Designing Robotic Teaching Assistants: Interaction Design Students' and Children's Views

Conference Paper *in* Lecture Notes in Computer Science · October 2015

DOI: 10.1007/978-3-319-25554-5_50

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Designing Robotic Teaching Assistants: Interaction Design Students' and Children's Views

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Abstract. This paper presents an exploratory study on children's contributions to the design of a robotic teaching assistant for use in the classroom. The study focuses on two main questions: 1) How do children's designs differ from interaction designers'? 2) How are children's designs influenced by their knowledge of robotics (or lack thereof)? Using a creative drawing approach we collected robot drawings and design discussions from 53 participants divided into 11 groups: 5 groups of interaction designers (24 participants), 3 groups of children with robotics knowledge (14 participants), and 3 groups of children without formal robotics knowledge (15 participants). These data revealed that (1) interaction designers envisioned a small or child-sized non-gendered animal- or cartoon-like robot, with clear facial features to express emotions and social cues while children envisioned a bigger human-machine robot (2) children without formal robotics knowledge, envisioned a robot in the form of a rather formal adult-sized human teacher with some robotic features while children with robotics knowledge envisioned a more machine-like child-sized robot. This study thus highlights the importance of including children in the design of robots for which they are the intended users. Furthermore, since children's designs may be influenced by their knowledge of robotics it is important to be aware of children's backgrounds and take those into account when including children in the design process.

1 Introduction

Involving users in the design of technologies is an important step to ensure the technologies' usefulness and acceptance. As robots in different forms are currently entering our daily lives, they are also entering children's lives as toys, programmable objects, teaching aids, or even as tutors (for example in the EMOTE project[1]). We therefore think that children's views on the design of robots for the classroom should be taken into account.

However, as Dautenhahn [1] indicates, what the word 'robot' means is not fixed and changes over time. In fact, real advances in robot technology, fictitious

[1] EMOTE project: http://www.emote-project.eu/

A. Tapus et al. (Eds.): ICSR 2015, LNAI 9388, pp. 502–511, 2015.
DOI: 10.1007/978-3-319-25554-5_50

capabilities of robots displayed in the media, and exposure to existing robots, may influence how children envision the design of a robot for use in the classroom. While it is hard to investigate the influence of exposure to robots in the media on children's expectations about a robotic teaching assistant, it may be possible to explore how actual knowledge of robotics may influence children's design contributions. Therefore, the aim of this study is to explore the design views on robots in educational settings with three groups: interaction design students, children without any formal robotics knowledge (non-robotics children) and children with some formal robotics knowledge (robotics children). By doing so, we want to explore the following research questions: 1) How do children's designs differ from interaction designers'? 2) How are children's designs influenced by their knowledge of robotics (or lack thereof)?

In the following section we present related research on the use and design of robots in education, leading us to define our study on children's contributions to the design of robotic teaching assistants.

2 Related Work

Human-Robot Interaction (HRI) researchers have addressed the deployment of robots in educational settings such as schools to help in assisting teachers in their classrooms. This is one of the main application areas in the HRI field. Mubin et al. [3], give an overview of the research development of robots in educational use within the HRI field, showing that robots in education are generally deployed as assistants to the teacher. Other researchers have presented findings of studies investigating children's design requirements for robots in different contexts. Sciutti et al. [5], for example, found that opinions on what features were considered important in a robot companion change with age: before the age of nine, children pay more attention to a human-like robot appearance; older children and adults are inclined to think more of its skills and functions. They also found that when children have been able to see and interact with a robot they pay more attention to perception and motor abilities in a robot, rather than just its shape. This suggests that actual experience with robots, such as in a robotics class, may influence children's design requirements.

