Using a Programmable Toy at Preschool Age: Why and How?

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Abstract. Robotic toys bring new dimension to role-play activities in kindergarten. Some preschool curricula clearly identify reasons for their inclusion. However, preschool teacher needs to revise usual teaching methods in order to use them. Offering a programmable toy or robotic-related activity doesn't mean immediate success in work with children. We document our research with concrete programmable device in a preschool classroom. Details of robotic-related sessions can help reader to design the quality game for preschool-age based on using a programmable toy.

Keywords: programmable toy, preschool, Bee-Bot

1 Introduction

What is a robot? 6-years old boy immediately responds: “It is controlled.” Some friends of him also use to play with a toy robot at home. Children from preschool[1] classroom named Frogs also understand numerous purposes robot can have:

“I would like to have a robot to clean up my shoes.”

“I would like it to tidy my bed.”

“I want a robot which would hoe in the garden instead of me so that I could ride a bike.”

However, nobody wishes to have a robot which “will ride a bike while you hoe in the garden.”

We have recorded children's comprehension to robots within wider research of the ways how digital technologies can become integral part of preschool curriculum. We have accepted the broad definition of digital technologies as devices which provide *interactivity*, *response* or *communication* [3]. This definition encompasses walkie-talkies, metal detectors, remote-control cars as well as programmable toys or computer.

We explore

- *suitability* of concrete *digital tools* for preschool use,

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[1] Preschool age means five to six-year-old children in our country.

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- the phenomenon of *learning with digital technologies*, especially the issues how teacher should organize learning and how digital devices influence preschool routine.

We pay special attention to programmable toys that young children can access and control in a simple manner.

[9] suggest that control aspects should be included into early experiences with technologies because

- much of everyday technology is controllable;
- engaging in control activities obliges children to deal with and to construct simple 'programs';
- control technology activities may help children to develop more *general abilities to think and learn.*

If we plan to enrich preschool learning by the use of digital technologies, we may consider programmable toys also from another point of view. Digital technologies spread into many kindergartens nowadays and there is a widespread belief among educators and parents that children will require technological competencies to succeed in the workplace [6]. However, some kindergarten experts argue that digital technologies are inappropriate choice for young children's play (see [1]). Young children need to learn in concrete learning environment, to create hands-on experience with their surroundings (Beaty, 1984, in [10]). In this situation programmable toys appear to be a good choice because

- they are *tangible* technological devices and children can directly manipulate with them,
- they can stimulate problem-solving in real conditions of children's environment.

2 Programmable Toys in Curricula

Slovak national programme of education for children in kindergartens [2] doesn't explicitly require use of digital technologies in kindergarten. Despite this fact we can find older computers in many preschool settings at present and computers from IBM KidSmart Early Learning[2] initiative appear in larger towns by now. However, we have no evidence some kindergarten uses programmable toys in its curriculum.

The attitude to digital technologies for kindergarten children is more positive in other countries. British curriculum [7] recommends practitioners to use programmable toys to support learning. The curriculum introduces programmable toys as a good example for developing knowledge and understanding of the contemporary world. In the field of mathematical development, children should develop the ability to describe simple journey and instruct the programmable toy in order to develop position language and estimation [7]. Australian ICT Learning Innovation Centre, department of Queensland Government has even published special document (see [5]) containing valuable teachers' ideas for using specific programmable toy, Bee-Bot, in kindergarten and at primary school.

[2] http://kidsmartearlylearning.org

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3 Robotics and Programmable Toys in Kindergarten Reality

Apart from Slovakia, we have discovered a few examples of good practice with programmable toys or robotics worldwide. [10] have observed children aged four to six during their interaction with Electronic Blocks building kit. Electronic Blocks have simple interface, based on Lego™ series for young children. Children have built and controlled remote-control cars and torches by connecting touch, light and movement blocks. By combining several blocks in correct order children have been able to design simple device and control it by sensors. They have developed short program sequences containing conditions (sensor input and output).

Robotics plays a vital role in the curriculum of Brazilian Escola Parque[3]. Kindergarten pupils have built models mostly from Lego™ parts. They have been able to design a new model according to their preferences. Some children have constructed complicated houses. They have spent much time by improving the model, but they haven't used any control elements. Other children have been more courageous, they have designed simple car models and connected small electromotors to them so that cars can move straightforward or stop. In case car didn't move, children would swap cables between battery poles. They have concentrated on designing a stable model. They have learnt basic notions about control in their work with motors. However, they will create programs for the models in computer much later, in three years period of time.

We have chosen different approach to programmable devices in the Frogs classroom in our research. We have preferred **programming aspect** of robotic toys to construction and design. That's why we have used a device which enables children to control it from the very first moments of play. In following part we will briefly introduce a programmable toy Bee-Bot™2. Then we provide reader with further details about its use in concrete preschool setting.

