Engaging young children to 'control' technology: emotion, negotiation, agency

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Abstract. This paper discusses how young children engage with 'control' technology and in particular how do they attempt to control the behavior of physical and screen 'robots'. Episodes of children-robot interactions are discussed based on data from a series of case studies where children with adults engage in specifically designed learning activities that aim to introduce young children to the basics of computer programming. The tools children use vary from the physical robot Roamer to the programming language scratch. The series of these case studies are connected with research and teaching as part of the Lab Unit on Mathematics Education and Learning Technologies where we attempt to develop methodologies for facilitating the use of technologies and mathematics in the early years for all children and their educators.

Keywords: engagement, control technology, early-years-curriculum, emotions, negotiation, agency

1 Introduction: robotics in education

Robotic-enhanced educational activities and computer programming have gained an added interest in early childhood education due to continuous advancements in digital tools that interrelate in creative ways physical, tangible and virtual features and provide user-friendly computational interfaces for learning. Seymour Papert (1993) was a pioneer and amongst the first to support the teaching of programming and mathematics by means of using the potential of Logo language. The idea of 'control' technology is embodied in Logo by means of the 'turtle' metaphor. As such, the young programmer has the mission to control the turtle's movements on a particular grid aiming to complete

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specific tasks in the context of collaborative project work (Hoyles and Noss, 1996).

Today, talking about 'robotics' in early childhood education one needs to include a variety of tools and environments. The floor turtle (e.g. the Roamer by ValiantTechnology, http://www.valiant-technology.com), is a robotic creature that moves around the floor according to specific instructions that require the learning of a symbolic code. The turtle soon migrates to the screen where it appears as a graphic object that receives and executes commands in the Logo programming environment, but also to the invention of tools that permit the haptic experience in programming such as tangible programming (see, Berns and Horn (in press)). A number of other programming learning environments have been further developed based on the idea of the 'screen-turtle' or 'screen avatar' aiming to engage students in playful learning experiences. Among them is ToonTalk (Kahn, 2004) and Scratch (Resnick,2007; Resnick *et al*, 2003). AgentsSheets and StageCast Creators have also been used for engaging students in programming through simulating and producing video games by making use of rule-based programming (Guzdial, 2003). The floor turtle led also to the development of robotic technology such us Lego Mindstorms and Cricket. Lego Mindstorms (see Martin, 1996) constitutes a set of programmable bricks, electronic sensors, motors, gears that can be combined together engaging students in multiple constructions (for a review of tools based on Terecop experience see Alimisis and Kynigos, 2009). Parallel to Lego Mindstorms, MIT Media Lab developed Cricket technology taking into consideration that students although interact daily with objects that sense and respond, (i.e. alarm clocks), they have no idea about the way these objects function. Cricket technology was developed aiming at encouraging children to 'create such types of interactive inventions' (Resnick, 2008, p. 19) and exploring concurrently the underlying science and engineering concepts.

It has been argued that 'robotics' and 'control' technology, from a pedagogic perspective, facilitate young children to engage with the informal learning of scientific concepts but also the development of skills for active problem solving, project work and group collaboration. As far as didactics is concerned, robotics provide opportunities to learn about varied aspects of 'control' technology (see also cybernetics) ranging from an understanding of technological objects as entities that can be constructed and programmed by humans towards doing specific tasks, to a realization of how mathematical ideas can be put to work along with technical, scientific and artistic knowledge about motion, motors, sensors and digital tools.