Woods [7] performed two studies to investigate childrens views on the design of robots in general. In the first she investigated childrens views on robot appearance, movement, gender, and personality. Children between 9 and 11 were asked to choose a robot picture and fill out a questionnaire. The pictures displayed different robot attributes: mode of locomotion, body shape, looking like an animal, human or machine, the presence or absence of facial features, and gender. The questionnaire contained questions about the robots appearance and personality. Based on this data Woods identified two dimensions in childrens evaluations termed 'Emotional expression, ranging from happy to sad, and Behavioral intention, including friendliness, shyness and fright versus aggressiveness, bossiness and anger. Human-machine robots were considered the most friendly, shy and frightened types of robots. However, each of the robot attributes in isolation could not explain why a robot was placed in each of these categories. Woods thus argued that robot designers should *"consider a combination of physical characteristics rather than focusing specifically on certain features in isolation"* [7]. Furthermore, there was also tentative evidence for the Uncanny Valley effect, where children were increasingly positive towards robots that were more human-machine like instead of purely machine-like, but showed a sharp drop in positive attitude towards robots that were very human-like.

In the second study a similar methodological approach using pictures and a questionnaire was adopted [8]. However, in this study the children were asked to choose one or more robots to write an interesting story about how robots would behave together in a school that was populated with robots, discussing both friendships and bullying behaviour. The results of this study were congruent with those of the first study. The children usually assigned the male gender to the robot images, but that they did not associate this with either particularly positive or negative qualities. However, when the female gender was assigned, this was associated with positive characteristics such as friendliness. Once more, the children expressed some discomfort towards images of too human-like robots. Related to the stories, boys wrote more science-fiction themed stories than girls, which the researchers attributed to boys being more exposed to films and computer games that depict science-fiction themes. Girls, on the other hand, more often assigned emotions to the robots.

Shin and Kim [6], interviewed school students to investigate their attitudes towards learning about, from, and with robots. They also asked them what their image of a robot was. While the students had a positive attitude towards learning from robots because they were perceived as more intelligent and liable to make fewer mistakes than human teachers, most were not favorable to the idea of robots teaching in schools. This was mainly due to robots lack of emotion, which they considered important for teachers. They also saw the robots as being male or genderless, which the researchers attributed to their exposure to robots in the media.

In general, previous studies that address children's design contributions for robots have applied questionnaires and structured interviews. However, allowing children to present their own imaginations of a robotic teaching assistant in school, similar to what Lee et al. [2] did for adults' views on the design of domestic robots, could lead to additional insights. Our study aims to understand the differences between interaction designers' and children's views on the design of a robotic teaching assistants, as well as investigate the effects of robotics knowledge on children's views.

3 Study

In the exploratory study described below, we followed the ethical guidelines for studies in HRI [4]. The interaction designers signed an informed consent form before participation. For the children, the parents and/or caregivers signed the consent form and the children consented orally to participate in the study.

Table 1. Demographics of the children's groups

Group ID —	Nr of children —	Mean age —	Gender (F, M)
No robotics knowledge			
C1	5	11.0	2, 3
C2	5	10.2	3, 2
C3	4	10.8	2, 2
Robotics knowledge			
C4	5	11.2	3, 2
C5	5	13.4	0, 5
C6	5	10.6	1, 4

3.1 Participants and Procedures

Interaction Design Students: Twenty four international second year masters students (age 23-40, M=27.5, SD=3.69) from the interaction design program at the Chalmers University of Technology in Sweden participated. Before the design session, the students had attended one lecture on HRI in which the aim was to expose them to a whole range of social robots with different application areas: therapy, education, and entertainment. Thereafter, they were asked to design a robotic teaching assistant for children between 11 and 13 years old. There were five groups (D1-D5) of 4-5 students with mixed nationalities and gender. They were not informed about a specific task for the robot other than that it should function as a teaching assistant in the classroom. During the design process they were left by themselves to freely discuss their designs. All groups were instructed that they had 20 minutes to discuss and draw an assistant robot on an A3 sheet using a variety of colored pens. One high quality voice recorder per group captured the discussions, which were held in English.

Children: There were two main groups of children from a Portuguese school: children without formal robotics knowledge and children enrolled in a robotics course at school. Each of these was divided into smaller groups of 4-5 children (C1-C6). Table 1 shows the demographics of these groups. Children in groups C4-C6 were enrolled in a robotics course, however, the children from groups C4 and C5 had completed two years of the course, but group C6 had only completed one school semester of the course. As the table shows, the gender distribution in the groups was unequal, which was due to the robotics course being optional, and attracting slightly more boys.

