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Using Educational Robotics for Teaching Mathematics for Life for SEN Students

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Abstract

The role of technology in education is today widely recognised. Technological tools provide new opportunities to emphasize the use of multiple representations in mathematics teaching and play an important role in practical and conceptual activities. In Special Education, the use of technology can provide appropriate learning environments for the development of the individual needs of children and young people with learning disabilities or special educational needs and disabilities, as well as for those considered gifted. This work deals with the use of robots as artifacts for learning mediation in Mathematics for Life, a math course intended for students with Special Educational Needs (SEN) aiming at the development of knowledge and abilities that enhance their personal and social skills, promote autonomy, and assist their integration into society. Participant observation was the main strategy and acquired the status of data collection method. The collected and analysed data emerged from the participation of two female students with SEN while constructing a learning scenery for activities with robots. The goal was to approach contents of plane and spatial geometry and the notion of time, which led to the construction of a scenery involving geometric shapes. The use of robots played an important role in the acquisition of the notion of time due to the fact that they can be visually examined during the execution of the programs developed for solving the proposed activities. In addition, the use of robots contributed to the acquisition of new skills and knowledge, and to the development of creativity and autonomy, as well as to the promotion of individual and social acceptance and appreciation of each student's abilities.

Keywords**:** *Special Educational Needs, educational robotics, Mathematics for Life.*

1. Introduction

The expression 'Special Educational Needs' (SEN) refers to all kinds of difficulties that may cause problems during the learning process [1], whether physical, sensorial, intellectual, emotional, social, or any combination of these. According to the Portuguese legislation, all students with SEN are entitled to a free public education appropriate and adjusted to their educational needs and their learning pace and ability. These learning difficulties may be temporary, requiring partial modification of the school curriculum in order to adapt it to the individual characteristics of the students with SEN at a certain moment of their development and educational trajectory, or permanent, requiring in this case widespread adjustments of the school curriculum with the purpose of adapting it to the particular characteristics of the students with special needs for much or all of their development and educational journey [2]. There are school curricula that are in such a way adapted for students with SEN that their curricular domains are based on different environments of everyday life and aim, above all, to develop skills of personal and social autonomy. They are functional curricula, in which the evaluation of the students subjected to them is focused on relational processes, emphasizing small learnings.

Portuguese legislation provides for the elaboration of an Individual Specific Curriculum (ISC) for students with special needs, within which these students are integrated into regular classes and, in some school times, go to a Functional Learning Room, where they develop the skills foreseen in the ISC, which are in accordance with their needs and aim to better integrate them into society. These students take courses such as Mathematics for Life, Socially Useful Activities and Work Experiences, among others of a more practical and functional nature, with the objective of promoting personal and social autonomy. The Mathematics for Life course is intended to help in the development of these students, making them able to participate in social life. For this to be possible, students need to experience mathematically rich situations and use mathematical concepts in the interpretation and modelling of real situations [3]. The curricular changes depend on the characteristics of the students with special needs, and the action plan must be adapted to each particular case. In this sense, the support of technological tools has been important for the development of the individual capacities of

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these students. In this article we present our experience with the use of educational robotics in teaching Mathematics for Life for SEN students.

2. Methodology

This research was done in a natural environment using a qualitative methodology. We participated in the activities taking an integral role in the group, as the qualitative research requires a share with the people who are under investigation. Our main goal was to understand how the use of robots can contribute to the learning of Mathematics for Life.

As a data collection method, we used the participant observation in order to not separate the events of their context and prevent loss of meaning [4]. Data collection was carried out in a classroom environment during four months of 2014. A logbook with detailed observation notes, conversations, and dialogue records was constructed, and audio and video recordings of the lessons were also made.

Our focus of interest was the learning of two female students that we observed in their natural environment to better understand their actions and the way things happened. The first student was in the 7th grade and has Down’s syndrome. The biggest obstacles for this student are in the acquisition, relatedness and application of knowledge, as well as in the apprehension, memorization and understanding of information. She can do analysis, synthesis and evaluation of situations just as long as it is not necessary logical and abstract reasoning. She presents problems of lack of concentration, which makes it necessary to strengthen and consolidate the learning, and shows no autonomy or initiative.

In turn, the second student was in the 8th grade and has a diagnosis of borderline intellectual functioning (BIF), which leads, among other things, to a slow pace of learning, with constant advances and setbacks. She presents difficulties in conceptualization, arithmetics, perceptual organization, spatial visualization and visual-motor coordination. She shows difficulties in understanding and interpreting practical situations arising from everyday life and presents difficulties in complying with standards and rules of socialization. Her fine motor skills are impaired, accentuated by tremors when she receives more precise activities. This lack of coordination hampers the orientation of movements in terms of writing calligraphy and daily living activities that require more precision and control.

