Children with Autism and Educational Robotics: Education and Development of Social and Cognitive Skills

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Abstract: Educational Robotics in Greece is being used increasingly, while it is hesitantly applied in Special Education as it requires a properly educational trained staff. The present study is a case study aiming to discuss the effects of the utilization of educational robotics in a Special Education School classroom and specifically on students with Autism to support their social skills, interaction skills, as well as cognitive skills. Lego WeDo kit and the Scratch environment were used to support the work of the participated students. Observation sheets, evaluation sheets, semi-constructed interviews before and at the end of the interventions, focus group discussion at the end of the whole intervention, were the research tools. The intervention had a positive effect on students improving their social skills. The cooperation and interaction of the students was remarkable. They progressively increased their ability to respond to instructions and were willing to share their effort with each other and the researcher. Most children stayed focused on the activity and tried to use the materials and resources responsibly. Sometimes weakness in respectful behavior towards peers and the researcher was noted, but all children followed socially acceptable behaviors. Children seem to have improved cognitive skills and they showed moderate improvement in content creation. Sometimes they showed enthusiasm, while they seemed to persist when they encountered obstacles or failures.

Keywords: Educational Robotics, Lego WeDo Education, Scratch, Educational Intervention, Autism Spectrum Disorder.

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Introduction

Educational Robotics has made its appearance in the field of education for children to develop their skills of understanding technological issues from an early age. Educational robotics is a useful tool as teachers can adapt their lessons taking into consideration the needs of their students. Educational robotics has been increasingly used in recent years in all levels of education offering students the opportunity to interact with each other and with the constructions they create. In Greece, educational robotics has been gradually integrated into schools, while its implementation in Special Education has been more hesitant due to the requirement for adequately trained staff and technologically equipped classrooms (Pennazio, 2017, Karatrantou & Panagiotakopoulos, 2011).

Autism Spectrum Disorder (ASD) is a neurodevelopmental disorder characterized by a diverse range of symptoms and behaviors that impact an individual's social interaction, communication, and behavior. Individuals with ASD frequently face challenges in social interactions, such as forming and maintaining relationships, interpreting social cues, and sharing emotions and interests with others.

In recent years, the use of robotics in education for children with ASD has been gaining attention as a means of supporting children's learning and social development. *Social Assistive Robotics* designed to promote physical contact, focus on robot-person interactions, and employ neutral interaction strategies, facial expressions, and communication gestures to encourage social relationships, as well as *Cognitive Companion Robots* designed to provide cognitive and emotional support and potentially aid individuals with ASD in various aspects of their daily lives, represent a dynamic new trend in research.

Autism Spectrum Disorder (ASD)

According to the American Psychiatric Association (2013), the term 'Autism Spectrum Disorder' deals with a broad range of neurodevelopmental disorders that share two common elements, impaired social interaction, verbal and nonverbal communication, and patterns of behavior that are characterized as repetitive while interests are limited (Grant & Nozyce, 2013). A person with an autistic disorder demonstrates deprivation in social interactions, communication, while behaviors and interests are attributed as limited and continuous and, in some cases, many difficulties in language development are observed.

According to the 5th edition of the Diagnostic and Statistical Manual of Mental Disorders the deficiency is limited to two domains, *social communication,* and *repetitive behavior* (Albo-Canals et al., 2013; Sharma, Gonda & Tarazi, 2018). Children are mainly unable to communicate and interact with others, and their behaviors are uncontrolled and intermittent as they find it difficult to develop bonds with other people as they cannot understand social rules. They face weaknesses in terms of play that requires cooperation and primarily choose to engage in their own preferences (Albo-Canals et al., 2013; Sharma, Gonda & Tarazi, 2018).

Autism Characteristics

Language and Communication Characteristics

Children show deficiencies in communication that are not compatible with their age and intellectual abilities. These deficiencies are characterised by speech delay, echolalia, pronoun reversal, poor comprehension, and even complete lack of speech. Some children do not develop oral language, but can make simple sounds at an occasional level, or show weaknesses in conversational skills, descriptions, and narratives. In fact, some of them have difficulty in articulating and understanding humour, irony, and metaphor (Sharma, Gonda & Tarazi, 2018). Non-verbal communication is of low-level and may involve reduced eye contact, and difficulties in perceiving facial expressions and gestures (Campisi et al., 2018).

Reduced eye contact and low-level facial expressions are among the characteristics that distinguish children with autism. It is noteworthy that individuals with autism are unable to share their interest in others, and there is a lack of initiative and responsiveness to social interactions in the environment. Children find it difficult to express what they feel and think such as pain, sadness, joy (Sharma, Gonda & Tarazi, 2018). At the same time, they experience difficulty in combining different sensory stimuli which has the consequence of altering their ability to form complex mental representations, which are necessary for understanding abstract language and responding to social cues (Baum, Stevenson & Wallace, 2015).