The same procedure as for the interaction design students was followed. However, the children did not receive a lecture on social robotics, and the designs were made at a separate classroom of the school with only the researcher present. The researcher kept a distance to enable the children to freely express their ideas; only intervening when asked a question. All groups were instructed that they had 20 minutes to discuss and draw an assistant robot on an A3 sheet using a variety of colored pens. One high quality voice recorder captured the discussions, which were held in Portuguese.

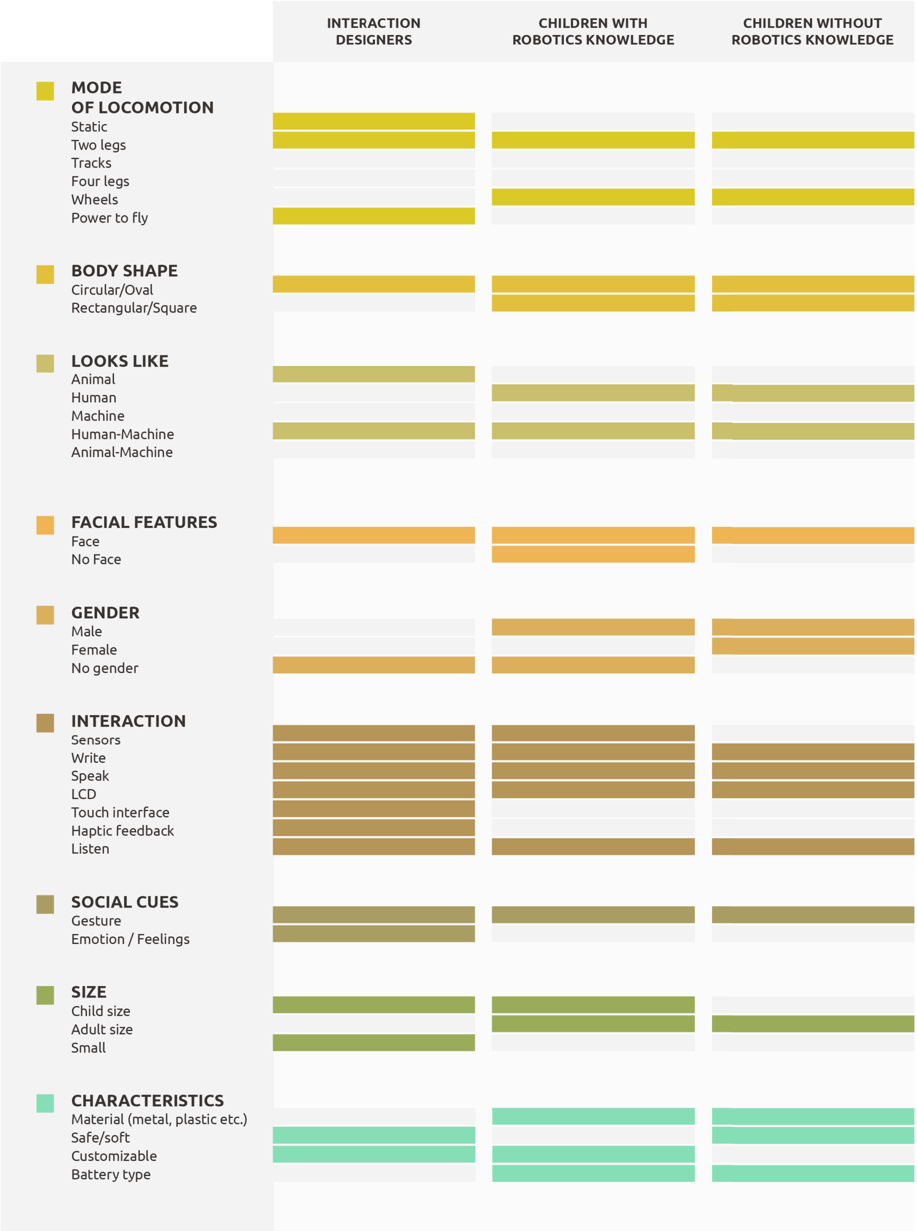

Fig. 1. A summary of the robotic attributes extracted from the design drawings of the three groups (interaction designers, children with robotics knowledge and children without robotics knowledge). The categories on mode of locomotion, body shape, looks like, facial features and gender are based on the categorization of Woods [7].

