Use of robots and tangible programming for informal computer science introduction

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**Abstract**

Children are exposed to technology, computer programs and games quite early but they only possess surface understanding about requirements for their realization. Children in 1st and 2nd grade (ages 7 – 9) are already familiar with basic computer science concepts, mainly through experience with more or less intelligent toys (robots). Taking mentioned into account introducing concepts of programming and behavior is required in early education. Results of the research based on specially made set of cards and robots used to encourage deep logical thinking and provide more immersive experience are presented in this paper.

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**1. Introduction**

Children are often exposed to technology, computer programs and games (Peach et.al, 2011) (Wartella & Jennings, 2000) quite early but they only possess surface knowledge about this matter, and they are not yet capable to fully understand the world they live in (Star, 2013). Computer games and smart toys like Furby, Aibo and similar robot toys are easily available to the large number of preschool and elementary school children (Cagiltay, Kara & Aydin, 2014). This exposure to technology in early ages has an effect on their school achievements and grades (Delen & Bulut, 2011). Therefore it is necessary to evaluate current teaching methods in elementary schools and to see whether they could be modified or expanded on order to make to most of current situation by adjusting them to

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the needs and capabilities of the modern day children. This paper presents the results of a research that was conducted with elementary school children. Research description and obtained results are presented and discussed.

2. Research description

In Croatia, school children are introduced to computer science in 5th grade (ages 11 – 12). We believe that children in 1st and 2nd grade (ages 7 – 9) are already familiar with basic concepts regarding computer science, mainly through experience with more or less intelligent toys. This claim is supported by our last year’s experiment (Zaharija, Mladenović & Boljat, 2013). In that experiment children were shown basic concepts like robot and simple movement commands, thus introducing them a concept of programming and basic programming procedures. It was noticed that all of the children were already familiar with basic concepts but they expected swift and very complex results from their written programs. Another thing that was noted, is that most of the children employed “trial and error” method for solving given problems, constantly changing their solution until they found the right one.

In order to avoid same situation happening again, we used specially made set of cards intended to encourage logical thinking and provide more immersive experience when dealing with robots. It should be noted that each group of children was only available for 30 minutes during organized workshops that took place as a part of annual School Day events. It is necessary to emphasize that the main goal of this experiment was not to present a formal approach to teaching but to motivate children and increase their interest to science.

Our workshop was organized in three main sections:

1. Physical level
   a. Introducing the robot
   b. Review through robot analysis
2. Robot behaviour
   a. Robot behaviour description and introduction to programming cards
   b. Implementing the behaviour in constructed robot
3. Demonstration
   a. Demonstrating different types of behaviour
   b. Demonstrating generalized robot behaviour with quadrocopter robot.

2.1. Physical level

First section of the workshop was dedicated to the introduction of the robot. Children were shown two Lego Mindstorms robots and some of the robots’ characteristics were described. This particular type of robot was chosen because Lego Mindstorms robots are often used for educational purposes, in elementary school (Lin et.al., 2010), high school (Church et.al., 2010) and as well in college (Cuéllar & Pegalajar, 2014). Main parts of the robot were presented to them - motors, touch sensor, ultrasound sensor, color sensor and the “brain” (i.e. central processing unit of the Lego Mindstorms robot, also called “the brick”). Children were then presented with printed cards, each of them containing the picture of one particular part described earlier. They were then handed a single piece of paper with two different boxes. One was labeled “Robot FEELS with this parts” (Figure 1a. – 1) and the other one “Robot ACTS with these parts” (Figure 1a. – 2). Their task was to put each card in appropriate box. Most interesting part of this experiment was to see how they would label the brain of the robot. Figure 1.a shows an example of this experiment, with different cards categorized in two boxes.

After finishing this step, children were then given the task to design their own robot, using familiar parts. Again, we used cards with pictures of various parts on them. Children were given a paper representing the base of the robot with 9 (nine) available slots that could be filled with one robot part of their choosing. They had at their disposal multiple cards depicting the same part so they could make many different combinations of robots. Figure 1.b depicts one example of robot design made by one of the children.
2.2. Robot behavior

After finishing the first part of the workshop regarding physical level of robots we moved into second phase associated with robot behavior. Similar to the previous phase, this one also consisted of two different sections. First the concept of robot behavior was explained to the children. Main goal was to teach them that there is a big difference between robot construction and robot programming and that it is not sufficient just to build the robot but they should also define its behavior. Few examples of robot behavior were described (follow someone, avoid obstacles, look for green color etc.). After that they were presented with another set of cards, depicting various concepts that could be used to define behavior. These concepts were mixture of sensor stimuli and available actions (near, far, move forward, move backwards etc.) as well as logical concepts (good/true and bad/false). Their task was to define a set of rules (i.e. behavior) for the robot they constructed in previous phase. This was done by logically combining available cards (for example – “near” + “move backwards” + “good”). Figure 2. shows an example of set of rules defined by one of the children for their robot.
2.3. Demonstration

Final phase of the workshop was to demonstrate their current progress using real physical robots. This was done by using two previously mentioned Lego Mindstorms robots. One robot was set to execute program containing rules corresponding to “good behavior” (i.e. robot would back off when he came too close to another object), while the other robot was running the “bad behavior” version of the program (going forward even when detecting obstacles in front of him and stopping only after he collided with something).

