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EDUCATIONAL ROBOTICS APPLIED TO EARLY EDUCATIONAL STAGES

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Abstract

Robots applied to education can offer us many advantages in the learning of students from the early educational stages, from the childhood stage. In addition to entertaining, they are a very powerful tool to motivate students and learn. Educational robotics in Early Childhood Education involves the initiation of computational thinking and support for the development of basic spatial notions (front, back, left, and right). In this paper, different activities are presented to develop spatial reasoning effectively. For the activities proposed we use the blue-bot robot as the application of educational robotics in a teaching and learning context. It is a small, very intuitive robot that draws the attention of children due to its attractive and transparent design. With this robot, programming languages consist only of five movement commands. With blue-bot robot in a playful way as a tool for the effective development of space rationing. This investigation is a qualitative research work, the application of robotic activities has been carried out with a sample of 21 children aged between 6-7 years. Five sessions were held, and

participant observation was used in each session. After the application and considering the results and motivation of the young students, we can affirm that the activities and workshops were very beneficial to introduce basic spatial notions using educational robotics. Children showed connections between content learnings with valuable social practices through experiencing.

Keywords

Educational Robotics, Early Childhood, STEM, Spatiality, Oral Skills

1. Introduction

This study addresses the application of robots in early childhood education. Despite being surrounded by technology, in the early ages, kids learn very little about this world of technology. The acquisition of basic notions involves work through a series of parallel phrases that are related to the psycho-evolutionary needs of students of these ages. With the project that is presented, we have worked on the development of our body diagram and the projection on objects outside our body. Furthermore, the use of robots in the classroom allows a global approach to be carried out since it is a resource that can be adapted to many types of content and subjects. However, in the research carried out, we must emphasize that in our case, one of the areas of development closely linked to the work of educational robotics has been the spatial development of the child. The sequential programming of orders, their structuring, and the control of an external object such as the robot, within a given space, can help the child to understand, consolidate and develop their spatial orientation in a more positive way and functional.

Through the design of meaningful activities on educational robotics, we can start helping our young to explore a new world for them using manipulative materials and manipulative robots. When students are using robots, children can learn about robotics, specifically about sensors, motors, and the digital domain in a fun way. Young children can become engineers playing with, joints, motors, sensors, gears, levers, and programming loops, and they can become storytellers by creating their projects. Considering all these aspects, the main objective of the research is to analyze if the work in the classroom with educational robotics improves the spatial orientation of the Early Childhood Education student in terms of their own body and external objects and if they improve social skills, self-esteem, and oral skills. Through the exploration of

this objective, the aim is to answer the following research question: Do Infant students improve the acquisition of basic spatial concepts with the use of educational robotics in the classroom? Do the social and oral skills and self-esteem of Infant students improve with the use of educational robotics in the classroom?

The results obtained allow us, teachers, to make decisions about the best methodological option and the tools to use in their daily work in the classroom, to carry out an educational intervention following the needs of the students, their context, and social demands.

2.Theoretical Framework

Following the guidance of various authors, we agree that it is the children who must educate computers, not computers that have to educate children (Blikstein, 2013, Bizarro Torres et. al, 2018). Therefore, robotics continues to be another tool in the educational field, it is a mere resource that will help achieve the proposed objectives and that is closely linked to the needs demanded by digital literacy. (Cacco et.al, 2014).

Computational thinking is support for cognitive development in Early Childhood Education. For its correct use, we must consider that Early Childhood Education students are in the preoperational stage (2-7 years) according to Piaget's theory of development (Greenberg et.al, 2013). At this stage, the child develops the symbolic function to act and understand the world around him, however, according to this author, he is not capable of developing organized, formal, and logical mental processes. For this reason, it is beneficial to use robotics in the Early Childhood Education classroom since it will allow the student to learn to structure sequences and mental processes with a functional and meaningful logic. (Greenberg et.al, 2013). The needs and characteristics of students of these ages make continuous motivation necessary to achieve functional and meaningful learning in which the student is the main agent of their learning (Mubin et.al, 2013).

To develop computational thinking in the children's classroom, it is necessary to use problem-solving processes that help children to structure their thinking and develop logical reasoning. This same competence can be applied to any area and educational stage, although in the Early Childhood Education stage it becomes more relevant since through the development of these strategies cognitive aspects are worked on that can help to overcome the limitations of preoperational thinking: centring, egocentricity, irreversibility, incomplete understanding of the

transformation. (Bizarro Torres et. al, 2018, Daniela et.al, 2019). Using robots in Early Childhood Education can help the development of basic spatial notions regarding the child's own body and objects in his environment. The structuring of the notion of space is reinforced when the child develops dynamic control and coordination of her own body, in addition to awareness of objects external to him. (Beers, 2002, Mataric, 2004., Afari et.al, 2017).