4 Analysis and Results

This section presents the analysis and results of the drawings and discussions by the different groups (interaction designers, children with and children without formal robotics knowledge). Figures 2-4 show the design drawings by the different groups. While the groups were allowed to write comments about their design in the drawing, these have been removed from the figures for clarity's sake, for example the size of the robot or materials. All recordings were transcribed, and if necessary translated to English. Unfortunately, one of the recordings of the interaction design students was corrupted and omitted. The first and second author then analysed the drawings, using Woods' [7] robot attributes as a first coding scheme, and adding new attributes when necessary. Thereafter, they extended the analysis by listening to the audio recordings and reading the transcripts to identify passages in which the participants revealed additional design features that were not present in the drawings alone, for example the size of the robot. If possible, they also tried to identify the reasons for the characteristics of the robot in the drawings. If an attribute was present in one of the drawings or transcripts of one or more groups it was marked as present. This resulted in the analysis presented in Figure 1, in which colored cells indicate the presence of a attribute. The third author independently analysed these characteristics based on the drawings and transcripts to determine reliability (Cohen's Kappa $k = 0.74$). In the subsequent sections we present some typical characteristics of the robots designed in combination with the reasoning behind it; we will present participants as follows: D1-1 = Designer from group D1, first participant, C4-2 = Child from group C4, second participant.

4.1 Interaction Designers

The five drawings of the interaction designers are presented in Figure 2.

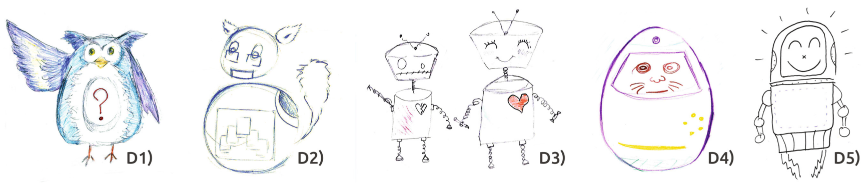

Fig. 2. Drawings of interaction designers

All drawings were rather small cartoon- or animal-like robots. There were several, slightly related reasons for this choice. First of all, the robot's appearance should not lead to a mismatch between the robot's actual and expected capabilities: *D1-1: Yeah, kind of [if it] like had some sort of normal head and arms and one of the girls just said 'thank you for this course' and he didn't respond to that because he is a robot. D1-2: Yeah, it's kind of weird. D1-1: So* *it's better to make it some sort of. D1-3: Pet?*. Second, the choice of appearance was related to the fact that the robot would be in the classroom together with the teacher. The following excerpt illustrates this: *D1-2: Because I think for me, if I have a teacher who already has authority, I don't want a teacher assistant to have authority as well. D1-4: Yeah. He need not to have so much authority but at the same time if it's super cute, I don't know, children won't learn anything. [...] D1-2: Professional but cute. [...] D1-3: What about an owl?*. Third, the interaction designers also wanted the robot to be not too intimidating, which led to the design of a relatively small sized robot (the same height or smaller than the children), as is illustrated in the following excerpt: *D3-1: I was also thinking about something, because they are students from 11-13, so usually they have a robot that is small, what about having a robot that is the same size as the students so they feel like hes a friend as well?*. Finally, the interaction designers consciously aimed for a non-gendered or neutral robot design, for example, one group discussed gender in relation to the robot's shape, *D4-1: Shall we go with the egg design? D4-2: Yeah, I like that. D4-1: I like that one because its more neutral*, while another group addressed color design in relation to the robot's gender, *D1-1:Just make it colorful! Probably make it half blue and half pink, as kids always thinking blue is for boys, pink is for girls. D1-2: Or super lime green. D1-1: Or do pink here and green here so they cannot say this is for boys or for girls. D1-2: Or just use blue as unisex.*

4.2 Children without Robotics Knowledge

The drawings by the three non-robotics groups are presented in Figure 3.

