Social Robot Assistant for Group Interactions with Secondary School Students: A Participatory Design Study

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Abstract

The application of social robots in group settings is an emerging area of research with the potential to transform numerous fields, particularly education. This paper explores the potential of social robots as assistants in collaborative group interactions among secondary school students through a Participatory Design (PD) study. This was achieved by conducting a focus group (10 participants, ages 11 to 15 years) that included discussions, robot interactions, and co-design activities. The findings reveal the students' challenges in group interactions, and their perceptions of how robots could assist them. The first part of the focus group was a exploration and co-design stage to encourage participants to discuss about and interact with social robots for group collaboration. This stage highlighted some of the challenges students face during group work and how they believe a social robot could assist them. The second part of the focus group involved getting the participants to discuss and co-design robot behaviours for a specific group collaborative task. This revealed the participants emphasis on the robot behaviours being clear, specific and relevant for the task. These insights contribute to the design of effective social robots for group collaborative settings for this user group.

Keywords

Human-Robot Interaction, Social Robots, User-centered Design, Participatory Design, Education

1. Introduction

Social robots have shown to improve human-to-human interactions by assisting group settings, which is common in the real-world such as education and healthcare [1]. Previous work has shown the effectiveness of such robots in improving task participation, fostering inclusion, and positively impacting group dynamics [2]. A promising area of research is the use of a social robot to assist a group in an education setting. A key motivation to use social robot assistants in education is to address some limitations of humans, who may have intrinsic biases and be logistically infeasible. Robot assistants could be developed to address some of these issues, by being neutral, always available, and patient [3].

To develop social robots for real-world scenarios, it is essential to incorporate the needs of the target users. To address this, a valuable approach is to conduct a Participatory Design (PD) study. PD refers to encouraging participants to co-design, where they can actively join in the decision-making processes to shape the direction of the robot design [4]. This process of 'mutual learning', where there is communication between researchers and target users, has shown to enable better robot co-design. This is often conducted by engaging the participants in a two-way exchange of knowledge and ideas, for instance, a focus group.

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However, there are limited PD studies which identify the needs of children and young people in group Human Robot Interaction (HRI) scenarios. Gillet et al. (2022) conducted a PD study to investigate how young people envision a social robot 'group assistant', which revealed that young people valued the robot for ice-breaking, turn-taking, and fun-making [5].

However, to the best of the authors knowledge, no studies have yet used PD with young people in group HRI settings, specifically for collaborative interaction nor for an education setting.

The objective of our study was to explore the following research question: *'how do secondary school students envision a robot as a social assistant improving a collaborative group interaction?'*. To address this research question, a PD study was conducted at a local secondary school. The methodology of Gillet et al. (2022) [5] was used as a basis for the our study. Similarly to that study, the participatory design approach taken in our study is also from Björling et al. [6, 7].

2. Methodology

The PD study consisted of one Focus Group conducted at a secondary school in the North-West of England. The study used three humanoid social robots: Pepper, Nao, and Furhat. The focus group involved engaging the participants and asking them to discuss their views about social robot assistants in collaborative group interactions, as well as ideas for possible designs for the robot actions.

The research question of this study is: *'how do secondary school students envision a robot as a social assistant improving a collaborative group interaction?'*.

The focus group was conducted in two parts: Part One aimed to explore how participants envisioned collaborative interactions, social robot assistants, and relevant robot behaviors through discussion and real robot interactions; Part Two, involved going through an actual group collaborative task where participants were asked to discuss and co-design robot behaviours. An overview of the methodology is given in Figure 1.