Behavioral Characteristics

Some behavioral characteristics that children may exhibit include self-injury and externalizing behaviors, such as hitting other people. These behavioral expressions are likely to be exacerbated when children are feeling anxious, such as when they are in a medical setting or in a new place. The duration and presentation of these behaviors may vary from child to child (Johnson, et al., 2016). Other observed behavioral characteristics include limited, repetitive, and stereotypical movements, such as hand flapping, finger flicking, or periodic object manipulation (toy serialization).

In fact, some of the children express limited behaviors and interests, which can be long and focused. Simultaneously, issues with routines arise as some children display a compulsive need for stability, often accompanied by intense outbursts of anger when their schedule changes significantly (Johnson et al., 2016). Very interestingly, the children's behavior that occurs in anything to do with play emerges.

Children's play possesses repetitive and non-functional behavior. Those children prefer not to play in group games, and they show an undue obsession and focus on specific games (Gena, Papadopoulou, Loukrezi & Galanis, 2007). Furthermore, children are sensitive to sensory stimuli, have a reduced reaction to pain, and strong reactions to sounds, lights and smells are observed. Other researchers find other behavioral characteristics such as mood instability, some anger outbursts, disordered behavior, difficulties sleeping or eating (Nicholas et al., 2008).

Educational Robotics in Special Education

Many researchers are recognizing the usefulness of robots or robotic constructions as useful and reliable tools for *intervention*, *guidance,* and *support* for students with difficulties. The hypothesis that educational robotics can improve the performance of students with difficulties in both primary and secondary education is related to Papert's theoretical approach (Andruseac et al., 2015; Daniela & Lytras, 2018). Today educational robotics is considered as a fun and interactive educational methodology that fosters *development*, *critical thinking*, *creativity*, *autonomy*, *responsibility*, *dialogue* and *learning* through playful activities and projects. Working in a educational robotics framework, children with special needs communicate and interact with the programming environment, while testing their *physical*, *mental*, and *psychological* skills through projects.

Children with special educational needs do not have many opportunities to explore their environment and society because of lack of interaction and independence and may be led to believe that they are not capable of doing anything on their own. Educational robotics can play an important role in developing the self-confidence of children with these difficulties through controlling their own robotic construction (Daniela & Lytras, 2018). Robotic constructions can represent "*real objects*" that exist and act in the external world. They can move in a three-dimensional space and interact physically with both the environment and the person. They also have adjustable sensory stimulation where they can promote a perceptual experience more than that offered by a videogame. Often, robotic construction is described as a partner in activities since it can adapt its behavior at any time and is considered fundamental for social and emotional development. Finally, robots can foster and support interaction and create a connection between children with severe communication difficulties and their peers (Hamdan, Amorri & Hamdan, 2017).

Few studies worldwide confirm in school practice the value of educational robotics in this area, as it requires specialised knowledge by the teachers and tools that are usually not available in the school environment. However, in recent years, efforts have been made to find new ways and methods of integrating robotics in classrooms with students with special needs and abilities. (Andruseac et al., 2015).

Applications of Educational Robotics in Special Education

There are many different educational robotics packages that can be used in the education process, making it more effective and meaningful. Some types of robots stand out for their autonomy and evolution, such as the Interactive Robotic Social Mediators as Companions (IROMEC) or the humanoid robot NAO and offer impressive possibilities regarding their functions. Other robotic kits are distinguished for their flexibility, such as Lego Mindstorms kits, which allow children to form robotic constructions with different characteristics at a time, thus offering exiting possibilities (Pennazio, 2017). In recent years several studies on the use of robotics in children with special educational needs have been implemented.

Fridin and Yaakobi (2011) presented a project in which the humanoid robot NAO was used with children with

ADHD in preschool. The aim of this study was for the children to be supported in learning and attention as well as in other cognitive and intellectual activities. The results of the study were encouraging.

In the research of Neto et al. (2014 as cited in Conchinha, Osóro and de Freitas, 2015), an educational robotics workshop was created for 24 students attending public schools, one of whom had Down syndrome. The researchers concluded that educational robotics could promote interdisciplinarity, adaptive teaching and the inclusion of students with special needs in activities.

In their research Conchinha, Osóro and de Freitas (2015) present a strategy for inclusion and consolidation of knowledge based on playful learning using educational robotics. Participants of this study were 2 students aged 14-15 years old who were diagnosed as having learning difficulties, and were asked to assemble, program, and interact with a robotic construction created with a Lego Mindstorms package.