Young children, in this sense, can become designers (including being programmers, engineers, artists, scientists, storytellers, musicians, etc) by means of playing with physical, iconic or tangible 'commands' or 'tools' that facilitate the writing of scripts for achieving specific actions. In parallel, children learn about how mathematical concepts could be applied in specific settings and as a means for problem solving, the value of analysis and synthesis as parts of problem solving, the details concerning a scientific method of inquiry and the potential interlinks amongst concrete and abstract ways of thinking (see Bers *et al*, 2002). Attempts for developing appropriate curricula as frameworks for pedagogical activities are often based on ideas rooted in Piagetian constructivism and Papertian constructionism. Albeit, the subtle differences amongst these two epistemological strands, they have inspired not only the creative production of 'tools' but also the development of curricular frameworks that enable the incorporation of such tools and ideas into the everyday activity of school-based timetables. It is interesting to note that curricular design, at most times, goes hand-in-hand with tool design (Papanikolaou and Fragkou, 2009).

One needs to note that such attempts are being designed mainly from a 'content' perspective –in other words having in mind the organization of what the children should (ideally) learn. For example, Bers (2008) talks about 'powerful ideas' that could be learned and links them to specific project type work that could be organized in classrooms. However, as also Bers *et al* (2006) argue, specific concerns have been raised concerning the developmental appropriateness and potential of an early introduction to robotics and computer programming, but also to scientific inquiry including exploration of mathematical ideas. At the same time, most curricular attempts stress the organization of pedagogical interactions in specific stages or phases of teaching space and time–often assumed as treating related but distinct abilities and content. This approach has proved helpful in dealing with the huge task of implementing robotics in education. At the same time, it sheds little light into the complexity of human-robot interaction in the process of engagement in classroom activity.

Taking the above into consideration, we would like, in the context of this paper, to delve into the complexity of how young children begin their engagement with robotic enhanced educational activity and with control technology in particular. Our focus has been to analyze, based on certain episodes, how children engage with the idea of 'controlling' robot behavior. Taking into account seriously the children's perspectives, our questions are of the type; How young children of preschool and primary school age engage with robotic enhanced activity? How children whilst interacting with adults and technology express their ideas about what a 'robot' is? What emotions drive their expressions? How their emotions transform, evolve and change as part of their engagement with the 'robot'? How do they appropriate the idea of 'controlling' the behavior of a 'robot'? How do they move about it?

2 The context of the present study

This paper discusses how young children engage with 'control' technology and in particular how they attempt to control the behavior of physical and screen 'robots'. Episodes of children-robot-adult interactions are discussed based on data from a series of case studies where children with adults engage in specifically designed learning activities that aim to introduce young children to the basics of computer programming. The tools children use vary from the physical robot Roamer to the virual 'robot' (the screen turtle or sprite) by means programming language scratch. The series of these case studies are connected with research and teaching as part of the Lab Unit on Mathematics Education and Learning Technologies where we attempt to develop methodologies for facilitating the use of technologies.

The episodes reported here derive from qualitative data collection (i.e. teaching experiment methodology; see Cobb *et al*, 2003) where children's work and especially their utterances whilst being involved in an activity, has been recorded (i.e. taped or videotaped). The transcribed utterances have been analyzed and certain themes have been located for further analysis and problematisation. Although children's work with Roamer and scratch are parts of different projects, we try here to relate our findings and discuss them under the optic of the notion of 'engagement' with robotic enhanced activities.

Our aim is to report some qualitative findings that narrate from the children's perspective, how they respond when engaged as beginners in learning experiences with either physical or virtual robots such as Roamer and Scratch. We are interested in the type of dispositions that come out as well as the ways according to which students respond to the 'floor turtle' and the learning environment of Scratch –two seemingly different contexts for programming since the first involves programming a physical entity (the floor turtle) whilst the second involves programming a virtual (screen based sprite). In the following, we outline what might be 'engagement' in the context of robotics in education and then we move towards discussing the outcomes of our study.