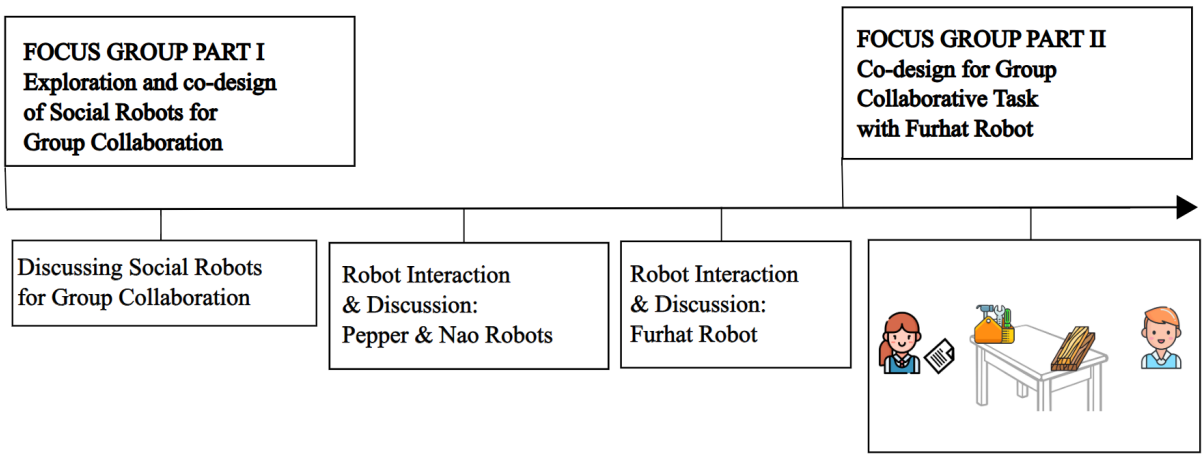

Figure 1: Overview of Focus Group activities.

2.1. Participants

The recruited participants were 10 students (6 boys, 4 girls) enrolled in a mainstream secondary school in North-West England, United Kingdom. The age range was from 11 to 15 years old.

2.2. Focus Group Part I: Social Robots for Group Collaboration

Stage One – exploration and co-design of the application of social robots for an interaction. The aim of the first stage was to collect the views of the participants regarding how they envision a social robot could improve a group collaboration. Also, specific robot behaviours, they believed would be beneficial in such an interaction.

Firstly, to encourage participants to discuss, we focused on rapport building, which involved engaging them to talk about any knowledge or previous experiences with robots. Then the participants were asked to think and discuss about the following: what a robot is, what a group collaboration is, examples of group collaborations and problems that may arise. Before interacting or seeing any of the robots, the participants were also prompted to discuss how a robot could improve a group collaboration. Afterwards, the Pepper, Nao, and Furhat humanoid robots were introduced to the participants. This interaction period enabled the participants to experience and discuss about the robots' behaviours. Finally, during the discussion, the participants were asked to 'co-design' by giving their thoughts about what robot actions or behaviours could improve a group interaction. Initially, the participants were asked the question in a more open-ended manner, and then asked to think about specific robot behaviors based on their interactions.

2.3. Focus Group Part II: Co-design for a Group Collaborative Task

This part enabled the participants to explore and discuss about the application of the Furhat social robot for a specific collaborative interaction: a group furniture assembly task as shown in Figure 2. This was primarily a co-design stage, when we asked the participants to give their thoughts about what behaviours the Furhat robot could take to improve this collaborative interaction.