A typical example is the research of Jacq, Lemaignan, Garcia, Dillenbourg and Paiva (2016) in which they tried to create an activity for students with writing difficulties with the help of a NAO robot. In fact, the CoWriter platform was used to implement the activity in which the child interacts with the robot to teach him/her writing. At each stage of the activity, the robot had to convince the participants that it needed strongly the child's help. CoWriter is based on learning by example and aims to develop the child's self-confidence and motivation. The study involved children with writing difficulties, some had audiovisual deficiencies, and some were under the care of an occupational therapist. The results of the research showed significant engagement of the children in the activities they were asked to complete. In fact, the time spent by the children to plan the activities systematically increased from one session to the next (Jacq, Lemaignan, Garcia, Dillenbourg & Paiva, 2016).

Hamdan, Amorri and Hamdan (2017) used a NAO robot to teach English to students diagnosed with dyslexia. The NAO robot with its capabilities is challenging, as through it students have the opportunity to practice their cognitive and social skills. Indeed, students participated in language processing activities and the results showed that students with dyslexia actively participated, were challenged, and practiced their cognitive, linguistic, and social skills. At the same time, they became more active, efficient, and able to overcome difficulties in writing or reading. Teachers in turn recognized the value of educational robotics, since they were able to adjust their lesson objectives and teaching as best as possible (Hamdan, Amorri & Hamdan, 2017).

The Aim of the Study and the Research Questions

The aim was to investigate whether and to what extent educational robotics activities could support and promote social interaction as well as cognitive skills of children on the Autism Spectrum through the construction and programming of simple robotic structures. The research questions of the study were:
Could educational robotics activities support students on the Autism Spectrum to empower their:

- social skills as *attention*, *collaboration*, and *interaction* skills?
- cognitive skills concerning concepts such as '*direction'*, '*orientation'*, '*problem design solution'*,

'*time*', '*programming commands*' and '*coding*'?

Method

The methodology of the research is based on the research works of Albo-Canals et al., (2018), Huijnen et al., (2017) and Sandygulova et al., (2019). The research is designed to me implemented with students in the autistic spectrum attending a special education primary school and it was a case study. The Lego WeDo kit and the Scratch programming environment (https://www.media.mit.edu/posts/member-collaboration-lego-s-wedo/, https://scratch.mit.edu/wedo-legacy,) were used as tools to support students' work.

The Research Tools

The research tools of the study are based on the research tools in the research works of Albo-Canals et al., (2018), Huijnen et al., (2017) and Sandygulova et al., (2019) and were adapted according to the needs of the educational procedure and the characteristics of the students.

The research tools used were:

G. *Observation sheets* during the intervention
H. *Evaluation sheets* during the intervention
İ. *Semi-constructed interviews before and the end* of the interventions
J. *Focus group discussion* with the students at the end of the whole intervention.

Observation Sheets

They are based on the ones used in the research of Albo-Canals et al., (2018) and Huijnen et al. (2017).

The sheets based on the research of Albo-Canals et al. (2018) are related to children's *behavior* while they are engaged with robotic constructions. These behaviors are categorized into three main areas:

Non-Verbal Communication: This category involves the observation of non-spoken interactions, such as body language, gestures, facial expressions, and other non-verbal cues expressed by the children during their engagement with robotic construction.

Verbal Communication: This category involves the children's spoken communication, including their use of language, the content of their conversations, and the way they communicate verbally working with robotic constructions.

Construction: The behavior related to the construction category focuses on how the children interact with and handle the robotic construction itself. This could involve how they assemble, program, or interact with the robotic components.

Category: Non-verbal communication	
Micro-behavior	**Description**
Gaze at robot	Participant maintains gaze on robot > 1 s
Gaze human	Participant maintains gaze on face/eye > 1s, not reciprocated
Mutual attention	Mutual eye contact between participant and another person
Group attention	Groupmates jointly look at same object
Pointing robot	Hand/finger/arms directed to robot
Pointing Person	Hand/finger/arms directed to person
Category: Verbal communication	
Micro-behavior	**Description**
Meaningful conversation	Meaningful, in relation to activity
Tangential conversation	Non-meaningful relative to activity
Echolalia/ scripting	Repetitive phrases
Initiates conversation	Participant begins talking to another person
Responds	Participant responds to conversation started by others
Interrupts	Participant verbally/non-verbally interrupts another person
Category: Construction/Dynamics	
Micro-behavior	**Description**
Turn taking	Participants takes turns in activity with one or more other persons
Collaboration	Participant takes part in negotiation, sharing, asking for opinion of others
Affect Sharing	Participant shares positive affect with at least one other person
Proximity	Participant is within 100 cm of another person
Distractive behavior	Participant disrupts activities of group mates (not conversation)
Ask help/permission	Participants seeks out adult input
Collaboration	Participant puts robot together with another student
Independence	Participant puts robot together alone
Disengagement	Participant is not focused on robot
Robot manipulation	Participant is actively attempting to manipulate robot
Robot access	Participant has access to robot

Figure 1. Observation sheets based on the research of Albo-Canals et al. (2018)

The sheets of Huijnen et al., (2017) are designed to capture information related to the *objectives* of the educational intervention and the *role of robotic construction* in ways as:

Educational Objectives: documentation of how educational intervention aligns with the objectives and of how robotic construction contributes to achieving these educational goals.