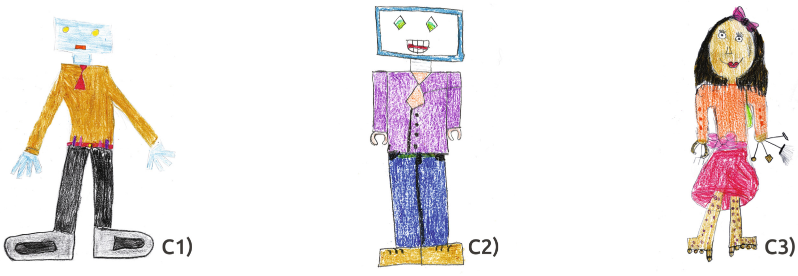

Fig. 3. Drawings of children with no formal robotics knowledge

The robot's appearance in these drawings was similar to a human teacher, with two legs and an adult size, as the following excerpt illustrates: *C2-1: I think the robot should look like a person, it is strange to be talking to a machine. C2-2: [The robot] should be like a person, and mimic a person.* Furthermore, the robot had to be representable as expressed in this excerpt: *C1-1: You could put those half torn trousers. C1-1: Dont ruin the drawing. C1-2: No, we do not want a bum teacher.* It also had a more formal look than a usual teacher: *C2-1: It should also have a tie like our school principal has.* All robots were clearly gendered, which was visible in the drawings and the discussions: *C1-1: Is it a female or a male teacher? C1-2: A male teacher. C1-3: It is a male robotic teacher, I have never seen a robota [Portuguese for female robot].* Another groups said:*C3-1: It is a girl-robot because we usually see the ladies, like moms and other ladies, as more friendly, like a good mother that cares.* While all robot designs resembled a human teacher some aspects were generally differing from a human teacher. First, while the robots did have some facial features they were sometimes rather crude and displayed on a screen. Second, the hands were usually different from actual human hands, displaying tools, LEGO-hands, or four fingers. The robots in all groups had a tool-belt (groups C1 and C2) or bag (group C3) to carry materials or tools. Finally, the body shape was more squared than in humans.

4.3 Children with Robotics Knowledge

The three drawings of the robotics children are presented in Figure 4.