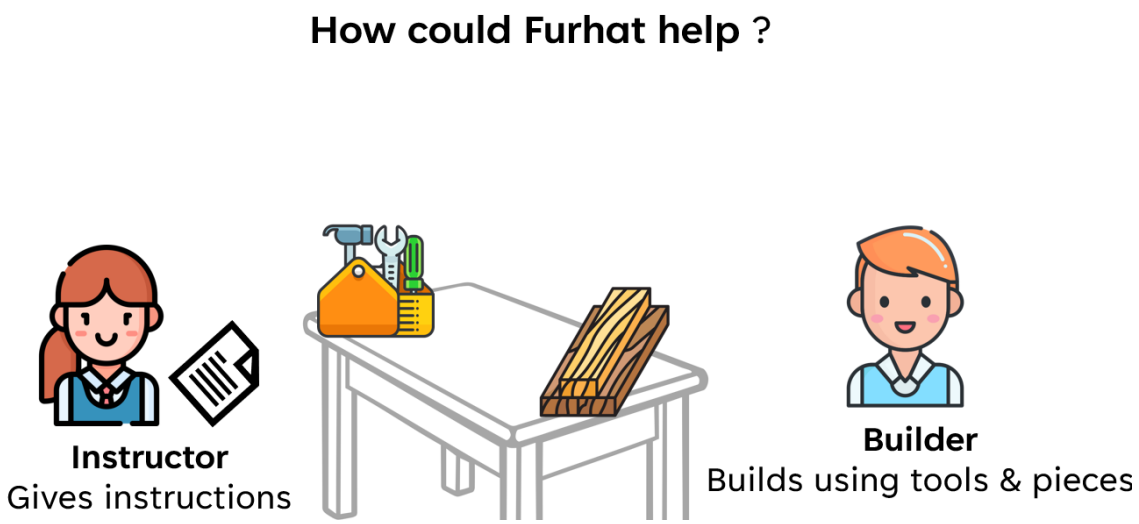

Figure 2: Illustration presented to the participants of the task.

The group task was a furniture assembly task, where two people had to work together to build something (e.g. a chair). The two people had different roles: an 'instructor' who had an instruction sheet and communicated instructions to the 'builder', who had to build the item. This task was based on previous papers on HRI and Human-Robot Collaboration studies [8, 9].

We went through the following three scenarios that may arise during the task and asked the participants to discuss how Furhat may assist:

- Scenario 1 - Human Instructor gives wrong instructions
- Scenario 2 - Both humans (Instructor & Builder) are stuck
- Scenario 3 - Both humans have no issues

The students interacted with Furhat throughout this process and gave their thoughts about various robot assistive behaviours (e.g speaking the correct instructions).

2.4. Ethical Approval

For the participant recruitment, we initially contacted secondary schools in the North-West of England via email, followed by phone calls if preferred, to request their partnership in the research study. The study's aims were explained to teachers in discussions. Participant recruitment began only after schools provided consent to participate. Teachers identified eligible students and confirmed in writing that they met the inclusion and exclusion criteria. Parental consent was then sought, with teachers facilitating contact with the parents/guardians, who provided consent for participation. Before the focus group, assent was obtained from students with parental consent using a student assent form. No coercion or pressure was applied at any stage. The necessary ethical approval was obtained from the Proportionate University Research Ethics Committee (UREC) Review.

2.5. Data Collection & Analysis

The entirety of the focus group was audio recorded, which was then transcribed by a member of the research team. Part I of the focus group underwent a qualitative analysis (thematic analysis), which is a standard practice for qualitative analysis, as well as for PD studies in HRI [5]. Thematic analysis involves extracting meaning to understand and interpret the data. The data can then be coded by themes that represent trends and patterns informed by the literature base deductively, as well shaped by ideas founds in the data that has been collected inductively [10]. Part II of the focus group was a different and smaller section of the study, which focused on a specific collaborative task with specific dynamics & robot behaviours. So it was transcribed and selectively analysed separately as shown in the section below.

3. Results & Discussion

A qualitative analysis (thematic analysis [10]) was conducted on the transcribed text data. A thematic analysis refers to a group of methods for "developing, analysing, and interpreting patterns across a qualitative dataset, involving a systematic process of data coding to develop themes" [10]. It is a qualitative analysis method used in HRI studies, such as Gillet at al. (2022) [5] and more broadly social sciences.

We adopted a hybrid inductive-deductive approach, whereby coding was guided by existent literature, but with a focus on generating themes from the data [11]. However, we felt the data was too thin and would result in a documentary style "cherry picking" analysis [12], so instead we carried out stages one and two out of the six-stages from Braun and Clarke (2006) [10]. The results below present the themes drawn from these two stages.

The overall results only provide a general insight into how the students envision social robots helping them when engaging in collaborative group settings. The students demonstrated a wide range of understanding and experiences with robots, as well as how the challenges in collaborative group settings could be addressed with various social robot behaviours. Compared to the related previous study [5], in our study the students emphasized the robot's role in improving the task performance in this collaborative setting.

The codes identified from the data are as follows. Note, that we will refer to each participant with an anonymised ID (e.g. 'S1' for Speaker 1).