3 Engagement- what might be?

An 'engagement stage' has been suggested as the first in a series of stages used to describe students' work on robotics-enhanced projects. An engagement stage is also proposed as a pedagogic framing for implementing the robotics enhanced curriculum based on a project learning approach. Papanikolaou and Frangou (2009) explain, in Chapter 3 of the final TERECOP report, that during the engagement stage '*students may be provided with an open-ended problem and get involved in defining the project and main issues involved*' (p. 110). This stage is followed by four more where students are expected to *explore* aspects of the robotic project and get familiar with devices and software (the explorative stage), to *investigate* questions and alternative solutions (the investigative stage), to *create* a solution by combining artefacts (the creation stage), and to *evaluate* their final products (the evaluation stage).

The authors in this TERECOP report, but also elsewhere, argue that these stages are not linear but iterative in the sense that any stage could potentially include aspects of the other in ways that promote an image of the child as 'designer'. According to Resnick and Silverman (2005) the child as 'designer' need to feel engaged but free '[…] *to design and redesign their artefacts, to mess with the materials, to try out multiple alternatives, to shift directions…*'. Conceiving 'engagement' in such an 'open' way allows us to consider that children's engagement moves beyond the boundaries of learning particular content (both mathematical and programming) towards a more social conception of learning about themselves as 'participants' in robotic activity that involves a strong notion of agency and identity-work. In relation to the above, we have observed throughout our studies the importance to recognize an additional stage that precedes and overlaps these five and could be described as a 'meta-engagement' stage (a stage that exists beyond any engagement stage but denotes the need to only to initiate but also to sustain engagement). At this stage, children, as beginners to robotic activities and computer programming, require time and space to explore their ideas about what a robot is including social images about robots, perceptions of controlling and regulating robot behavior, as well as the very need of requiring a 'program' as a mediator for 'causing' and 'controlling' this very act.

As a result, in the following, we will be discussing the complexity and multiplicity around 'engagement' for children as beginners to robotics by paying attention at three interrelated layers; first 'engagement as the expression of deep emotions', second 'engagement as negotiating boundaries of control' and third 'engagement as agency to control the behavior of the other'.

4 Engagement as expressing deep emotions

Throughout the episodes analyzed, it was commonly observed that children's initial engagement in the learning experience with Roamer and Scratch was followed by the expression of *deep emotions.* Children were met to be excited or sometimes threatened by the idea of interacting with a 'robot'. The joy and the fear co-existed and were verbally expressed. For example, as we see in episode A1, although Peter gets excited John feels threatened. This 'fear' by John raises a number of questions concerning the underlying reasons for his verbally expressed emotions. What does it cause 'fear'? Is it related to the looks of the robot itself? Is it the fact of being exposed to an ‘unknown cognitive area’ that requires of him a complex understanding of what does a human-machine interaction might mean to himself personally? In other words, John’s anxiety might be related to the ‘fear’ of the unknown object or to the ‘fear’ of how the unknown object could interact with him and how its behaviour could become controlled and regulated.

	Peter: Wow! Look at him! John: I am feeling fear! Peter: Why? He is smiley.

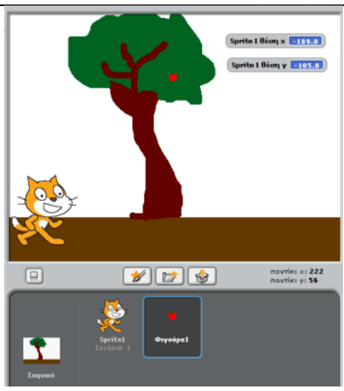
Episode A1: fear for the ‘robot’ - roamer

Deep emotions were observed to be closely associated with children’s tendency to assign anthropomorphic genres to robots. Roamer but also the sprites in the Scratch language are personalized and become sometimes human or animal creatures. As seen in episode A2, the context of a game provides a joyful atmosphere where the robot becomes a friend and a partner –sharing the activity.

	Researcher: We can play a game entitled: ‘Let’s make Roamer visit our friends’ Would you like to start this game? Children: yes!! [excitement] Researcher: Hmm…what about sending Roamer to Lilly? Children: Yes, to Lilly!!