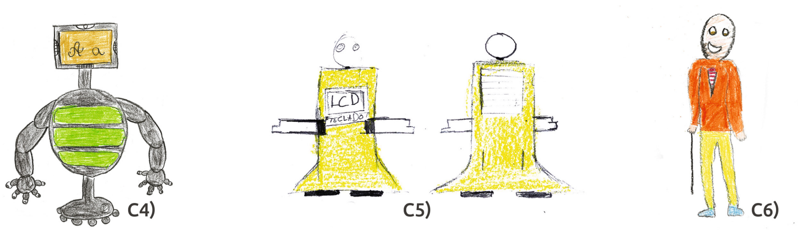

Fig. 4. Drawings of children with robotics knowledge

The robot of group C6 showed a clear resemblance to the robots drawn by the non-robotics children. This group of children was slightly younger and had started the robotics course later than the others. Therefore, our analysis mainly focuses on the designs of group C4 and C5. For these groups the appearance of the robot was more machine-like, and the children showed a clear awareness of the fact that a robot is a machine: *C4-1: But imagine you want to talk with the robot. C4-2: The robot gets up and goes to you. C4-3: And as you are. C4-1: Yes, but the person who will coordinate it is. C4-2: It will make it autonomously. C4-1: And if it loses his mind and you cannot ask it some questions? C4-2: No, but it is planned to do certain things, is not planned to have a head and do what he wants.* The robots were bigger than the interaction designers' robots but smaller than the adult sized robots in the non-robotics groups. Some aspects that were more machine-like in these drawings than in the non-robotics groups' drawings were the legs and the face. Instead of simply drawing two legs these groups applied their knowledge about the challenges behind smooth robot movement. For example, group C4 discussed: *C4-1: Legs no, [...] those robots can lose their balance or something like that*, and group C5 stated: *C5-1: Wheels, and we put up a kind of black line on the ground for it to follow.* Although the robot designs included a simple representation of a head, the faces did not show many facial features and they could also be used to display other information as shown in Figure 4(4). The children in this group reflected on having an iPad that could act as the face but also display information exhibited by the class teacher: *C4-1: a kind of iPad that showed things that the teacher wanted*.

While the non-robotics groups generally envisioned human-like interaction through speech and the use of tools placed in the robot's hands from a tool belt or bag, the robotics children explicitly included sensors, microphones, LCD screens and speakers to realise the interaction.

In comparison to the interaction designers, all children, both the robotics and non-robotics groups, mentioned the materials to construct the robot, such as metal, carbon-fiber, and aluminium. Furthermore, many groups reflected on how the robot would be powered, including solar energy and battery options.

5 Discussion and Conclusions

This study aimed to explore two questions: 1) How are children's views on the design of robotic teaching assistants different from interaction designers' views? 2) How are children's views on the design of robotic teaching assistant influenced by their knowledge of robotics (or lack thereof)? Concerning the first question, interaction designers often envisioned a robotic teaching assistant that was clearly different from a human teacher, for example a smaller animal- or cartoon-like robot. Their reasoning was that the robot should be professional but non-threatening, not having the same authority as a teacher but working in parallel with the teacher. In contrast, all children envisioned a human-machine robot instead of an animal- or cartoon-like character. Furthermore, children focused more on the materials and how the robot was powered, while the interaction designers were more concerned with the robot capacity to display emotions. Concerning the second question, the children with some formal knowledge of robotics were more inclined to design a robot with machine-like characteristics, while children without any formal robotics knowledge envisioned a rather human-like robot similar to a rather formal teacher but with some robotic details, such as a screen as head and robotic hands. These children also designed a way for the robot to carry on some tools that can be used in the classroom. While Sciutti et al. [5] found that children below the age of nine pay more attention to human-like features than older children and adults, we thus saw a similar effect related to children's formal robotics knowledge.

The robots designed by the children were rather similar to the robots that the children in Woods' [7] study thought were the most friendly, shy, or frightened robots. In contrast, the animal-like robots designed by the interaction designers would, according to Woods' study, fall in a category scoring slightly lower on these characteristics. In the study by Shin and Kim [6], many children were not favorable towards a robot as a teacher because a robot lacks emotions. It is therefore interesting to note that several drawings of the children only envisioned a limited display of emotions on a screen. We conjecture that it is possible that since children, especially those with some robotics knowledge, do not think that a robot can have real emotions, the face is less important to convey emotions.

This study has some limitations: first, the number of participants, and especially the number of groups was rather small. Second, while the interaction designers were a culturally mixed group, the children were all Portuguese. Third, while the interaction designers, as part of their education, had seen a range of social robots, the children were not introduced to different robot designs. This was done consciously, in order not to level out any differences between the groups of children, but it may have increased the difference between the children and the designers. Finally, we are aware that participants, including the children without any formal robotics knowledge, have been exposed to robotic ideas through the media. This was for example visible in the excerpt where one child mentioned that he/she had never seen a female robot. The designs of all groups thus represent a mix of design characteristics taken from the media, imagination, and in some cases, formal knowledge of robotics. Despite these limitations, our study presents distinguishing attributes for a robotic teaching assistant extracted from children's and designers' drawings that highlight the importance of including children in the design process of robots. Furthermore, children's contributions to the design may be influenced by their knowledge of robotics. Therefore, when including children in the design process, one needs to consider how factors such as knowledge of robotics may affect children's design contributions.

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