Intervention Details: The duration, frequency, and location of the educational intervention are described. This information helps in understanding the logistical aspects of the intervention.

Summary of the Intervention: This summary highlights both the aspects that participants found easy and those they found challenging during the activity.

These observation sheets (see Figure 2) serve as a comprehensive record of the educational intervention, allowing researchers and educators to evaluate its effectiveness, identify areas of difficulty, and make informed decisions for improvements in future interventions.

Intervention name:	
FOCUS ON OBJECTIVE (S): On which objective(s) does the intervention focus? Multiple objectives possible	**Role of the Robot:** What roles does the robot have? Note multiple possibilities.
Imitation in play	Provoker
Making contact	Reinforcer
Imitation in social/interpersonal interaction and relationships	Trainer
Turn taking	Mediator
Orientation to listen	Prompter
Social routines (greet, say goodbye, introduce)	Diagnoser
Attention	Buddy
Learn a new form of communication	
Talk – use verbal abilities	
Train or practice new skills	
Follow up instructions	
Pose a question / ask for help	
Having fun	
Develop interest in play	
Other, namely:	

Goal of the session:			
Characteristics of the target group:	Level of functioning		
Please describe the child	☐ High		☐ Not applicable
	☐ Normal		☐ Specific level
	☐ Low		☐ Multiple levels
Session properties			
☐ Individual session ☐ Group session ☐ Free ☐ Structured ☐ Semi-Structured	Duration and frequency	Who? Describe the professional and their role	Where? Describe the environment
Summary of the intervention			
Intervention summary	Options for the gradual increase or decrease of difficulty to ensure transfer. Easier: More difficult:		Measurements Reference to literatur Scenario code

Figure 2. Observation sheets based on the research Huijnen et al., (2017)

Evaluation Sheets

The evaluation sheets are based on the tools of Albo-Canals et al., (2018) which refer to the *Positive Technology Development Checklist*, a structured way to assess and evaluate various aspects related to *technological development* in children describing whether children needed support to complete the activities carried out per session. The checklist addresses the categories of *communication*, *collaborative behavior*, *content creation*, *creativity*, and *behavioral choice*. Each category is rated on a scale from 0 to 3.

Scoring criteria
0: Particular behavior not observed. Task not complete
1: Needed almost complete or complete support
2: Needed moderate support, but partially independent
3: Needed almost no or no support

Tasks/ behaviors	Score	Category
Students take directions from teacher (e.g. sits when told)	0 1 2 3	Communication
Students responds back to the teacher (answering questions…)	0 1 2 3	
Student initiates relevant communication with teacher	0 1 2 3	
Student shares their work with teachers	0 1 2 3	Cooperative behavior
Student shares their work with classmates	0 1 2 3	
Student helps to clean up at the end of the session	0 1 2 3	
Student can create a functional program for their robot	0 1 2 3	Content creation
Student is enthusiastic/interested about their project/creation	0 1 2 3	
Student persists in spite of obstacles or setbacks	0 1 2 3	
Student can put robot blocks together	0 1 2 3	
Student can scan the code	0 1 2 3	
Student is playing/exploring different robot parts, blocks	0 1 2 3	Creativity
Student is exploring in unexpected ways	0 1 2 3	
Student is having fun as they work on their projects	0 1 2 3	
Student is focused on the activity chooses to engage with it	0 1 2 3	Choice of conduct
Student is able to focus on the task	0 1 2 3	
Student is respectful to peers and teachers	0 1 2 3	
Student are using materials and resources responsibly	0 1 2 3	

Figure 3. Evaluation sheets based on the research of Albo-Canals et al. (2018)

Semi-constructed Interviews

The interviews (Figure 4) are based on the research of Sandygulova et al., (2019) between the classroom teacher and the researcher and were taken before and at the end of the interventions.

Questions before of the activities.
What are the child's capabilities?
What weaknesses does the child express?
Could you describe the social skills of the child?
How does the child interact with his/her classmates?
How does the child interact with the teacher?
How does the child react to changes in his/her schedule?
How does the child express his/her emotions?
To what extent does the child use technological devices such as tablets, mobile phones, and computers?
Do you believe that engaging with robotics will help the child with his/her social skills?