The appearance of technological scaffolding as a support material for educational processes have given rise to what is known as «Engineering educational», which aims to find new didactic approaches using technological components, making modern developments, not just the space for applications that improve the quality of life of people, as it also becomes a space for reflection and knowledge construction. (Jung, 2018, Turan, 2020). One of the first manifestations of educational engineering, it is known as «Educational robotics» aims to bring into play all the capacity exploration and manipulation of the knowing subject in the service of construction of meanings from her own educational experience. Educational robotics starts from the theory of Piaget that there is no learning if there is no student intervention in the construction of the object of knowledge (Beers, 2002, Misirli et.al, 2014).

In this way, for learning to take place, the student must be located within the logic of construction of the object or concept of knowledge, thus, must "learn to learn", to promote these conditions, environments can be created to perform the inventive involvement of the agent who learns or to make the relationship between the object of knowledge and the subject who learns. Robotic technology is used in different areas from medicine, cars, rehabilitation, education, household appliances. Robotics from ages it was used mainly in industry, the last decade has seen its expansion towards the service and entertainment sector. For example, the cleaning industry and technology such as I-robot, Roomba, or Dyson have developed sophisticated robots for domestic use vacuuming and washing floors, etc. (Eguchi, 2016; Jung, 2018; Daniela, 2019). Even today, we have robots operated remotely from the Internet (Lai et al. 2019). In this search for utility in domestic use, several companies have also developed educational robotic as Bee-Bot, Blue-Bot, InoBot, ProBot, Dash & Dot, etc., with an educative intention. Educational institutions are increasingly aware that they must prepare students for the future and there is undoubtedly robotics. Many investigators (Mataric, 2004., Mikropoulos, 2013., Kim et al., 2015., Miller, 2016, Turan, 2020) are concerned about how Robotics helps us to incorporate scientific

and technological knowledge from the early age of children, such as the new STEM methodology (Science, Technology, Engineering, and Mathematics).

Research on robots in schools for kids is still in its early stages. Many previous studies have examined the technological properties of educational robots or robotics curricula rather than learners (Rogers, 2003, Kopcha et.al, 2017). According to Jung, besides, the advantages of educational robots have been generalized, without recognizing the different types of educational robots. Comprehensive and detailed investigations of how young children engage with educational robots and what they learn through robotics education are still needed. (Murphy, 2001, Jung, et al., 2018). However, it necessary to precise that «educational robotics», as a tool that supports the teaching-learning processes from the perspective of education, takes the dimension of means and not of end. It is not intended that students acquire competencies in industrial automation and control automatic process, it is only sought to make robotics an excuse to understand, do and apprehend reality (Polishuk, 2011, Sergeyev, 2010., Francis, 2015).

Thus, from the perspective of the theory of the psychology of Vygotsky robotics allows educational processes, due to the active, participatory, and cooperative nature of students, favouring their evolution from a point of development cognitive development to a point of potential cognitive development, through social interaction with their peers and with the teacher, managing to overcome their zones of proximal development. In this process, since the beginning, the teacher plays the role of mediator, but to the extent that the process takes place becomes a facilitating agent of the process educational (Bers, 2002., Calder et. al, 2018., García-Valcárcel, et al, 2019).

According to Hermelin, «educational robotics» aims to allow students to put into play all their exploration and manipulation skills since students are the protagonists. Educational robotics in Early Childhood Education involves the initiation of computational thinking and support for the development of basic spatial notions (front, back, left, and right), so can develop spatial abilities (Hermelin, 1986., Bizarro et al., 2018., Turán et.al., 2020). We need to develop spatial abilities for effective learning, for training, for working, and even for playing. Many researchers have used spatial cognition as a vital skill for performance in mathematics, engineering, drawing, science education, in physical education... (Highfield, 2010, Liu et al., 2010., Francis, 2015).

But not only in this area, but also in others with a highly visuospatial ability such as

engineering, architecture, and construction (Mataric, 2004, Mubin, 2013., Benitti, 2012). Different activities are proposed to develop spatial reasoning effectively with a blue-bot robot. Spatial reasoning is one of the most functional skills that we have developed as human beings. We have cognitive processes by which mental representations of spatial objects, relationships, and transformation are constructed and manipulated (Sergeyev et.al, 2010, Bizarro et. al, 2018). We can improve it with Robots. The educational proposal that we present is based on recreational activities with educational robots, seeking to develop conceptualizations that allow them to address everyday problems related to the appropriate use of technology, since this knowledge is essential in the socio-cultural interaction and the interaction with the natural environment of the citizens of the 21st century (Misirli et.al, 2014., Ospennikova et al., 2015., Afari, 2017., Alimisis, 2018., Klaharn, 2017). Additionally, it seeks to motivate through stimulation of the scientific curiosity of the knowing subjects, the inquiry, experimentation, and construction of knowledge that reduces distance existing between scientific knowledge and the knowledge used by people in everyday life (Bers, 2008., Kim et al., 2015., Daniela et. al, 2019, Vicente et.al., 2021).