Episode A2: The ‘robot’ as partner to games

The sprite of the cat in Scratch also gets a humanized nature in the context of a scenario narrated by Timothy (see episode A3) that allows him to identify emotionally with the cut-sprite. The sprite ceases being an abstract virtual screen entity and transforms into a concrete cat (a poor cat) that needs Timothy’s care and affection.

	Timothy: 'Miss! I have the cat. And a tree. An apple tree. The cat is going to walk. And an apple will fall. Directly here [he points]. Poor cat [laugh]

Episode A3: The 'poor' cat!

Another aspect related to the deep emotions expressed by children was a tendency to expose a mythical and magical dimension to robots' behaviour. In the context of experimenting with Roamer, children expect that the executing of commands is accompanied with flames appearing out of the robot (see episode A4) as the Roamer is moving on the floor.

Researcher:	What about the movement of the Roamer? Is everything ok with the number of its steps?
Stefanos:	Will flames appear from the mouth of the robot? Will we see sparks?

Episode A4: The mythical robot

5 Engagement as negotiating robot nature and control boundaries

A first reading of episode A4 exemplifies, despite the researcher's efforts to turn attention to a rational use of the robot, how children mythologise the nature of the robot. However, on a deeper reading, one can realize that their initial reaction contains seeds of doubt (i.e. the way they pose the question; Will flames appear? Will we see sparks?) initiating their engagement towards negotiating 'robot' nature. This negotiating process needs to be seen as a move amongst mythical-rational and becomes apparent in episode A5 where children wonder 'Do robots really speak by themselves? The following episode A5 calls us to read this negotiation process as a dialogue amongst children, the adult and the robot.

Thomas:	This is a fun tool!
Researcher:	Roamer is calculating the steps that he has to make. Now he has to move across the corner…
Dimitris:	But does it speak?
Researcher:	This is difficult for him. How many steps should we select for Roamer in order to instruct him move across this side?
Dimitris:	Does Roamer speak?
Researcher:	No, actually he can only 'hear' commands.

Episode A5: Demystifying the 'mythical' robot

This 'negotiable mood' in combination with the contribution of the adult-mediator is worth arousing one's interest as it sets a basis whereupon students can problematise about 'control' effects and reflect upon the boundaries of this mythical-rational dimension. The mediator tries to bring into focus that the robot remains an object that can only follow instructions and can be controlled and regulated. Humans are the ones that can control it. Such an approach moves children to demystify the robot and triggers mechanisms towards strengthening their agency to control.

6 Engagement as agency to control robot behavior

As explained above, the emerging dialogue amongst 'robots', children and adults entails potential for strengthening children's agency. Below, we show examples of how these initial emotional states interrelate explicitly mechanisms that strengthen children's agency to control and regulate 'robot' behavior.

Students' 'deep emotions' were gradually seen to give pace to a rational engagement with task. Whilst the rational coexists with the emotional, the mythical dimension becomes disputed and its relative boundaries are questioned. The following episode (see episode B1) denotes how emotional and rational states become interwoven.

Focusing on Dimitris' words, we see how the warning *'Be careful'* signifies 'Do not touch it!' Forbidding to touch the buttons entails also a realization that 'touching the button' means 'executing a command'. And at the same time entails a realization that 'addressing a command' is a serious thing –almost dangerous. A command is a step amongst others and belongs to a series of commands. The warning 'be careful' is also related to the will to be systematic in giving (and following) commands to the robot –and thus, it acts as a seed for programming.