4 Bee-Bot, the Programmable Toy

The programmable toy Bee-Bot[4] was awarded as the most impressive hardware for kindergarten and lower primary school children on the world educational technology market BETT 2006. It uses Logo-related principle of controlling floor robot. It enables the child to program a journey on the square grid.

The design of a toy is adapted to a child user – the toy has a shape of a yellow bee with black stripes. (This design is not fixed. It can be slightly modified by the use of special plastic shells, on which child can stick paper antennae, woolen wings etc.) The toy has a small connector for a toy carriage or other moving device in its back part.

We can control the toy by a few colorful buttons. By pushing them the child enters a sequence of simple instructions for motion or rotation of a toy.

- Four orange buttons serve for a backward/forward motion and rotation to the left/right.

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[3] http://www.escolaparque.g12.br/
[4] http://www.bee-bot.co.uk/

- The central button is a green GO button. It launches interpretation of the whole sequence of pushing buttons.

There are two more buttons, two blue buttons for erasing memory (CLEAR) and short break in executing commands (PAUSE) in the toy controlling part. User interface in fact copies interface of successful Pixie[5] robot and adds child-friendly design to it.

The child can enter up to 40 instructions in one programmed sequence. User cannot modify the length of single step or size of angle rotation. These parameters are constant (which is comprehensible in relation to the target group of users), the toy moves in 15 cm in one step. Pushing rotation buttons means right angle rotation without changing toy's position.

The toy provides a simple feedback to the user. After completing the whole sequence of instructions its eyes will blink and the toy will hoot. Pushing the buttons in the mode of creating programmed sequence has also been accompanied by a silent peep sound.

Sounds can be disabled by a discreet switch in the bottom of the toy.

The way of controlling the toy is simple. Children get used to the green GO button very fast. This button is the only green button in the whole interface; moreover it is located in the central part of the toy. The slight problem appears by two blue CLEAR and PAUSE buttons. They have same colour and are placed symmetrically. The titles of the buttons can therefore be supplemented by a picture sticker for young children that cannot read, in order to distinguish between them easier.

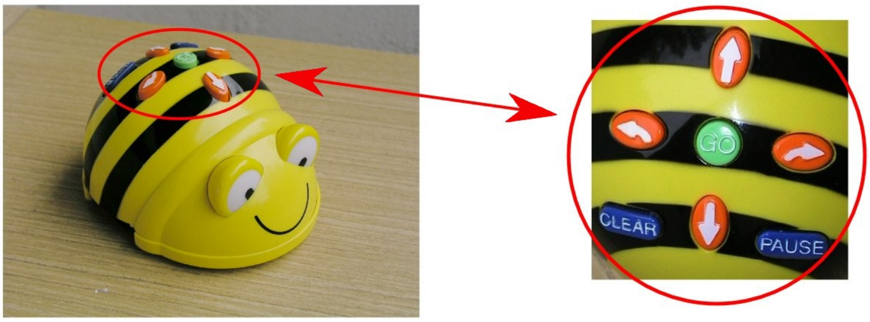

Fig. 1. Bee-Bot interface

In our qualitative research study we have observed particular problem with CLEAR button for several times. Before entering new instructions, the child shall clear the toy memory. Otherwise previous sequence of instructions is saved and by pushing buttons the child will simply add new commands in the end of program sequence. This default behavior of a toy makes sense for specific type of activity similar to *Bee-Bot knight* [4]. The activity *Bee-Bot knight* starts by locating the toy to the castle. From that starting point the toy begins its journey in several phases: on the first day it travels to collect the shield, next day to collect the shield and the sword and so on. The landscape on which the Bee-Bot playing fairy-tale character moves

[5] www.swallow-systems.co.uk/pixie/pixie1.htm

doesn't change at all. After picking the knight accessories the teacher manually transfers the toy to the castle.

We can describe the script of similar activities by these features:

- the whole story consists of several connected phases,
- Bee-Bot is placed in the same location in the beginning of each phase,
- each phase contains repetition of all previous phases i.e. of the whole program sequence.

In case of mistake child has to enter whole sequence of commands from the very beginning one more time. If we consider different type of activities (for example moving Bee-Bot from one place to another one), saving previous instructions and the possibility to reuse them won't produce any extra effect.

On the other hand, CLEAR button develops idea of memory, saving instructions in as simple interface as possible.

The toy can be introduced in variety of age groups and school subjects (see [4], [5]): from early years to lower primary school children, for development of literacy, numeracy, natural sciences, history, geography, but also citizen or religion education.