3. Data analysis and interpretation

After the data collection, the written class records and audio and video recordings were analysed. In this analysis the focus was on the learning of the two female students who participated in this study.

In order to develop this project, it was necessary to find common points of interest. The students had the desire to travel with their favourite artists, this being the idea that triggered the development of the project involving robotics. The artists would be on a bus that would travel down a street. The motivation for building a scenery with a street (path) where a bus (robot) would move began with a dialogue about the students’ interests, having also been considered the prior knowledge of their difficulties in assigning meanings and internalizing some concepts. The construction of this scenery allowed the creation of trajectories that facilitated the acquisition of the required competencies and the exploration of several concepts related to Geometry.

At the beginning of the robot’s construction, the students felt some difficulty, especially the student with fine motricity problems, who needed more help. Once they understood how to follow the instruction manual to get the robot assembled, and how the parts should be selected, they understood how everything worked and managed to move forward without much guidance. They were very happy when they saw the final result, and at that moment they wanted to know how the robot moved, as it is possible to observe in the excerpt shown in Fig.1.

Taking advantage of the motivation to program, the teacher spoke of the need to count the time so that they could put the robot into action. The following classes were to explore the notion of time with analog and digital clocks and work out the difference and the relationship between minutes and hours. This process was interspersed with other learning activities and the scenery construction.

Students: What now? It doesn't move! How to make it move?
Schoolteacher: What did I say you should do?
Students: Tell the robot what it had to do.
Schoolteacher: Then that's it. I will show you how to program the robot.
7th grade student: What is that?
Schoolteacher: The robot is like a Lego. It has lots of pieces that we put together according to a manual and after it's built it's a machine that does not understand voice instructions but if we give him the instructions in a way he can understand, then he is able to perform basic pre-programmed functions. To "tell" him what we want him to do we have to speak in a language he knows. And this is the language we work with in this program called Mindstorms NXT.
7th grade student: This seems difficult.
8th grade student: My brother would like that. He's in the informatics course.
Schoolteacher: It's not difficult and I'm here to help you anyway. I'll give examples, and only then will you do it alone.

Fig.1. Excerpt from a dialog between teacher and students about how to move the robot.

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During some classes, the students worked individually in the construction of solids for the scenery, and in others learned how to read analog and digital clocks in order to be able to recognize terms associated with time based on the time shown on clocks and apply their understanding of the concept of time in practical situations, such as that involving bus schedules or television schedules, as well as learned to solve other problematic situations involving the notion of time.
The exploration of the robot's software and the different functions required for its programming occurred approximately simultaneously with the acquisition of the notions of hour and minute and led the students to develop very simple experiments with each of the different functions available. They had a lot of difficulty until they realized that the robot programming was related to the way people make a journey, having explored the software and experimented until they understood what they would have to do to program a robot. Fig. 2 shows the excerpt of a dialog during one of these robot programming attempts.

Schoolteacher: Let's do an experiment. I'm going to walk around this table and you will tell me what I did.
8th grade student: You will move.
Schoolteacher: Yes. I'm going to start walking now. Will I always be on the move or am I going to have to make some stops?
Students: The teacher is walking and has now stopped.
Schoolteacher: I'm going back to the beginning and you will say again what I'm doing.
Students: Walk, stop, walk, stop, walk, …
Schoolteacher: And why did I stop?
7th grade student: To turn around.
8th grade student: Because you can't turn if you're always walking.
Schoolteacher: So that's how you have to think about the robot. Think of it as if you were doing the course yourselves.
Students: Can we move and change?
Schoolteacher: Yes, go ahead. Do whatever you feel is necessary. I am here to help. Work together and think about the outcome you want.

Fig.2. Excerpt from a dialog about programming the robot.

The students began to realize that day-to-day tasks could be described in a sequenced and structured way. This, coupled with the fact that they started programming, motivated them much more. After the scenery was completed, they began to characterize the bus, which made them enthusiastic because they wanted the passengers to be television artists (see Fig.3).
In the dialog shown in Fig.3, it can be verified that the students used the notions of Geometry with familiarity and that, during the moments of exploration of the robot's trajectory, they had to use the notion of time.