<table><tr><td></td><td>Dimitris: Be careful! What buttons should you press?!
Researcher: We press 9 and 0. Fine. And now the green button for execution.
Dimitris: Wow! Look at him!
Stefanos: I am feeling fear!
Dimitris: Why? He is smiley.
Researcher: Would you like to repeat the movement?
Students: Yes!!! [with excitement]</td></tr></table>

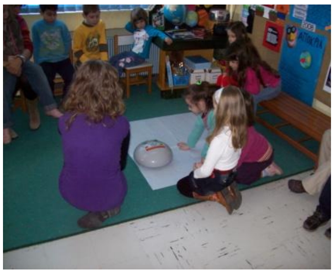
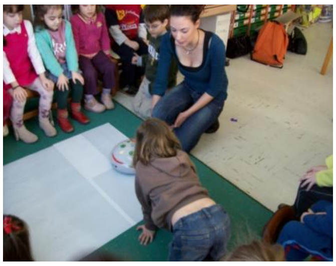
Episode B1: Beware the buttons

In a similar way (see episode B2) children using Scratch are getting to realize that they should take an active role in controlling the cat. Emotions may still exist and the 'cat' may still be treated as a pet but now it seems that there is an extra dimension to the story that children try to narrate by means of scratch. In episode B2, we see how Kevin wonders about what comes next in the story he has created (and composed in the scratch screen) with his cat. Having created the cat and the scene where the cat is located, Kevin as the author of the story considers what might be the next steps including specific roles and actions. Kevin asks 'what can I do with you 'cat', now?' and this very question provides him an entry to the idea of programming by making explicit the potential of controlling robot behavior.

Kevin: 'I have a cat. And a fish. Hmm… what can I do with you 'cat', now?

Episode B2- what comes next?

Morever, children's negotiable process is constructed as part of interacting with robots and adults with whom they can negotiate the extent to which the 'mythical' or 'magic' powers of such robots exist (see episode B3). Interestingly, the interaction with the robot sets the basis whereupon a game can be planned. Although the idea for the game is usually generated by the mediator (see episode B3) the emergence of a 'game mood' due to the physical presence of the robot cannot be disputed. In the context of the game and encouraged by the adult (who acts as mediator) children start problematising the mythical dimension of robots and start engaging -even with hesitation- with the idea of controlling the robot. An interesting issue is that students start identifying with the one who controls the robot For instance, in the following episode Maria can see herself and her classmates behind the controlling of Roamer as she says: we did not press the green button.

 	Researcher: We can play a game entitled: 'Let's make Roamer visit our friends' Would you like to start this game? Children: yes!! [excitement] Researcher: Hmm…what about sending Roamer to Lilly? Children: Yes, to Lilly!! Researcher: How can this happen? Maria: perhaps this button? [hesitation] Researcher: Ok! This button. But how many steps? Maria: Six Researcher: Six? Are you sure? Let's see. Maria: no…we did not press the green button! Researcher: Right. [she presses the green button] [The robot moves directly to Lilly!Students are clapping]

Episode B3: First steps to the idea of 'controlling' the robot

7 Conclusionary remarks

Based on the analysis of the above episodes, we have been sensitized towards paying more attention on children's engagement with robots as an ongoing process. Exploring in depth the notion of engagement from the children's own perspective two issues could be denoted.

As it has already been explained three interrelated themes of 'engagement' were observed. Engagement was perceived first as a state of expressing deep emotions. Children assign a mythical dimension to robots and verbalise their emotions (excitement, fear, joy). Deep emotions were soon seen to embody seeds of doubt as far as the nature of robot is concerned. The identification of seeds of doubts in students' verbalised thoughts sets a basis whereupon problematization about 'control' effects and reflection upon the boundaries of the mythical-rational dimension could be raised. In this way, the initial emotional state seems to interrelate explicitly mechanisms that strengthen children's agency to control giving pace gradually to the rational one.

The mediator/teacher/ curriculum developer is worth taking into consideration the existence of these three interrelated themes of engagement. In the context of a learning experience with robots (tangible or iconic ones) it seems that is of great significance to provide students with the opportunity to express themselves and their feelings; through such an approach it is likely students to enter the process of demystifying robots. The need for controlling the robot then comes more naturally and the idea of programming is shaped through a process of problematization upon the boundaries of the mythical-rational dimension.

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