The 5-Step Plan: Guidelines for Teaching Children Robotics as Experience Design Partners

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ABSTRACT

This doctoral research examines how children (aged between 7 and 14) can be involved in the design and development process of service robots. Thereby the goal is twofold: (1) offering tools and materials to teach children interdisciplinary project management and research skills, and (2) proposing and validating a child-centered approach for service robot development (also considering other relevant stakeholders such as peers, teachers, and parents) in parallel. Current similar approaches as Robocup Junior focus on teaching robotics on the basis of technical problem solving in a team. The aim of this PhD thesis is to provide a more holistic approach by proposing and validating guidelines for teaching children robotics as experience design partners (or product developers). This will foster critical technology users, and at the same time improve future robotic products (as children are our future users).

Categories and Subject Descriptors

I.2.9 [**Computing Methodologies**]: Robotics – *commercial robots and application*

K.3.2 [**Computers and Education**]: Computer and Information Science Education – *computer science education, information systems education*

General Terms

Design, Human Factors

Keywords

Child-robot interaction, participatory design, teaching robotics

1. RESEARCH TOPIC & MOTIVATION

Robotics is different from other modes of learning because by integrating various disciplines it involves more subject areas than other motivating contexts. So, while learning the necessary “hard” skills to build a robot (e.g. engineering or design), children also develop “soft” skills, like working in a team or expressing their ideas [9].

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For this reason, many projects around robotics are offered to children in various ages which involve different approaches of teaching. Technology kits like Arduino or Blocks, for example, focus on skills in technical and scientific problem solving by emphasizing the detail [3]. Robocup Junior, also with a strong hands-on component, changes the perspective from focusing at single parts to factoring in the combination of many parts into a whole, but still emphasizes technical problem solving, so the robot can complete an instructed task [10]. Coming from Human-Robot Interaction (HRI), *Teutolab* teaches children programming skills for robot learning and behavior with complete robot platforms like Pleo or NAO [12]. This is also a more holistic approach but still from one perspective to look at robotics, i.e. from the perspective of the robot’s interaction with humans in an environment adapted to humans.

What if we gave children the possibility to design their own robots from the scratch as experience design partners [5, 8]? Garzotto [8] defines experience as the use of a product along the time, and argues that developing technology in an educational context creates a more holistic view (product focus) underlining a number of benefits: collaboration and discussion skills, project/goal oriented attitudes, and capability of reflection and critical thinking (as well as reflecting on technology) for children; and innovative solutions in the way technology can be exploited in an educational setting.

The motivation for this PhD thesis is to set a clear focus on robotic technology for children designed with children to achieve specific learning benefits adapted to each child’s unique personality and interests. Therefore, the approach will be twofold:

1. Teaching children hard and soft skills needed in robotics based on personality and interests, including interdisciplinary thinking and product development, while showing them different facets of robotics. This will increase public awareness for robots and foster critical technology users.
2. Involving children as experience design partners (or product developers) along with other relevant stakeholders such as teachers and parents in the design and development of service robots, in order to develop new use cases for child-robot interaction which may go beyond therapy and education. Children are our future users; they already develop different interaction skills and perspectives of looking at technology than their parents.

2. APPROACH & METHODOLOGY

In [6] Fails and colleagues describe different methods and techniques to involve children in the design of new technology for children. They also state that depending on the cognitive level of a child she may need abstract concepts to be explained in a more concrete manner. Consequently, as a first application tool we developed a 5-step plan for children ages 7 to 12 to design and develop robots as product designers. The concept was guided by two questions: "can 7- to 12-year-old children be taught robotics from the product developer perspective", and "what kind of robots do they imagine, when they are not limited by technical and economic constraints". We wanted to know if children also dream of robots that will free them from repetitive, time and effort costing tasks as we adults do, like tidying their rooms or doing their homework.

In a 1.5-hour-workshop with 25 children of ages 7 to 12 with the subject "how do I design my own robot", we explored how far this roadmap would take the children in planning their own robot and translating their ideas into a low-tech prototype.

First, the children listened five minutes to the story of Jasmin, who wanted to build a robot to tidy up her room. She had many ideas what the robot should do and how it should look like but did not know where to start. This is where the 5-Step Plan stepped in (many pictures and examples, and little text):

Step 1 – Robot Task ("assignment")
Different robots have different assignments; some vacuum clean, some mow, some help workers in an assembly line, and some help older people in their homes. What would your robot do for you?