3. Scope of Study

The scope of the study is to investigate whether students early ages through educational robotics using the Blue-Bot robot will learn better spatial reasoning and will be more motivated in the tasks. The main objective is to evaluate the effects of robot-supported spatial learning and recognize if more abilities are developed with their use.

The specific objectives of the project activities are:

- Listen and verbalize directions.
- Invent short stories that include, within them, one or more routes.
- Perceive one's own body in space.
- Move within space, following a short series of commands.
- Know how to orient oneself in space.
- Recognize commands: right, left, forward, backward, turn, stop, pause.
- Transfer physical activity to paper, create maps: use and draw lines, arrows, points, shapes.

- Understanding the capabilities of Blue-bot: the way it moves, what can and cannot do, how it is done, why it sounds and flashes, what are its limits.
- Development of oral skills, social skills, and self-esteem.

4. Methodology

This investigation is qualitative research work. The study is carried out through an action-research model whose objective seeks to investigate the social situation of the infant class, being an attempt to improve the teaching-learning processes. There is no claim referred to collect scientific evidence that validates theories and hypotheses to later apply them in practice but to make an improvement in didactics through educational robotics. Our focus is research in the classroom, but there is no claim empirical analytical testing of theories or hypotheses; it is intended to promote reflection on educational practices, seeking to understand phenomena to identify routes of action that allow people to improve their quality of life based on the analysis they make of their context and from your own experience. We have studied the literature about educational robotics which perspective views robotics as a tool to teach robotics itself. We have analyzed 40 studies using teaching methods of robotics education in connection to STEM education. The application of the activities has been developed with a sample of 21 students aged between 6-7 years. Five sessions were held, and participant observation was used in each session. The general purpose of the project is to use robotics education to stimulate some of the essential knowledge of early childhood education that allows the child to begin to know himself, orient himself, become aware of spatiality, acquire correct lateralization, acquire the ability to abstract, increase mnemonic processes.

4.1 Selecting a Proper Robot

For the activities proposed for the infant stage, we use the blue-bot robot. It is a small, very intuitive robot that draws the attention of children due to its attractive and transparent design. With this robot, programming languages consist only of five movement commands.

4.2 Learning use Blue-Bot

The commands of Blue-bot are these: go forward, go backward, turn left, turn right, and pause. You can press a sequence of commands, which are stored in the sequence memory. You can store a maximum of 200 commands. When we press GO blue bot executes the commands. If

you press the x bottom you clear, you erase the memory. When a program has finished the robot makes a sound and flashes.



Figure 1: *Signal Blue-Bot Robot. The Blue- bot allows the Children to see the Mechanism.*
(Source: Own Photo)

We can use the robot with very simple directions from kindergarten (left, right, up, and down), and with older students, everything will depend on the difficulty of the activity.

4.3 Activities and Proposal

Below are proposed several activities applied in early childhood education. The interactive sequential instruction proposes to present the content of the activity or lesson gradually, continuously checking the file learn and provide constant feedback. Scholars play in teams and solve exercises in groups.

- **Game Board with Images with Blue-Bots.** The robot needs a surface on which it can move freely. We can use a game board decorated with a series of figures (triangle, square, circle, etc.) so that students must lead the robot following a sequence of figures to show it the way on a game board. If we try this activity in a cooperative group, it will be an excellent way to develop language skills. A final goal will be that the child can achieve after the proposed actions through the field of experience the knowledge of the world the 15 centimetres' steps of the robot produce a rhythm that helps the child to experiment with enumeration.
- **Learning Geography Map or a Physic Map with Blue-Bots.** We use a real map to learn the geography map with a robot, for example, «we can do a travel around the world». Students will learn to move the robot considering the basic directional commands while learning geography by themselves having to trace routes from one point to another

on the map. Children should try planning a route before pressing ‘Go’ (‘Basic Programming’) and the game will start.