8th grade student: Let's glue the artists today? The teacher brought the robot and cardboards.
Schoolteacher: No, we still haven't made the robot look like a bus. We have to do a box to place the robot, so it looks like a bus. Only then we can glue the passengers. Do you remember saying you had already thought about the shape we should give the bus?
7th grade student: Yes, a rectangular prism.
Schoolteacher: So, we'll have to find a way to put the robot inside a rectangular prism. How are we going to do that?
7th grade student: We have to measure.
Schoolteacher: What else? Are we going to make a closed box, or do we make it open?
7th grade student: It's better to do it open so we can use the wires.
Schoolteacher: Yes, I did not remember that. We have to be able to pass the program to the robot and it is best if we can open the box we are going to make. Let's get to work!

Fig.3. Excerpt from a dialog about the robot characterization.

At the end of the project, the students had to move the scenery to a presentation room. As the space was different, they were forced to change the route of the bus (robot's trajectory), which implied in the modification of the previously developed program, namely in terms of time. The students demonstrated initiative, self-confidence and sufficient autonomy to make such a change (as can be seen from the excerpt of Fig. 4), requesting help only to make small adjustments related to the change in direction.

Schoolteacher: Something isn't quite right. The bus was almost in the garden of this house. What went wrong?
Students: Time. It was a lot…
Schoolteacher: Want help?
Students: No!
7th grade student: Can we try it?
Schoolteacher: Yes, make your experiences.

Fig.4. Excerpt from a dialog about the need for programming changes.

The students made the necessary changes in the programme and then made a presentation of the work developed. They explained what they had done using the correct terminology, which aroused the admiration of the people who already knew them.

4. Conclusion

The requirements of SEN students are greater than those of students who attend regular classes. It is necessary to innovate using new technologies to facilitate the students' learning, whether they are students with SEN or not [5]. The challenge now is to integrate all the tools available today to create practices that can help and motivate students and facilitate learning and knowledge consolidation. The development of innovative technological tools such as robotics leads to new possibilities for the implementation of authentic learning scenarios, which can foster the development of skills like problem solving, teamwork, communication, independence, imagination and creativity [6].
Through imagination, individuals find themselves in the world and conceive new challenges, explore other alternatives and foresee possible futures, which eventually insert into their identities other meanings and perspectives. The construction of the scenery for the bus (robot) route was the physical reproduction of what they imagined and demanded a sequence of actions that they had to control. It was necessary to measure, to plan, to adjust the robot's travel time and, as they were building the scenery and the robot, the **concepts** of perimeter, edge, area, and units of measurement **emerged**. This enabled reflection and understanding of the options that were taken throughout the process and helped them to describe situations and **communicate** discoveries and mathematical and other ideas using oral and written language appropriate to each situation. The programming of the robot was a complex and challenging task that involved the acquisition of different knowledge, such as those previously mentioned, and allowed the development of students' personal and social **autonomy**, since the school's community a priori did not have the expectation that they would be able to program robots.

Finally, the cut/paste and fit processes, necessary for the construction of the scenery and the robot, contributed to the development of the **psychomotricity**, and also to the emergence of aspects of the individuality which allowed that the observation and interpretation of what they had imagined to be represented in the final work.

References

[1] Drigas, A. S. and Kokkalia, G. K. "ICTs and special education in kindergarten", International Journal of Emerging Technologies in Learning, 9(4), 35-42, 2014.

[2] Correia, L. M. "A escola contemporânea e a inclusão de alunos com NEE", Oporto, Porto Editora, 2008.

[3] Oliveira, C. and Oliveira, H. "Modelação matemática no ensino profissional: As tarefas e o conhecimento extra-matemático", in J. P. da Ponte, Ed., Práticas Profissionais dos Professores de Matemática, pp. 57-77, Lisbon, Instituto de Educação da Universidade de Lisboa, 2014.

[4] Lessard-Hébert, M., Goyette, G., and Boutin, G. "Investigação Qualitativa: Fundamentos e Práticas", 4th ed., Lisbon, Instituto Piaget, 2008.

[5] Nwabude, A. A. R. "How would virtual learning environment (VLE) enhance assessment for learning mathematics by the special education needs students (SENS) in secondary education sector", in N. Popov, C. Wolhuter, B. Leutwyler, G. Hilton, J. Ogunleye, and P. A. Almeida, Eds., International Perspectives on Education (BCES Conference Books, Vol. 10), pp. 410-417, Sofia, Bulgarian Comparative Education Society, 2012.

[6] Sergeyev, A. "Meeting twenty-first century robotics and automation workforce needs in the USA", in M. S. Khine, Ed., Robotics in STEM Education: Redesigning the Learning Experience, pp. 171-194, Cham, Switzerland, Springer, 2017.