Step 2 – Robot Control
How would you tell your robot what to do? Would you talk to it in a secret language or with signs? Would the robot understand your thoughts? Or would you use an app to control it?

Step 3 – Robot Morphology ("looks")
There are four different ways how robots look like [7]:

1. like machines
2. like cartoon characters
3. like animals (zoomorphic)
4. similar to humans with a head and body (anthropomorphic)

How would your robot look like?

Robots can be made of different materials like metal, plastics or wood. They can feel smooth, hard, furry, etc. (the children could feel different materials from a bag before taking them out). How would your robot feel like?

Step 4 – Robot Behavior
In order to make the abstract word "behavior" more concrete, we described personas with which children could identify. Would you like your robot to be rather like a butler, a teacher, a protector or a friend?

We also explained that robots could not behave as they liked and had to obey rules, and introduced the Three Laws of Robotics [1] ("the rules of the game"):

1. A robot must not hurt a human or allow a human get hurt.
2. A robot must do everything you say, except when a human gets hurt by its actions.
3. A robot must protect itself, except it obeys an order or protects a human from being hurt.

Step 5 – Robot Parts
The last step links the previous steps together. There are different parts to build a robot. Some are used in every robot; others depend on what the robot does, what it looks like or how it should behave. All robots have a brain (the microchip) and at least one of three senses (visual, audio and haptic sensors). Most robots also have wheels or legs (for locomotion), and many have arms and hands (for manipulation); motors and gears are needed to move these parts. A battery gives the robot energy in order to work, like food gives you energy to think, run and talk. Finally, the robot has a body, where all these parts need to fit together, and which is covered by a hull to make it look attractive and nice to touch.

Once through all five steps, you should go back to step one and check if the robot has all the parts to do the tasks you have given it, then step two to check the controls, then three, etc. A robot is developed in many iterations.

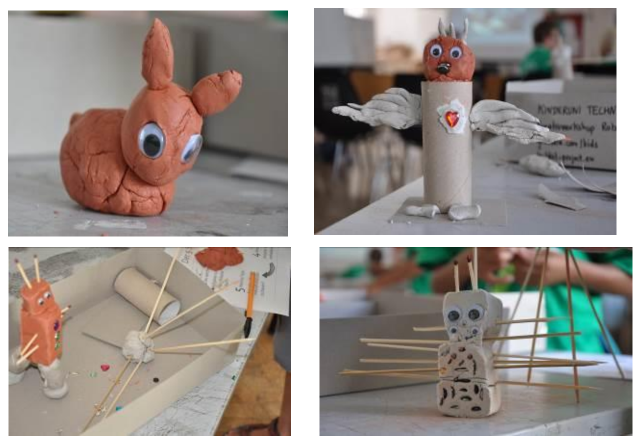

Figure 1. Low-tech prototypes from the workshop (first row, left, cuddly friend of 8-year-old girl, right, singing and flying friend of 12-year-old girl; second row, left, household robot with four arms and protector robot of a 7-year-old boy, right, a household robot for everything of a 7-year-old boy with many arms and sensors

After the presentation of the 5-step plan, the children were divided into five groups according to their ages. Each group had a tutor who worked with them briefly through the 5-step plan again and answered their questions. Then, materials (modelling clay, sticks, toilet paper roll, eyes, and decoration) were distributed. Each child had the same set of materials and 45 minutes to translate his or her ideas into a low-tech prototype. Figure 1 shows four of these.

The children enjoyed the workshop and had many interesting ideas. Many children specified household chores as their robot's task. One boy even said, he wanted a robot for his mother, so she would not have to do chores. Many robots had more than two arms to do many chores simultaneously. The influence of science fiction and media was especially present in boys who were interested in technology. Many boys also opted for robots that protected them. Their robots looked like machines, robot cartoons or anthropomorphic. Girls were more for cuddly friends to share secrets with. Their robots looked anthropomorphic or zoomorphic.

In overall, the 5-step plan looked promising to reach the research goals set for the PhD thesis.

3. RESEARCH GOALS & METHODS

This PHD Thesis aims at proposing and validating guidelines for teaching children robotics as experience design partners based on the 5-step plan.