The range of ideas for using Bee-Bot in numerous creative ways covers the basic and the only functionality of the robot – to plan the journey on the square grid map and to test the solution by executing whole sequence. Bee-Bot doesn’t provide more ways how to control it. Related software product Focus on Bee-Bot[6] simulates the behavior of the toy on screen. The software serves as an introduction to 2D and 3D computer screen representations ([9]) similarly to most on-screen control programs (Pip simulator, 2go, Jelly-bean Hunt).

The software and the physical toy are fully autonomous.

5 Robotic Activities in Kindergarten

Currently, our research team focuses on developing attractive activities and effective practice for learning with digital technologies at preschool age. We believe that robotics is one of the fields of computer science that has great potential for learning with technologies for young children.

We work on design and evaluation of various activities and tools for preschoolers. We use methods of participant observation and field notes to record and analyze positive and negative aspects of pedagogy of our sessions with preschool class. Our sample consists of 24 preschool children from partner kindergarten, with equal ratio of boys and girls.

We have conducted four sessions related to controlling programmable toy Bee-Bot. Each session has lasted from thirty minutes up to one hour.

We have been also trying to identify key ideas important for learning with control technology in preschool classroom. They can help preschool teacher who wants to effectively integrate control technology into classroom practice to avoid some mistakes we have made.

Table 1 outlines topics and methods used in each session.

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[6] www.focuseducational.com

Table 1. Topics and methods of robotic-related sessions

Topic	Method	Output
Tell me...what a robot is	Discussion	Individual, informal comprehension of the word 'robot'
First steps with Bee-Bot	Introductory presentation Group work in large groups	Comprehension of Bee-Bot's control buttons
Alarm clock alive	Motivation story Group work in small groups	Design of simple program sequence (forward and backward motion)
Birthday party	Motivation story Group work in large groups	Design of simple program sequence (forward, backward motion, simple rotations)

We had started most sessions together with all children by some introductory presentation or motivation story. Afterwards children were split into groups based on their choice.

In initial sessions we were looking for the successful script of the activity as well as to getting familiar to children whom we hadn't known before. The very first meeting *Tell me...what a robot* is consisted from informal discussion with children. We have brought out a few children ideas from this session in Introduction.

We supposed children would be charmed by a new toy. On the first session children immediately took possession of Bee-Bot with no respect to new technology. Still, they weren't able to discover the principle of robot's motion because they didn't notice it had repeated previous program sequence before executing new one.

However, we found out fast that the toy itself wouldn't provide strong motivation to sustain children's attention for longer time. We encountered serious problems on the session *First steps with Bee-Bot*. Why?

- We didn't provide children with concrete problem task. We didn't use any story mat for a Bee-Bot to move on. We tried to fix this problem by building a route from wooden building blocks. However, they didn't fully compensate original square grid. Children couldn't use accurate commands to move a robot to the end of the route, they just guessed.
- Problem of controlling the robot itself was interesting only for a few children.
- Number of children in each group was too high to offer each child enough opportunities to play with Bee-Bot more than once. Children soon became impatient and inattentive.

Session *First steps with Bee-Bot* has led us to conclusion that we need to completely rethink our approach to children. We attended preschool class two more times in order to observe teaching methods that class teacher used. We have soon revealed that we should not rely on single activity with no choices. Then we have designed *Alarm clock alive* activity which has proved to be very successful.

5.1 Alarm clock alive

The activity has combined a powerful narrative with design elements – criteria also valid for designing popular digital games [11]. In the beginning we built map of the town from the square paper parts (castle, house, road) and asked children to place small toy figures on some parts of the town. We used the Bee-Bot as an alarm clock, we navigated it to some figure. After completing its journey, Bee-Bot hooted and awoke the figure.

We used funny badges of different colours to split children into equal groups. We worked with two groups and Bee-Bot in parallel, the other two groups worked on their own town plan. They could paint new buildings to it, colour black-and-white templates or draw some detail to existing buildings.

Children thought up different stories about the Bee-Bot, while playing. They used Bee-Bot as an alarm clock or a watchman walking through the town, taxi-driver who helped a friends to visit each other's house or a sheppard looking for lost sheep. Motivation to this activity was an intrinsic one; it arose from the story about the town. Children appreciated playing with Bee-Bot as we can see from their final remarks. Eleven children randomly chosen by class teacher (six boys, five girls) said:

- Three boys and one girl appreciated whole activity: „I enjoyed it all. "
- One girl and one boy reported playing with the bot: „I enjoyed how we played with the bee. " The boy used the term 'click' instead of play.
- One boy and two girls enjoyed painting activity and playing with the bot. Another girl used the same words, but different order: „I enjoyed most how we played with the bee and drew. "
- One boy and one girl didn't mention the bee in their answer. Instead, they stated: „I enjoyed playing with the towns", which recalls the whole activity and story-creating for programmable toy.