Questions after the end of the sessions
How did children interact with their classmates during the activities?
How did they interact with the researcher during the activities?
How did they interact with the robotic construction?
Did they express emotions? What emotions?
Did they express emotions related to the activity before it?
Did they express emotions related to the activity after it?
Did they express desires related to the activity? How?
Do you believe that engagement with robotics helped the child in his/her social skills?
Have you observed any change in the child's behavior during the activities?
How would you characterize the child's reaction to the robotic construction?

Figure 4. Semi-constructed interviews based on the research of Sandygulova et al., (2019)

Focus group discussion.

The focus group discussion with the students took place at the end of the whole intervention. Asking children about the positive effects and seeking feedback at the end of the sessions is a child-centered and insightful approach to assess the impact of the educational activities, improve the quality of the educational activities, and ensure that they align with the needs and experiences of the children involved (Figure 5).

"Questions after the end of the sessions for the children"
Did you enjoy the activities?
What did you like the most?
Was there something you didn't like? If so, why?
What was challenging for you?
What do you think you learned from what we did?
How did you cooperate with your classmates?
Did you enjoy working with the other kids?
Could you express your opinion?
Did your classmates listen to you?
Did you listen to the other children?
Were you helped by your classmates?
Did you help any of your classmates?
Would you prefer to do the activity by yourself?
Did you get tired of the activities? If yes, why?
What made you tired?
Do you think you could do the activity on your own?
Would you like to do more activities?

Figure 5. Focus group questions.

Reliability and Validity

All the research tools were checked for validity and reliability as required by the rules of educational research (Panagiotakopoulos & Sarris, 2015). The evaluation and observation sheets used as well as the questions for the interview before and after the intervention, were translated from English to Greek by a person who speak the English language perfectly. Afterwards, a reverse translation was made from Greek to English to check whether the meaning of the statements and the questions remained the same without meaningful differences (back translation) (Brislin, 1970). After that, three experts, one in educational robotics, one educator, and one expert in children with special needs specifically in autism, reviewed the tools and commented on their validity. The purpose was to check whether the statements and questions could answer the research questions, whether they were completed and appropriate for the purpose of the study. Some comments by the experts regarding the wording of the questions and statements and appropriate corrections were made.

Procedure

The educational activity had a duration of twenty (20) hours in total (two (2) 2-hour sessions per week for five (5) weeks), it was based on nine (9) worksheets and consisted of two distinct phases:

A. *Familiarization Phase*

The Familiarization Phase consisted of two 2-hour sessions in one week:

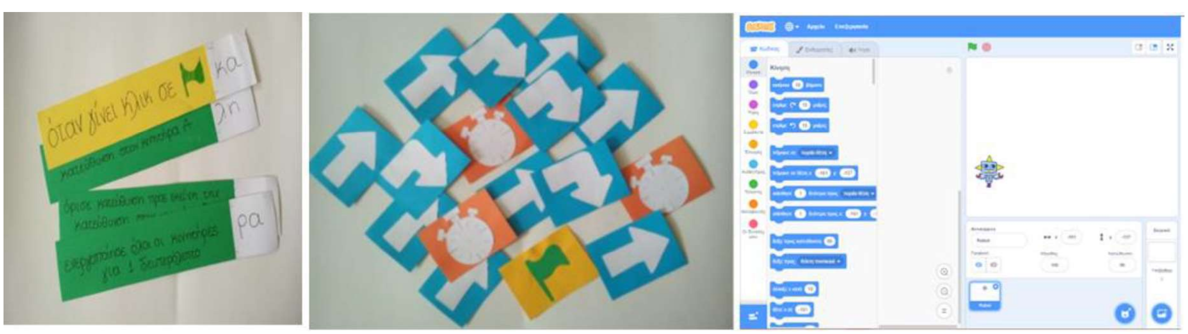

Figure 6. Snapshots of children's tools while working

1st Session: During the first session, students became familiar with the Scratch software (Figure 6). They used basic programming commands, such as those required to move a character on the screen in specific directions in order to follow a predetermined path (*Worksheet 1 - Phase A*).

2nd Session: The second session introduced students to the Lego WeDo educational robotics kit. During this session, students engaged in assembling a robotic construction using numbered images as a guide. They also programed this robotic construction to move within the room (Worksheet 2 - Phase A).

B. *The main Activity Phase*

The Main Activity Phase is structured to progressively introduce students to various aspects of robotics, programming, and problem-solving supporting their creativity and problem-solving skills. It called students for hands-on learning experiences and completed in a session for feedback and discussion, ensuring that students have the opportunity to reflect on their experiences and learning throughout the program (see Figure 7).