In order to help theme generalize the idea behind robot programming and behavior we used another type of robot, completely different from those two previously presented. Robot in question was A.R. drone quadrocopter. Children were show that this robot is differently constructed (it has no wheels but has four motors and can fly) but it still has some similar characteristics (it possesses an ultrasound sensor but one that is pointing down i.e. measuring his distance to the ground when flying). Goal of this demonstration was to show the children that this type of robot is also able to exhibit good behavior – when the robot detects that it is too close to the ground or some other obstacle it automatically ascends in order to avoid crashing into ground or said obstacle. Figure 3. shows one of the demonstrations using Mindstorms robot.

![Fig. 3. Demonstrating different types of robot behaviour to one group of children using Lego Mindstorms robots.](image-url)
3. Research methodology

For the purposes of data collection during this experiment, we used appropriate qualitative research method (Creswell, 2013) with descriptive approach, mainly through participant observation and interviews (Seidman, 2012). Participant observation was public and with moderate researcher involvement while the interviews were unstructured as that was most suited for our target group.

Subjects for the experiment were chosen between 2nd and 3rd grade of elementary school children because it was determined that they did not have any formal education regarding computer science concepts since our last year’s (2013.) encounter. Sampling was judgmental (Kumar, 2012), done by the teacher who selected the children that were generally more interested in selected topic. Subjects were divided into four different groups, each one consisting with 9 – 12 children. Figure 4. shows one group of the children during the experiment, along with the teachers observing and collecting data.

![Fig. 4. One group of children during experimental phase](image)

During the observation, we took photographs of completed solutions as well as photographs of the steps between in order to draw conclusions regarding problem solving procedures that the children used.

4. Results

During all three phases of the experiment there were some interesting observations. Some of them are presented in following sections.

4.1. Physical level

Majority of children accurately classified robot motors as parts used for acting and sensors as parts used for feeling. Problem was sorting the brain within one of those two categories. After brief discussion many children concluded that the brain is used both for feeling and acting so they positioned the card with the picture of brain in
the middle thus positioning it in both categories. Final conclusion was that the brain was controlling the whole body (robot).

There were also some interesting observations during the robot designing phase. Most of the children used typical setup similar to the real robots they were shown before (two wheels, one brain and one of each type of sensors). However, some children used different designs with more parts of the same type. Each child with different design was asked to explain their design. There were some interesting designs as well as explanations for those designs. Some children used more than two wheels (“So our robot goes faster than the other ones”) or two ultrasound (“So it can look in front and behind him”) and touch sensors (“Because I want it to have two hands”). In two different occasions children designed the robot with two brains. When asked to clarify their design, one child explained that the first brain is used for consciousness and the other one for sub-consciousness and that he learned those terms from TV. Second child’s explanation for having two brains is that second one is used as a backup, in case the main one breaks.

4.2. Robot behavior

During this phase most of the children were able to define basic robot behavior in a way that when robot detects something near him it should back away and move forward when he is detecting that objects are far away. It was interesting to see that along with the rules representing good behavior (marked with “good – ok” card) they also defined unwanted type of behavior (going forward when something is near is not good). It should be noted that not all of the children has successfully completed this task – some were able to do so only after getting the help from one of the teachers while few children were unable to finish the task regardless of the received help from the teachers.

4.3. Demonstration

This part was mostly demonstration of different robots and their behavior. There was very little or no active involvement of children in this phase so there were no particular data collected, aside from few remarks regarding robots and demonstration.

5. Conclusion

Children reacted positively to this type of workshop and were quite active and interested throughout all three phases of the experiment. It could be noted that great number of children already possess not only basic knowledge about computer science and robotics but they are also familiar with more complex concepts (taking their age in account). This coincides with our claim that children could be exposed to formal education regarding computer science earlier than it is currently the case (5th grade in elementary school). Given the results obtained from experimental study described in this paper, we believe that these kind of workshops are encouraging active involvement of children during classes. That would make them more appropriate for learning this type of matter then current teaching methods, especially when taking into consideration the age of the children.

After examining the results of second phase of experimental study (the one related to programming robot’s behavior) it was noticed that not all of the children were successful in completing their task, even with the help of the teacher. Contrary to that, results from the first phase (regarding robot parts and construction) were significantly better. That also leads to the conclusion that children are already familiar with basic concepts but some of them lack the deeper understanding of those concepts. In order to expand that knowledge it would be advisable to incorporate workshops like this in the official school curriculum, at least in the form of optional (elective) class.
References