There are two main goals:

1. Teaching children robotics: offering tools and materials to teach children interdisciplinary project management, product development and research skills
2. Children as experience design partners: proposing and validating a child-centered approach for service robot development (also considering other relevant stakeholders such as peers, teachers, and parents)

In order to reach these goals, we have been granted a science communication project “Schräge Roboter” (“crazy robots”). As known from areas of wearable computing and child-computer interaction, children between the ages of ten to thirteen are an ideal group to be engaged with technology in a playful way [2, 11]. Consequently, in this pilot project we will work with junior high school classes (children ages 11 to 13).

It is an important aim of the project to show children different aspects of robotics, and evoke curiosity in the majority of the classroom. Buechley and her colleagues’ studies with the Lilypad Arduino show that girls are especially interested in applicable aspects of technology [4]. Therefore, we believe that children, who are not interested in circuits and machines, will most likely benefit from the holistic approach of our concept.

We have planned three two-hour workshops. Two of them will take place in the classroom. One workshop will take place during the class excursion at the Vision for Robotics Lab of the Vienna University of Technology where the class will also meet experts in machine vision. Between these workshops, the children will have the possibility to repeat the material in the classroom under the guidance of their teacher with materials prepared by the project team and the teachers. The workshops will be attuned to the teachers’ pedagogical goals and concepts, as well as to the interests of the children (participatory design).

In a first plan, the concept of the project is like following:

Workshop 1 – Robot concept

In the first phase of product design and development the user needs are identified and translated into requirements which are then aligned with technical and economic feasibility requirements. In this workshop, children think about a robot which they would like to have for themselves, and thus define their own user needs. Then they translate these user needs step by step into a presentable low-tech prototype.

This workshop will be similar to the 5-step plan workshop described in Chapter 2. The goal is to teach children a general view of robotics, and how to translate their ideas into low-tech prototypes. At the same time, we hope to gain insights in use cases of child-robot interaction which are new and unique.

Workshop 2 – Robot experts

The next phase of product design and development has the focus on the development and testing of design based solutions in iterations. Interdisciplinary thinking, problem solving and team work are important skills needed in this phase. In this workshop children have a peak into the „real” world of robotics, and are offered to solve a robot specific problem from the domains mechatronics, design or HRI in a team.

This workshop will take place at the Vision for Robotics Lab of the ACIN Institute at the Vienna University of Technology, and aims to show children how experts work in a team, and how many detailed parts are meant to flow seamlessly together into a greater whole.

Workshop 3 – Robot experiment

In the last phase of product design and development, the physical product or service is finalized and launched. Final tests, evaluations and feedback loops are important in this phase. In the last workshop children are offered to evaluate a final product in a scientific set-up.

This workshop aims to teach scientific working in robotics. The children will learn to set up a research question, either in the domain mechatronics or human-robot interaction, and design a study or experiment. Then, they will conduct the study, evaluate it, and finally, present their results.

The present work for this thesis is the refinement of the concept with as much input from experts as possible. We have started a collaboration with two junior highschool teachers who work on the concept with the project team, and will participate with their class in the workshops.

There will be two other workshops in July 2014 based on the 5-step plan, one with children ages 7 to 12 for 1.5 hours, and one with girls aged 10 to 14 for 5 hours. These workshops are already planned pilot studies for the proof of concept.

In September 2014, the kick-off workshop of the project with the teachers of the participating classes will take place. The three “Schräge Roboter” workshops will take place from October 2014 to March 2015.

4. EXPECTED CONTRIBUTION

The research done for the PhD Thesis contributes to the areas of IDC, HRI, HCI, and Teaching Robotics. The expected outcome of the work – empirically validated guidelines and approaches for teaching children robotics as experience design partners (or product developers) – can be a valuable tool for all researchers who work with children on technology. Additionally, the project work will foster critical technology users (teachers and children), and improve future robotic products (as children are our future users).

5. SHORT CV

I am in my second year PhD studies, which are embedded in the nationally funded project “Schräge Roboter” (Crazy Robots). My background is in mechatronics engineering and business. Before pursuing my PhD research, I worked as technical project manager and key account manager in the transportation and oil&gas industries. Now I work in HRI and would like to combine my knowledge from my previous work with Robotics in Education and Participatory Design for Children. My future plans are the development of methods and techniques to teach children skills that help them understand and develop technology or manage complex projects.

Taking part at the Doctoral Consortium would be very beneficial for me because I would meet other researchers who also work with children to discuss different perspectives on my ideas. I also hope to contribute with a novel perspective on participatory design with children, which combines scientific thinking with project management to develop relevant interdisciplinary research questions, and to adapt methodologies from HCI and HRI for the work with children.

6. ACKNOWLEDGMENTS

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