the tone for activities, it was intentionality shared by researchers and teachers to seek and to take advantage of times when the inclusion of the contents were significant and (or) emerged from working with robots.



Figure 4. Students discussing robots' programming

When students started the robots project, teachers were aware that Year 2 students haven't yet learned how to make conversions between different measures of time (hours, minutes and seconds). Because robots' programming was made by defining the time (in seconds) in which motors and sensors will produce some outputs, that knowledge emerged from programming robots.

Students needed to make those conversions between minutes and seconds more frequently to better program the robots' actions.

By programming robots, students learnt to predict how a robot will move from one place to another, by establishing time and directions for that action. Robots programming was a very productive field for mathematical concepts' emergence such as positioning, orientation, duration, trajectories, direction and movement. By dealing with robots was a powerful opportunity to make students solving mathematics problems in a very specific context.



Figure 5. Robots moving in lines and roundabouts

When students were filming in the second moment of scenario's implementation, they wanted to put roundabouts and streets to define robots' trajectories (Fig. 5). This intention emerged when Year 3 students were working on arts classes, creating the 'floor' for the filming.

The researcher knew that those students had not studied yet the circumference and lines' positions in their regular classes. The construction of roundabouts and streets on the floor seemed to represent a good way of students discuss and expand those mathematical topics.

By assuming that, the researcher talked with Year 3 teacher and with the arts teacher and purposed that the construction of roundabouts and streets could be made both in regular classes and in arts classes. This interdisciplinary was essential to promote the discussion about mathematical issues that emerged from constructing the scenarios required for the filming.

In regular classes Year 3 students analysed how they could construct the roundabouts using circumferences. This situation led to the discussion of certain mathematical topics such as the study of the circumference elements and its definition (radius, diameter, chord, arc,...). At that moment, those students also learnt how to use compass to perfectly draw circumferences. Those mathematical topics had not been studied before in the Year 3 classes. Its study emerged from the work with robots and from students' willingness of programming robots to move in roundabouts.

There was also a connection between the way the lines were placed on the floor (Fig. 5) and how students claimed that robots would be programmed to travel over them. The parallel lines emerged from students not wanting that certain robots met each other's when they were moving across them.

Students noticed that it was possible that two robots moving in two intersecting streets (lines) would not find each other. However, students concluded that if it was a requirement that two robots would not find each other it will be easier to guarantee it if they were moving in two parallel lines, instead on intersecting lines. In terms of programming, by using parallel lines, students would not have to worry about time and distance so that the robots do not meet each other.

Once again, in this moment of scenario's implementation, Year 3 students had not studied yet the mathematical definition of the lines positioning. Those students were talking about those lines (streets) but they didn't used the mathematical terms such as parallel or intersecting lines. That terminology was used by the Year 4 students when they were talking about the positioning of the streets (lines) on the floor.

Researcher and teachers promoted the discussion between students from both classes

about those words and their meaning in mathematics. The meaning of parallel and intersecting lines was negotiated in the practice of constructing the floor (in arts class) in which the robots would be moving in the filming.

It surely has been a great contribution to students' mathematics learning that this learning scenario was designed involving students from two different school levels, working together with robots. The position of Year 4 students represented a significant contribution to the emergence of mathematical contents on the school practice of Year 3 students. The study of the lines was a great example of it.

Students of Year 3 expanded their knowledge about lines and started using a mathematical vocabulary that was from now on shared by all students that were working on the project. On the other hand, students from Year 4 needed to make those contents clear to others, contributing so that these specific topics also become clearer to themselves.

5. Conclusions

Modern technologies are changing the world we live on, as a result also give us a multitude of tools and ways of learning.

In this learning scenario, robots transformed the way students and teachers participate and the forms they were engaged in a school practice [3].

The use of robots in this learning scenario contributed to the emergence of mathematical concepts, and others. Robots were a powerful tool to students perceive, use, expand and talk about mathematical concepts.

Despite the contributions that robots brought to this learning scenario, we cannot disregard the working methodology advocated. Our positioning towards learning – as participation in social practices – led to a working methodology with certain characteristics that potentiate the learning scenario. Cooperation and interdisciplinary activities that characterized the project, formation of heterogeneous working groups, with students from both classes, positioning of teachers and researchers, decision-making and a negotiated sense of responsibility and accountability were certainly aspects that potentiate this learning

scenario [4].

By arguing that learning occurs when people participate in social practices, we may say that there are many aspects that we identify as mathematics learning. Mathematics learning implies the learning of mathematical concepts but also the way students use them to solve problems and the way they negotiate the meaning of those concepts in different school practices (mathematical or not) [5].

There are many other components that we assume as crucial to mathematics learning, beyond the learning of mathematical concepts, as we mentioned above. To communicate mathematical ideas in a coherent manner and with a correct vocabulary, to test hypotheses and formulate conjectures, to evaluate statements and strategies from others, to develop and evaluate inferences, are essential aspects that we identify as mathematics learning. Throughout scenario's implementation, it became clear that many of these aspects have emerged naturally in a natural way, in the way students participated.

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