Organization of taking turn is a question of high importance. Sometimes teacher decides not to use programmable toys in the class because „*there's an awful 'I want a go, I want a go, I want a go! as opposed to actual just looking what it teaches us and how we are doing it*." [8]. Class teacher acts here as experienced observer knowing character of each child. She needs to provide equal chance to access a robot for all children, boys and girls, shy and self-confident ones. In two cases we saw children struggling to ask for their chance – for example a diffident girl didn't want to use Bee-Bot in the group of other children watching.

5.2 Bee-Bot and birthday party

In the last robotic session we prepared cardboard grids to create 3-D houses for children. Every house was then „settled", personalized by a child's face picture. Children should use Bee-Bot as a postman to deliver birthday invitations to their friends in the same town. The activity showed us special social relationships among children, some children refused to place their houses in the same town as a particular guy they didn't like. In such cases our team needed a support from class teacher to solve children interpersonal conflicts.

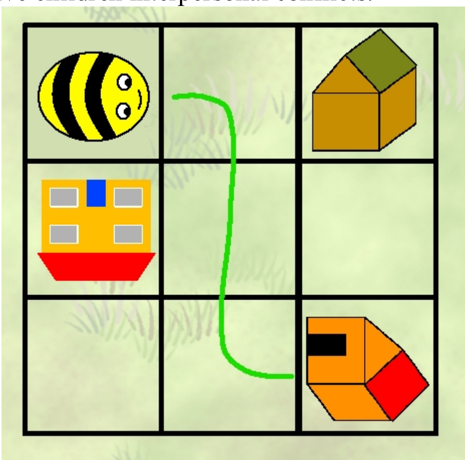

Fig. 2. Problem task set up by children

We noticed a group of boys trying to move a bot from one place to another one for a long time. They got more than five unsuccessful trials and they still didn't give up. Most of the time one boy was controlling the robot, while other boys made suggestions how to program it. The boy told the researcher he was teasing his brain. Although he and his friends had tried many times, they didn't succeed. In the end of the session a boy summed up: „I didn't like the brain – teaser", although number of trials suggests that the group found the puzzle hard and still motivating.

When we analyzed this activity, we realized we had not taken care of monitoring and assessing child's progression with the toy. We observed special cases, children which excelled in work with a toy or those who showed clear miscomprehension of it. We didn't take notice about average child-users. Therefore we plan to prepare checklists mapping progression of each child. Some children succeeded in five from eight stages suggested for planning Bee-Bot's progression [4]. The most advanced one is described as Program Bee-Bot to move several steps forwards and backwards, including turns, in one sequence before you push GO button.

We need to provide feeling of success to each child. The proposed checklists can help us to do so. They will contain stages which child should reach or the behavior we can notice when he or she is playing with the bot. The researcher should tick a mark for every ability observed in the session.

Table 2. Checklist for introductory activities

	Sofia	**Paťo**	**Dorka**	**Lukáš**
...can go forwards		X	X	X
...can go backwards		X	X	
...can go forwards and backwards in one	X			

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program sequence				
...counts number of steps needed to move the bot	X	X	X	
...can correctly say where the bot will stop				X
...can PAUSE the bot	X			
...advises to the friends	X			
...is a shy one.			X	X

6 Conclusion

Although children from the Frogs classroom haven't shown any shyness in using programmable toy as a new kind of digital technology in their classroom, the toy itself doesn't mean fun and meaningful play to them all the time. *Learning about technologies* [6], the activity *First steps with Bee-Bot*, in which we had introduced control elements of the toy to children, was interesting for children for very short time. On the contrary, children played essential role of story-writers in open-ended story about helping citizens of the colourful towns. They chose the way how the story would develop, set up own goals, challenges for a movement of a toy. Some children clearly demonstrated deep comprehension to principles of Bee-Bot's control, the others were cautious and their self-confidence didn't increase during whole series of activities with the programmable toy. However, all children enjoyed playing with the toy. *Learning with technologies* seems to be appealing to preschool children.

We evaluated several forms of work with children and Bee-Bot. The most successful model manageable by two teachers is splitting whole class into groups of no more than five members, with some groups designing, drawing, painting or building parts for Bee-Bot scenery. A group of children can challenge Bee-Bots together with one teacher. Teacher should be present in Bee-Bot group for managing taking turns, encouraging shy children and constantly providing challenges for a group. She plays important role also in monitoring and assessing children's progression.

The variability of the tasks for Bee-Bot is constrained because of its simple interface without possibility to change some parameters of its behavior. Still, it has manifested its attractiveness in open-ended activities including design elements.

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