- **Create a Choreography with Blue-Bots.** In this activity, some objectives can be consolidated inherent in the field of experience «The body and movement». First, the child can create a comparison between her own body and that of the robot, focusing on the parts that make up the bodies of both and focusing on the functionality of the latter. Then, we can make comparisons between the possible movements that the child and the robot can comply with. We can make the child perceive the difference between voluntary movement and human thought and then programmed and man-induced to the robot.

Many activities, inside of the project, foresee the use of one's own body, movement, and perception of the self within a space: it will undoubtedly be a goal linked to the awareness of one's own body, both still and in motion, and relative to the cognition of spatiality. The teacher will provide the students with the directions that they must type in the robot. At the “ok” signal, all the robots will begin to move to create a choreography. Of course, there are other possibilities such as the students themselves designing their choreography.

5. Result and Discussion

We base the evaluation on observations and notes collected during the different activities and on the results obtained by the child during activities. We have compared skills, knowledge of the child before and after the didactic application trying to focus attention on the different objectives proposed at the beginning of the project.

The children were motivated and curious about the different activities and especially with the robot. The children showed acquired autonomy and increasing self-esteem towards their skills. Students especially learned to orient themselves in a small space and to use and recognize terms such as right, left, forward, backward, turn, stop, continue, pause.

The didactic application allowed to transform educational practice as it was the first time where activities that involved technology were carried out in a well-founded, allowing design and recreational activities with robots’ educational programs that promoted meaningful learning. Achievements of student were related to content and skills of different subjects (spatial skills, numeracy, scientific inquiry skills and oral skills). All the tasks allowed children to improve their

vocabulary and express themselves with more complex sentence structures. Participation of children in the task allows also them to develop more advanced spatial abilities than non-participating students. The study reveals that students also improve their concentration and were able to create cognitive flexibility to apply to learned abstract rules.

Table 1: *Students Participating in the Study*

	Girls	Boys	Total
Activity 1	11	10	21
Activity 2	11	10	21
Activity 3	11	10	21

Table 2: *Summary Table of the Results Observed (Avg) and Scored with a Likert Matrix as Well as their Final Score Weighted by Impact.*

	Rating (Avg)					Total (sum)	Final Rating
	1	2	3	4	5		
Spatial skills	0	0	2	7	12	94,00	4,48
Oral skills	0	0	4	7	10	90,00	4,29
Autonomy	0	0	1	2	18	101,00	4,81
Social skills	0	0	0	1	20	104,00	4,95
Self-esteem	0	1	2	4	14	94,00	4,48

Despite the successful application methodology, the research limitations are the sample size, 21 students. The data collected by the young age of the participants (6-7 ages) is based on the observation of the students, their ability, and their motivation. In future investigations, we will increase the sample and investigate what differences there are in learning between the groups that have played with the robot and those that have not. Another limitation was the duration of the study: this application was short, with only five sessions using robots. The results of the review present a limitation of previous research in that it has focused on robotics education only as an instrumental means to support spatial skills, oral skills, autonomy, social skills, and self-esteem.

Research articles supporting our practice state that using robots helps encourages children to use their imagination and be innovative in design. Educational robotic art from children remains to be investigated, but robotic art already stimulates interest in adults. Robots suppose a different mode of learning. It is multidisciplinary and involves more subject areas than other motivating contexts. (Johnson, 2003, Ospennikova et.al. 2015., Eguchi, 2016, Jung et. al., 2018,

Cahapay, 2021). Additionally, as Jung et.al noticed, robot-supported teaching requires more effort and time from teachers and is also more demanding for students, at least in the beginning. (Chapai, 2021, Highfield, 2012., Jung, 2018).

6. Conclusion

These activities carry out have created experiences and learning spaces that allow students to guide their learning activities based on their particularities and their training needs, inviting students to go through a search for personal growth around their playful dimension, involving scientific work and discovery, which was applied into practical knowledge and in conceptual knowledge built on the argued social interaction of students, researchers, and teachers. We create recreational activities with robots educational to develop conceptualizations that allow them to tackle everyday problems related to the proper use of technology. From the perspective of reinforcing the contents of the curriculum, the experience with educational robots allows students involved in their activities, knowledge, and skills of different disciplines that are part of the Curriculum. Students showed connections between content learnings with valuable social practices through experiencing. Intrapersonal and interpersonal attitudes also were developed. In the proposed activities the students performed the tasks as a team, making the students find meaning in the collective work and employing metacognitive processes that, without them knowing it, gave meaning to the intrapersonal constructions of knowledge, based on self-confidence and responsibility. This experience broke the monotony of the classes since didactic instruments were used that in most situations, they were novel for students and teachers, allowing the constructionism to achieve significant learning attitudes, spatial skills, oral skills, autonomy, social skills, and self-esteem.

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