Investigating early childhood children's mental representations about the programmable floor robot Bee-Bot

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ABSTRACT

A preliminary study concerning early childhood children's mental representations about the programmable floor robot Bee-Bot is presented in this study. It is about a case study that takes place in four preschool settings. Children's mental representations were recorded through individual-focused interviews and depicted in individual drawings. The results show that while children may attribute an animate identity to the robot, they provide evidence and depict data for its properties and basic operational features, which are gained through educational activities in programming.

KEY WORDS

Educational robotics, programmable floor robot Bee-Bot, children's mental representations

RÉSUMÉ

Cette étude présente une recherche préliminaire concernant les représentations mentales des enfants de la petite enfance à propos du robot programmable au sol Bee-Bot. Il s'agit d'une étude de cas qui se déroule dans quatre établissements préscolaires. Les représentations mentales des enfants ont été enregistrées par le biais d'entretiens individuels ciblés et représentées par des dessins individuels. Les résultats montrent que si les enfants peuvent attribuer une identité animée au robot, ils fournissent des preuves et décrivent des données pour ses propriétés et ses caractéristiques opérationnelles de base, qui sont acquises par des activités éducatives de programmation.

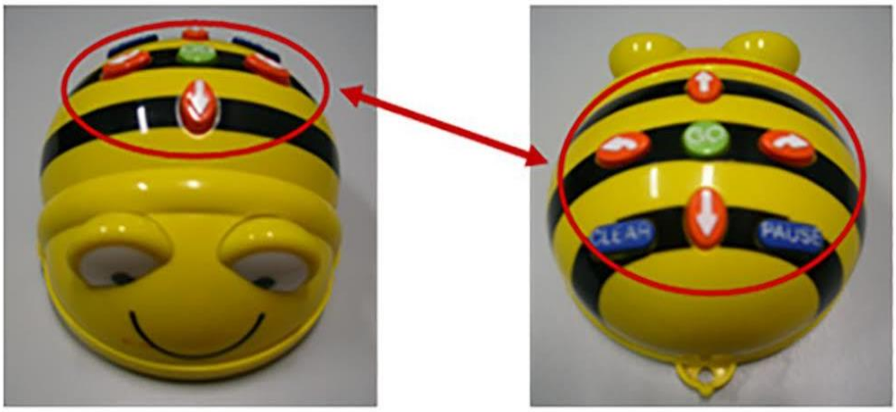
MOTS-CLÉS

Robotique éducative, robot de sol programmable Bee-Bot, représentations mentales des enfants

INTRODUCTION

The 'educational robotics approach' appeared in the 1960s through the Logo educational movement. It is a pedagogical approach where learning occurs either through robots or about them through project-based learning. In terms of teaching, it is an established approach that recruits programmable methods in enhancing the so-called skills of the 21st century. Nevertheless, principally, it is defined by the use of information technologies in the context of their ability for observation, analysis, modelisation and control of various physical processes (Depover, Karsenti, & Komis, 2007). It is about an approach which allows the trainee to familiarise with information technologies, with the broad sense of the term, and use them to determine a project structure and find a specific solution to the given problem by contrasting their opinion with others (Denis & Baron, 1993; Leroux, Nonnon, & Ginestié, 2005). A specific category in educational robotics is the programmable floor robots, a reproduction of Logo toys that apply mainly to early childhood children. These toys are programmable floor robots that the user controls, and they are supposed to move and follow paths accordingly. The user sets out and determines the number of commands that are input in the robot, under specific circumstances, by following the principles of the Logo programming language, which favours the development of metacognitive ability, during which children rethink the procedures of thinking they have followed, improves the ability of problem-solving and promotes spatial orientation (Clements & Sarama, 2002). One of the most widespread programmable floor robots is the Bee-Bot, which embodies the Logo turtle philosophy and the programming principles of this specific language for its control. Thus, children can program a path on the floor either on a themed mat or on a free enquiry/play activity. The programmable robot Bee-Bot has the shape and the colours of a bumblebee. The programming of the moves is on the upper side of the robot (tangible interface) and is based on seven buttons grouped in different colours and shapes, thus helping the user organise visual cues for operating and functioning the robot (Figure 1). The commands for controlling the robot's movements regarding direction and orientation are through the four orange oval buttons. The central green round button 'GO' functions for the execution of commands of a program. The two blue oval buttons support different nevertheless essential operations. Using the 'CLEAR' command, a user can erase commands from memory, whereas the 'PAUSE' enables them to stop the execution of commands instantaneously. In this type of robot, the memory command appears to be a milestone to young children's interpretation as each user needs firstly to erase and then insert their new program unless it is planned otherwise from the problem under study.