Figure 7. Snapshots of children's work

1st Session: Introduction to the world of robotics, playing with a robotic construction - Exploring the students' capabilities (Worksheet 1 - *Phase B*).

2nd Session: Introduction to the programming environment of Scratch. Programming a screen robot to reach its destination (Worksheet 2 - *Phase B*).

3rd Session: Building a real robot with the help of images. A game - Children give it a name and provide commands without any conditions (Worksheet 3 - *Phase B*).

4th Session: Programming a real robot to reach its destination - Condition: the path to the finish (Worksheet 4 - *Phase B*).

5th, 6th, 7th Session: Programming both virtual and real robots - Condition: guiding the two robots to the correct fruit according to the story-puzzle (Worksheets 5, 6, 7 - *Phase B*).

8th Session: Interview with the class teacher - Feedback and discussion with the students.

Participants

The participating students were seven (7) boys aged 9-14 years old who attended a Special School in Patras Greece. In Table 1 characteristics of the participating students are described shortly. This data derived from the interview with the classroom teacher before the start of the intervention. Based on these characteristics the researchers were enabled to prepare and design the educational activities more effectively.

Table 1. Participants' Characteristics

Name	Age	Sex	Stereotypical behaviors	Favourites	Additional notes
DK	14	Boy	Excessive verbosity	Computers Volcanoes, Planets Nature	Easily distracted Accepts changes if they are known in advance Expression of emotions
GB	12	Boy	none	Computer games	Upsets the team's balance Expresses sympathy (especially with BB) Guidance for expressing emotions
BB	11	Boy	none	Computer games Superheroes, Cars	Considerable insecurity Requires guidance Leadership role within the team
E	12	Boy	none		Bilingual environment Inadequate reading and writing skills Desire for socialization Loses interest easily
FD	13	Boy	none	Flags of countries	Isolation Disturbance when the routine changes Guidance and reminder of rules
GS	9	Boy	none		Weaknesses in reading and writing Desire for interaction
D	12	Boy	none		Difficulty in reading and writing Outbursts of anger Difficulty in teamwork

Results and Discussion

The results of the study are presented below as they derived from the analysis of the data collected by the research tools, and they combined with each other in order for the research questions to be answered.

Familiarization Phase

During this phase the results were obtained from the combination of the researcher's and the class teacher's free notes observing the students participating and interacting in the activities. Students expressed enthusiasm for the screen robot, showing a strong interest in the activity. They actively engaged in the session, indicating their willingness to participate in the learning process. They named the screen robot '*Phineas'*, and experimented with various programming commands, indicating a proactive approach to learning. Students successfully guided the screen robot, Phineas, to reach the finish flags, demonstrating an understanding of the basic commands. During the 2nd session, they were excited about the Lego WeDo educational robotics kit, and they put active participation efforts assembling a robotic construction with the help of numbered images. They named the robot '*Ferb'* and experimented with programming commands, arranging syllables in the correct order and creating words.

Main Activity Phase

Based on the *evaluation sheets*, figure 8 summarizes the results for each category (*communication, cooperative behavior, content creation, creativity, and behavior selection*) for each child during each session at the Main Activity Phase.

