Co-designing with kids an educational robot*

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Abstract— **In this paper we report the methodology and the main results obtained in a co-design session with kids. We involved kids as co-designer helping us in shaping form and behavior of an educational robot we are developing in our HCI lab.**

I. INTRODUCTION

Educational robotics [1], [2] is a methodology that allows children to learn thanks to robots. It teaches children and young people to build a robot from scratch and to program it. It uses a simple and practical approach to robotics, robot operation, computer programming, visual coding, and learning of technical subjects such as science and mathematics. It is a fun method that uses robots to stimulate curiosity and the use of logic in children and young people: in this way they learn to solve small problems of increasing difficulty while having fun. In our HCI lab (Turin University, Computer Science Department in collaboration with the ICxT innovation center) we are designing and realizing an educational robot. The robot is made of a very common hobby robotic kit, an Arduino Mega, an Arduino motor shield, a USB powerbank battery, an ESP8266 board for wireless communication and an Android-based smartphone. The robot has four independent motorized wheels and employs differential drive steering to move and steer. It can be controlled trough a web page, USB and HTTP Rest API, using a standard set of controls, compatible to the one used by code.org. We decided that the external body of the robot will be almost completely 3D printed, allowing great design freedom and customization. The head of the robot will be made of an Android-based smartphone able to show facial and vocal expression: an Android application will display an animation of the face of the robot, and relays voice recognized commands to the microcontroller of the robot.
However for the specific creation and design of the appearance and structure of the robot, together with its personality, we decided to follow a co-design methodology with children [3], [5], according to the paradigm of cooperative and participatory design [4] in which the subjects involved may become member of the design team and collaborate actively in the design process. The participatory design methods include brainstorming, storyboarding, pencil and paper exercises.

II. CO-DESIGN METHODOLOGY

On November 2017 we carried out a co-design session with 25 children (11 females and 14 males). They all were in the third grade of elementary school and were 7 to 8 years old. The children were divided into 4 groups, each one composed of about 6 children and a facilitator, namely a University student involved in the project.

The participants were asked to define with us the features of the robot we are developing in our HCI lab: its name, its physical appearance, its facial expression, personality and character. We specified some robot general features to guide their activities and to contain somehow their fantasy: The robot has social capabilities, is programmable by children and can also act as an assistant that helps them to learn coding; It will have a medium size, more or less as big as a little dog; It will have a toy style, i.e., it is not human-like or animal-like; It can have some lights and a screen; it can emit any sound and voice; it can talk; it will move on wheels. In order to avoid influencing the children, we decided not to show them any robots.
Taking free inspiration from the approach described in [7], we carried out the session according to the following aspects characterizing both the kids activity and co-design methodology:

- We explained children that their work is important and that they were part of the co-design team and not just target users;
- We created 4 groups, as heterogeneous as possible (we asked their teachers for an help);
- There were 4 adult facilitators (one per group, university students involved in the projects) and 2 coordinators supervising all the groups and taking notes and video;
- We made kids draw a lot of images and then each facilitator helped her/his group elicit the main characteristics of the robot in the form of keywords or short sentences, trying to reach a consensus among all and to contain the influence of the most exuberant children;
- Facilitators followed the children's work, coordinated them by moderating and took notes on how their discussion takes place.

The overall co-design activity lasted for two hours, organized in the following phases.
Phase 1 (5 min.): the coordinators introduced the project and presented the people involved.
Phase 2 (5 min.): the coordinators introduced the above methodology, explained and anticipated the upcoming phases and suggested the kids to adopt the following strategies for a successful co-design: Listen to others; There are no bad ideas; Rest assured when you ask; You must be a united team; Do not judge others; Encourage crazy ideas; You all win, because the final robot will be the mix of all your

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proposals and you will be mentioned as project team every time they talk about it.

Phase 3 (40 min.): in this ideation phase We suggested the kids to write many ideas on different post-its. With the help of the group facilitator, they look for common factors among the ideas to converge on a single one, mixing together the most shared aspects. In this step, facilitators tried to focus on the most shared or feasible ideas without forcing the robot prototype to include many different characteristics just to please everyone.

Phase 4 (40 min.). During this phase, in each group, "the big idea" was elaborated as follows:

1) Draw the robot, characterized by shape, color and overall appearance;
2) Choose three moods and try to represent them with three different expressions of the robot's face; then, draw the three expressions so as to highlight the mood of the robot. The three representations may be drawn by different components of the same group;
3) Find a name for the robot;
4) Explain with some sentence which is its personality (e.g., it is playful, maternal, servile, a hero).

Phase 5 (30 min.) During this final phase each team presented its main idea and others could comment and ask questions. Facilitators and coordinators took notes on what children do and say and fostered the discussion.

III. RESULTS

The analysis of all the materials produced during the co-design session (notes, videos of the final presentations, post-it, drawing, field observations, etc.) was inspired by the Grounded Theory, a well defined qualitative research methodology that emphasizes the generation of theory from data, in an inductive process of data analysis [6]. We analyzed and integrated and all the collected materials in order to discover possible interconnections and make them emerge during the phases of the methodology. For the aim of our study, we concentrated on the first two phases of data analysis involved in the Grounded Theory methodology: *open coding*, the analytical process through which concepts are identified starting from the analysis of the collected material, and the properties and dimensions of these concepts are discovered; *axial coding*, the process of relating categories to their subcategories, termed "axial" because coding occurs around the axis of one category, linking categories at the level of properties and dimensions.

We involved other 6 students that closely examined data and compared them for similarities and differences, and started to accumulate concepts. After that, we started with them the inductive process of the investigation and definition of main categories, subcategories and variables involved in the phenomenon under study. The main concepts/suggestions emerged from the overall process are:

- The robot should be a child professor/assistant who teaches and plays with them and sometimes can also be a bit severe. It is not just a friend but educates in a fun way;
- It has to express (positive) emotions thanks to its voice, its cartoon-like face (e.g. big eyes and smiley face, etc.) and its luminous physical parts. Hence the idea of using a slightly transparent material for the body with small leds with diffused light inside. Notice that in most of the drawings, the nose was absent while the presence of the mouth is also considered important to emphasize the emotion behind the interaction;
- Most of the children, all but one, imagined the robot as a male or kind of gender-neutral;
- Its body must be a little bit squared, and several groups have detected playful and colorful dresses/accessories inherent to the character imagined for the robot: Hence the idea of integrating the final prototype with one of those proposed by children(hat, bow, cape, etc.), and print its body dressed in a jacket and a papillon;
- It would be required the presence of different useful supports in order to make it a 'handyman': stack, water jet, radio, cameras, stove, etc.;
- The robot should have arms, which we imagined to be passive and replaceable.

IV. CONCLUSION AND FUTURE WORK

Following the results of the co-design study, we have designed the appearance and structure of the robot with OpenSCAD, and 3d printed its body (dressed in a jacket and a papillon) using a slightly transparent white material. At the same time, starting the kids' drawings, we are create facial animation with Adobe Photoshop, reflecting the leading human emotions. We are also implementing a set of lesson to be executed by the robot, following the Course 2 of code.org[1], and deploying a cloud-based structure to manage its intelligent and affective interaction.

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