FIGURE 1



The tangible interface of the programmable floor robot Bee-Bot with basic logo-like commands

The integration of the programmable floor robots in early childhood education, presuppose the understanding of the way children perceive and represent them. However, the literature review provides a few studies about children's representations and ideas for robots, and specifically for children of early childhood age. Greff (2005) studied the representations of children of preschool age (5 years old) for the programmable floor robot Roamer. The aim of the study was the children to depict the procedure of implementing steps for the programmable robot. In conclusion, the stages of the development of the procedure were recorded, as well as the important criteria about teaching that have to be taken into account in similar procedures such as: a) the appearance of the conventional object at an early stage and then withdrawal from the children's field of action, b) the individual action instead of the action in group level and c) the support from the researcher during the outline of their project. Highfield and Milligan's researcher (2008) reports the representation of a child of preschool age through side moving of the programmable toy for the attainment of circular movement. Bhamjee, Griffiths and Palmer's research (2011) about representations and perceptions of children 7-9 years old, mentions that there is some confusion about the quality and the operation of robots. The quality of the robots is divided into an animate or non-animate object, whereas the children attribute autonomy on their function and at the same time the need for human intervention. In more recent studies, preschool children's mental representations about robots initially tend towards human-like entities (Monaco et al., 2018) or anthropomorphic attributions (Berghe et al., 2021); even after a pedagogical intervention, the shift to more mechanical attributes was not likely.

PURPOSE AND QUESTIONS OF THE RESEARCH

The purpose of the present study is to highlight the mental representations of early childhood children and especially 4-6 years old, about the programmable robot Bee-Bot, before the delivery of a robotic scenario-based teaching intervention (Komis et al. 2013; Misirli & Komis, 2012, 2014). The study involves the presentation of a series of variables, which were gathered using research protocols of interviews. The variables related to the properties and the basic operational features of the programmable robot Bee-Bot were:

1. Q1: 'What do you think this object is?'
2. Q2: 'What do you think this object does?'
3. Q3: 'How does this object flies/moves?'
4. Q4: 'Are all the buttons the same?'

The question of the research is shaped as it follows: Which are preschool children's initial representations about the properties and the basic operational features of the programmable floor robot Bee-Bot.

METHODOLOGY

In the present study, the 'case study' (Yin, 2009) applied to four preschool classes. For the realisation of the study, an educational scenario-based that focused on organising an appropriate learning environment for programming concepts to be taught by using the programmable robot Bee-Bot from the field of educational robotics was planned (Misirli & Komis, 2014). Within this frame, the preschool educators trained and delivered the educational scenario in their classes. This scenario comprises of six stages: a) deciding on the teaching topic, b) assessing of prior knowledge and representations, c) setting the objectives of the scenario, d) developing teaching-material of scenario activities, e) evaluation (assessment of final knowledge and representations), and f) instructions-remarks (Komis et al., 2013). The teaching material of the scenario was the programmable floor robot Bee-Bot with the themed-mats and command-cards (pseudocode) as developed by the researchers. The data collection about children's representations was accomplished using qualitative techniques of a case study such as a focused interview (Yin, 2009) following a certain set of questions and following the line of inquiry as reflected in the research protocol and an individual drawing of the Bee-Bot. Both techniques are included in assessing prior and final mental representations and knowledge of the educational scenario that preceded or followed with activities.

The focused interview included two major axes: i) questions concerning the mental representations about the properties and basic operational features of the programmable floor robot and ii) questions concerning the mental representations about the control and spatial orientation of the programmable robot. The latter axe is studied in a different study (Misirli, Komis, & Ravanis 2019). For each command-button, every child described the idea/representation that they formulated. In addition, to each interview, there was a corresponding drawing of the robot by each child with the respective description. The answers in interview questions and descriptions of children's drawings collected before the experimentation with the programmable robot. The sample of the study consisted of ninety-two (92) children (n= 42 boys, n=50 girls) between the ages of four and six (M=5,4) and was selected randomly based on teachers' willingness to participate in this project. The children were arranged in groups of four to six persons. The research took place in the natural setting of the 'case' (Yin, 2009), thus in natural classroom conditions.

DATA ANALYSIS

The individual interviews were organised in a qualitative way and were classified in four categorical variables (four variables with nineteen values in pre-test presented in Table 1.

TABLE 1

Variables Q1, Q2, Q3, Q4 (interviews' questions) and values (pre-test)

Variable label	Pre-test Value categories
Q1_ What do you think this object is?	1= Q1I_Ignorance
	2= Q1I_Object
	3= Q1I_Animal
	4= Q1I_Object/Animal
Q2_ What do you think this object does?	1= Q2I_Ignorance
	2= Q2I_Imaginery idea
	3= Q2I_Description Action
	4= Q2I_Description Action Operation
	5= Q2I_Description Operation
Q3_ How does this object flies/moves…?	1= Q3I_Ignorance
	2= Q3I_Imaginery idea
	3= Q3I_Motion mode
	4= Q3I_Power mode
	5= Q3I_Operation mode
Q4_ Are all the buttons the same?	1= Q4I_Ignorance
	2= Q4I_Buttons Confused
	3= Q4I_Buttons Yes
	4= Q4I_Buttons No

The children's drawings with the respective descriptions were organised in a qualitative way and were classified in three categorical variables (three variables with six values in pre-test) presented in Table 2.