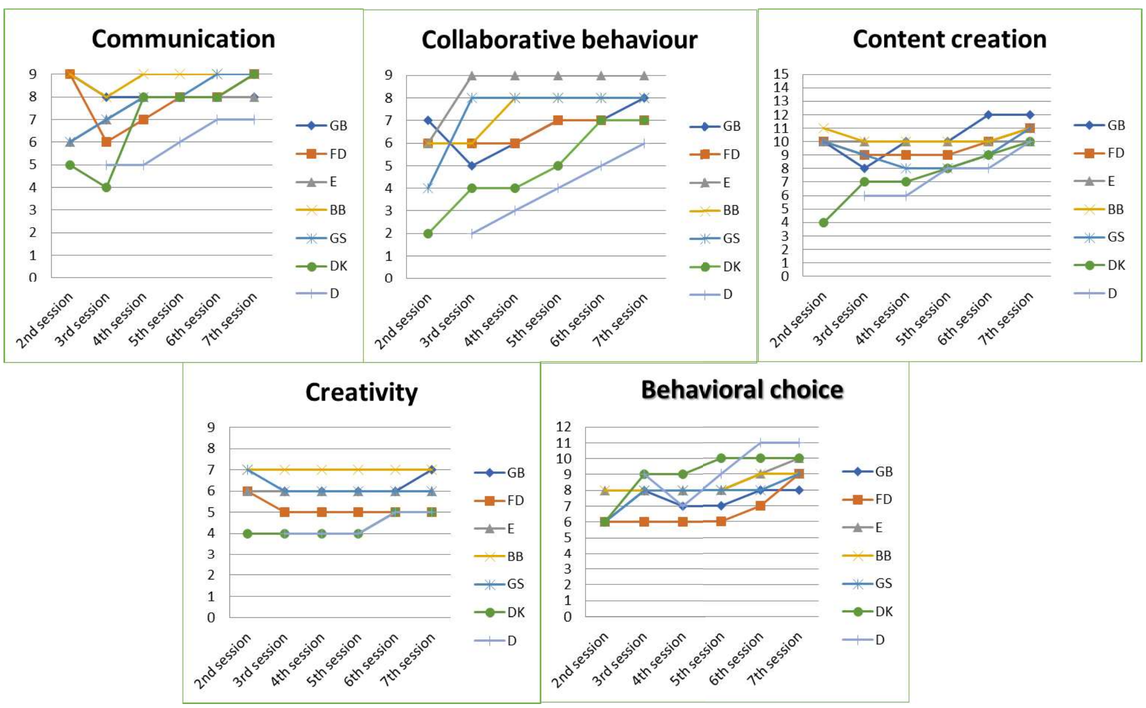

Figure 8. Results of the evaluation sheets for each category, each child during each session during the Main Activity Phase

Combining the results of the observation and evaluation sheets and taking into consideration the verbal and non-verbal communication among children during the construction and the programming can be supported that:

Communication: most children improved their communication and social skills; they could receive and follow instructions by the researcher, respond to questions as the sessions progressed and were able to start discussions. *Collaborative Behavior*: the cooperation and interaction among students was remarkable, as they worked together on the implementation of each activity. They were willing to share their ideas and efforts with each other and the researcher during the activities, they seemed to interact with each other and to cooperate to solve the problem each time. Most children stayed focused on the activity and tried to use the materials and resources responsibly. It is important to notice that children learned to wait their turn during working. Furthermore, they were willing to help with the classroom cleaning.

Content Creation: children showed enthusiasm for creating the program when it was a functional one. They were characterized by perseverance to solve problems despite obstacles or failures, combining coding commands and paying strong attention to create a functional program. Furthermore, children seem to have improved cognitive skills regarding concepts of '*direction*', '*orientation*', '*problem-solving solution*', '*time*', '*programming commands*', '*code*'. Finally, it seemed that the educational intervention was fun and motivating for the students.

Creativity: children were working exploring different parts of robotics construction, sometimes they were exploring in unexpected ways, and they seemed to having fun while working on the activity.

Behavioral Choice: most children were focused on the activity, showed concentration on the work and respect to the team using the material responsibly. Sometimes weakness in respectful behavior towards peers and the researcher was noted, but no extreme behaviors were observed as children followed socially acceptable behaviors and most showed improvement in terms of interaction.

During the *Focus group discussion* remarkable findings arose. The feedback from the children showed that:
Most of the children enjoyed the activities while programming *Ferb* and *Phinea* to perform various movements. They stated that the activities were challenging for them as well as easy and enjoyable, particularly when giving commands to the robots. These responses reflect the positive experiences and teamwork observed among the children during the activities, as well as their enjoyment and learning during the process. It also demonstrates the development of social skills such as *patience*, *collaboration*, and *mutual support*.

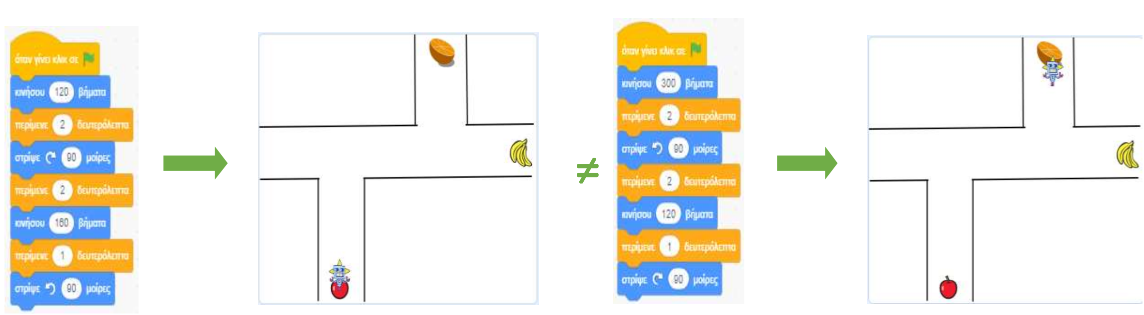

Figure 8. Parts of children codes

Combining the findings of all research tools, and especially based on the *interview with the teacher of the classroom after the end of the intervention*, it is notable that the educational activities had a positive impact on children's learning and understanding of various concepts such as:

Direction and Orientation: Children effectively used auxiliary cards to plan the path that the robotic construction should follow, indicating their ability to understand and apply concepts related to direction and orientation.

Problem-Solving and Design: The activities facilitated problem-solving and the design of solutions. When faced obstacles, children actively attempted to devise solutions, they recognized their mistakes through testing and trial-and-error. They worked hard to identify the incorrect commands each time, demonstrating their problem-solving skills and their ability to adapt and refine their programming. These observations showed how the educational activities not only enhanced technical and cognitive skills but also encouraged the development of problem-solving abilities and the understanding of fundamental concepts related to direction and orientation.

Understanding Programming Commands: Children showed an improved understanding of programming commands, recognizing that each command produces a distinct result in the robotic construction or the screen robot. This signifies their ability to associate specific commands with their corresponding actions.

Understanding the Concept of Code: Children introduced to the concept of code, realizing that the placement of commands in a specific order is crucial to achieving a desired result, recognizing the sequencing and logic required in coding to produce the desired outcomes. These observations highlight the children's increasing proficiency in fundamental programming principles and their ability to manipulate commands and code effectively to control the behavior of the robotic construction and screen robot.

The findings based on the interview with the teacher of the classroom after the end of the intervention confirmed the possible benefits for the children concerning new behaviors or concealment of behaviors with a focus on their collaboration.

It is noteworthy to notice that the heterogeneity of the students in the classroom makes it necessary to have an educational tool that can be adapted to the needs of each student. Adaptive robotics-assisted educational interventions are a powerful educational medium due to their adaptability (Huijnen et al., 2017). Children with their participation in such educational interventions' express feelings and thoughts regarding the programming and assembly of robotic constructions (Conchinha, Osóro & de Freitas, 2015). They develop social skills through their collaboration and understand the importance of solution planning (Andruseac et al., 2015, Kalamatianou & Karatrandou 2022). Through their work with simple robotic constructions, childrens'creativity, responsibility and dialogue are developing as found in the research of Conchinha, Osóro & de Freitas (2015) and Andruseac et al., (2015).

Conclusion

The aim of the study was to investigate whether and to what extent educational robotics activities could enhance social interaction and cognitive skills in children on the Autism Spectrum, achieved through the construction and programming of simple robotic devices - constructions.

The findings of the study showed that the educational intervention with the Lego WeDo kit had a positive effect on students improving their social skills. The cooperation and interaction of the students was remarkable, as they worked together on the implementation of the activities. They progressively increased their ability to take instructions from the researcher and responded to her questions. In addition, children were willing to share their effort with each other and the researcher during the activities. Most children stayed focused on the activity and tried to use the materials and resources responsibly. The children's ability to focus and concentrate on the activities improved gradually, indicating an increasing ability for sustained attention.

Children appeared to engage with each other and collaborate effectively in problem-solving activities. They demonstrated responsiveness to both the researcher's guidance and questions, as well as those posed by their classmates, creating an engaging and interactive learning environment. Collaboration was a prominent aspect, with the children working together to tackle the assigned tasks.

They initiated discussions and asked questions, showcasing their cooperative spirit. They also learned important social rules, such as the need to wait one's turn. This illustrates the integration of essential social norms within the educational setting, contributing to social development. It is worth noting that one student gained recognition from their peers for active participation in the activities, which suggests the acknowledgment of individual efforts within the group. Over the sessions, there seemed to be a gradual improvement in the children's behavior. While occasional lapses in respectful behavior towards peers and the researcher were observed, no extreme behaviors occurred, as the children generally adhered to socially acceptable behavior and showed improvement in their interactions.

In terms of content creation, children showed moderate improvement as the sessions progressed. At times, they exhibited enthusiasm during the activities, while in other instances, they demonstrated persistence when faced with obstacles or failures. It appeared that the children enhanced their cognitive skills related to concepts such as 'direction,' 'orientation,' 'problem-solving solutions,' 'time,' 'programming commands,' and 'code'. Finally, the educational intervention seemed to be enjoyable and motivating for the students.

The limited number of participating children in the study, as well as the short duration of the intervention, serve as limitations of the study, preventing the generalization of the findings and conclusions. However, the observations and results of the intervention collectively indicate a positive and collaborative learning environment in which children improved their cognitive and technical skills. More importantly, they also demonstrated support for their essential social and interpersonal competencies. Longer-term interventions are required to contribute to the scientific discussion regarding the benefits of educational robotics activities for children on the Autism Spectrum, particularly in promoting their social interaction and cognitive skills.

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