TABLE 2

Variables D1, D2 and D3 (drawings' coding) and values (pre-test)

<table>
<tr><th>Variable label</th><th>Pre-test
Value categories</th></tr>
<tr><td rowspan="2">D1_Initial Representation of Imaginary Content</td><td>1= D1I_Representation Imaginary Content_YES</td></tr>
<tr><td>2= D1I_Representation Imaginary Content_NO</td></tr>
<tr><td rowspan="2">D2_Initial Representation of Operation</td><td>1= D2I_Representation of Operation NO</td></tr>
<tr><td>2= D2I_Representation of Operation YES</td></tr>
<tr><td rowspan="2">D3_Initial Representation of Functional Definition</td><td>1= D3I_Representation of Functional Definition Semi-complete</td></tr>
<tr><td>2= D3I_Representation of Functional Definition Incomplete</td></tr>
</table>

The seven categorical variables that relate to the children's initial representations gathered from focused interviews and drawings, about the properties and basic operational features of the programmable floor robot, were analysed with the method of multiple correspondence analysis (Benzécri, 1992) as presented in the table below (Table 3).

TABLE 3

Children's initial representations for the programmable floor robot Bee-Bot

<table>
<tr><th colspan="3">Description of Axe 1 for the variable values</th></tr>
<tr><th>Variable label</th><th>Title of variable values</th><th>Frequency</th></tr>
<tr><td colspan="3">1st group: Absence of mental representations</td></tr>
<tr><td>D3_Initial Representation of Functional Definition</td><td>Absence of reply</td><td>45,000</td></tr>
<tr><td>D2_Initial Representation of Operation</td><td>Absence of reply</td><td>45,000</td></tr>
<tr><td>D1_Initial Representation of Imaginary Content</td><td>Absence of reply</td><td>45,000</td></tr>
<tr><td>Age</td><td>Absence of reply</td><td>18,000</td></tr>
<tr><td>Q1_What do you this object is?</td><td>Absence of reply</td><td>18,000</td></tr>
<tr><td>Q2_What do you think this object does?</td><td>Absence of reply</td><td>20,000</td></tr>
<tr><td>Q3_How does this object flies/moves…?</td><td>Absence of reply</td><td>23,000</td></tr>
<tr><td>Q4_Are all the keys/buttons the same?</td><td>Absence of reply</td><td>29,000</td></tr>
<tr><td colspan="3">2nd group: Semi-complete mental representations</td></tr>
<tr><td>Q2_What do you think this object does?</td><td>I_Imaginary idea</td><td>43,000</td></tr>
<tr><td>D2_Initial Representation of Operation</td><td>I_Representation of Operation_NO</td><td>37,000</td></tr>
<tr><td>D3_Initial Representation of Functional Definition</td><td>I_Representation of Functional Definition Semi-complete</td><td>25,000</td></tr>
<tr><td>D3_Initial Representation of Functional Definition</td><td>I_Representartion of Functional Definition Incomplete</td><td>39,000</td></tr>
<tr><td>Q1_What do you think this object is?</td><td>I_Animal</td><td>64,000</td></tr>
</table>

D2_Initial Representation of Operation	I_Representation of Operation_YES	28,000
D1_Initial Representation of Imaginary Content	I_Representation Imaginary Content_YES	43,000
Q4_Are all the keys-buttons the same?	I_Buttons_NO	75,000

Description of Axe 2 for the variable values		
Variable label	**Title of variable values**	**Frequency**
3rd group: Incomplete mental representations		
D2_Initial Representation of Operation	I_Representation of Operation_YES	28,000
Q2 What do you think this object does?	I_Description Action	28,000
Q1 What do you think this object is?	I_Object/Animal	21,000
Age	*5-6 years old*	*45,000*
D1_Initial Representation Imaginary Content	I_Representation Imaginary Content_NO	22,000
Q3_How does this object flies/moves…?	I_Power mode	9,000
Q3_How does this object flies/moves…?	I_Motion mode	21,000
2nd group: Semi-complete mental representations		
Q1_What do you this object is?	I_Animal	64,000
Q3_How does this object flies/moves…?	I_Imaginary idea	26,000
D1_Initial Representation Imaginary Content	I_Representation Imaginary Content_YES	43,000
Q2_What do you think this object does?	I_Imaginary Interpretation	43,000
D2_Initial Representation of Operation	I_Representation Operation_NO	37,000
D3_Initial Representation of Functional Definition	I_Representation Functional Definition Incomplete	39,000
Age	*4-5 years old*	*26,000*

As shown in Table 3, three groups of children's initial representations appear for the programmable floor robot.

The first group lacks ideas in verbal formulations (from 18 to 29 children) and their depictions (45 children in total). In particular, regarding verbal formulation, the children's representations about the properties and basic operational features of the programmable robot are absent either because they did not come up with an idea or were partly participated in the teaching intervention due to absences. The picture of children's depictions in total is formed accordingly. Their drawings about the programmable robot are absent.

The second group contains the most significant number of children (between 25 and 75), a big part of which belong to the age group of 4-5 years old. In this group, the initial children's mental representations are related to the idea they formulate about the properties of the programmable robot and its corresponding depiction. As regards the properties and basic operational features of the programmable robot, the prevalent idea among most children is that it is an 'Animal' and/or a 'Bee' in question 'What is it?', by attributing its corresponding behaviour that is 'It will extract honey', 'It will fly' for the question 'What it does?'. On balance, the question 'How' is approached by its corresponding way of action, such as 'With its wings' or 'With its sting'. Thus, associating the variable 'What do you think this object does?' with the variable 'Initial Representation Imaginary Content' complete correspondence is observed.

The majority of the children seem to recognise the existence of buttons on the top of the programmable robot, for which they state that they are different between them. Nevertheless, they do not depict the operation system (buttons) or its symbols, and they do not use functional definitions in their descriptions. In some cases, they have depicted it even partly (Initial Representation of Functional Definition Incomplete). This specific variable is associated directly with the children (37 of 39), which do not mention elements about the movement of the programmable robot in their verbal descriptions and consequently mental representations (Initial Representation of Operation_NO). Proportionally, the operation system (buttons) or the symbols appear partly in the representations of a minor part of children and the use of operational definitions in their description (Initial Representation of Functional Definition_Incomplete).

In the third group, the representations appear more structured than the previous. Most of the children belong to the age group of 5-6 years old, and about the properties and basic functional features of the programmable robot, the idea for the question 'What is it?' takes the value 'Object_Animal'/'Car-Bee' prevails by attributing to its corresponding behaviour to the question 'What it does?' that it 'Goes on', 'It moves'. On balance, the question 'How' is approached by its corresponding way of action, such as 'With its wheels'. A very few children refer to the necessity of batteries as an indispensable element for the corresponding way of action of the programmable robot. Correlating the above variables to the variable of the children's representations, it arises that the children enter more elements that relate to the operation system (buttons) or the symbols appearing on the programmable robot. In addition, they use operational definitions in their descriptions even in the circumstances they have partly depicted it (Initial Representation of Functional Definition_Semi-complete). Therefore, consistency is attributed to the verbal description of their representation by mentioning that the robot 'It moves' or 'It moves as the arrows show' (Initial Representation of Operation_YES). Drawing from Table 3 it appears that there is direct correlation to the group of children whose verbal descriptions of their representations report that the programmable robot 'It moves' or 'It moves as the arrows show' (Initial Representation of Operation_YES).

DISCUSSION AND CONCLUSION

The results of the present study provide data about the representations of children of preschool age concerning the quality and basic operational features of the programmable floor robot Bee-Bot. They show differentiation among the three groups that formulated. The development of programming concepts and algorithmic thinking to children of preschool age with the use of the programmable floor robot Bee-Bot, may be facilitated through the designing and implementation of the appropriate educational scenarios (Komis & Misirli, 2011; Komis et al., 2013; Misirli & Komis, 2012, 2014). The designing and implementation of meaningful activities with explicit scaffolding played a catalytic role in developing corresponding mental representations, which enhanced the development of programming abilities to children of preschool age, as appears from previous results and suggested by Newhouse, Cooper and Cordery (2017). Although most of the children continue to attribute in their descriptions of drawings an animated property to the robot, they enter features that correlate to the programming procedure for its control and operation with the corresponding use of functional definitions to appear more systematically. Similar results presented from Berghe et al. (2021), in their study with a social robot. In addition, those children seem to emphasise the procedure required for creating a programme without giving the relevant outline of the robot as suggested by Greff (2005), for narrowing the emphasis in the procedure of programming drawing. The final drawings of the children of the third group and the corresponding formulations provide elements about the control and operation procedure of the programmable robot in accordance with the relative activities they were taught. We found some interesting preliminary data corresponding to initial drawings of the children and we tried to prove evidences of how a structured robotics scenario-based intervention shapes children's mental representations. However, a more systematic analysis of drawings needs to be completed and give statistical significance to our preliminary results. To this end we should use a methodological framework to categorise and validate the drawings of initial and final representations.

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