Code: Previous interactions or impression of "robots"

There is a noteworthy variation in students' knowledge and perceptions of robots. Some students demonstrate more advanced and niche knowledge of the capabilities of robots, referring to videos of

the 'Tesla robots' from internet media. Others have more basic experiences, such as seeing costume robots in museums or playing with toy robots.

The vocabulary used by students also varies widely, with some describing Tesla robots as 'advanced', but then proceeding to say not as advanced as other robots 'Atlas from Boston Dynamics.' Other students have limited vocabulary and/or knowledge. To ensure enriched data, it would be valuable to probe further in future studies when students make comparisons or mention past experiences. For example:

- One student compared robots, so it would be interesting to hear how they thought these robots compared or differed? What features are unique to a type of robot and the related purpose of that robot? What features are preferred or disliked?
- One student mentions previously using robots in school, where they programmed them. What was their experience like of using a robot in school? How did students interact with robots in the school setting?

Code: Communication during tasks

The students provided some insightful examples of general communication (e.g., "talking" – S4, "give instructions" – S2) as well as non-verbal communication (e.g., "thumbs up and thumbs down" – S5, "pointing and gestures to things" – S2). However most examples provided by students were unfortunately general and surface level, and not specifically ways they themselves communicate during group work (e.g., "sign language" – S5, "morse code" – S4).

To deepen this understanding, it would be valuable to encourage students to share specific examples of their communication during school-based group work tasks. This could highlight how their communication styles help or hinder task completion, offering a clearer picture of their experiences of successful group work, or indeed experiences of struggling with group work.

Code: Challenges experienced in group work

The challenges students mentioned are broad. They identified common issues in group work (e.g., "Not everyone's voice is heard", "difficulty interacting socially"), but did not necessarily relate these to their own experiences.

To enhance this data, it could be valuable to ask students to share specific instances of group work, including both positive and negative experiences. This approach avoids presuming challenges were experienced by students and instead builds a balanced understanding of their group work dynamics, including successful strategies and genuine struggles. This would then enable us to explore areas of genuine struggles for students in group work, and genuine successes. Future work should look into standard focus group methodology when extending this study.

Code: Perceptions of how robots could support group work

Students provide general and surface level examples of how robots could support them in the classroom (e.g., 'get some information and research', 'give me ideas', 'manage a classroom'). However, these ideas are not yet contextualized within specific group tasks, and there's a lack of consensus on these thoughts.

In future studies, prompting students for more detailed examples and encouraging group discussions can enable us to gain a better understanding of how they envision robots contributing to group work and whether alternatives already available to them. For instance, teacher feedback, peer support, use of computers, might be more beneficial and/or desirable. For example: a student suggested that a robot like Furhat could help individuals with learning disabilities communicate ("Some people that have learning disabilities, and Furhat could help them communicate") follow up with questions to understand the specific ways the robot could facilitate this.

Results of Focus Group Part II : Co-design for a Group Collaborative Task

The group collaborative task was a furniture assembly task, where two people had to work together to

build something (e.g. a chair). The two people had different roles: an 'instructor' who had an instruction sheet and communicated instructions to the 'builder', who had to build the item. Relevant parts of the discussion are selectively quoted and discussed below.

We went through three scenarios that may arise during the task, allowed the participants to interact with Furhat, gave several options for the robot's behaviours in each scenario, and asked the participants to discuss:

- *Scenario 1 - Human Instructor gives wrong instructions:*

Figure 3: Illustration of Scenario One presented to the participants with the possible robot behaviours to co-design.

The scenario illustrated in Figure 3 was presented to the participants. The most preferred action for Furhat was providing the correct instruction. Furhat simply stating "that's wrong" or asking "are you sure?" was considered less helpful, potentially confusing, or discouraging. Also, the students noticed the value of Furhat have an 'oracle-like' knowledge of the task, such as knowing all the instructions.

- *Scenario 2 - Both humans (Instructor & Builder) are stuck:* The scenario illustrated in Figure 4

Figure 4: Illustration of Scenario Two presented to the participants with the possible robot behaviours to co-design.

was presented to the participants. Participants were divided on whether Furhat should intervene automatically or wait until asked for help. The students emphasised that Furhat waiting until asked for help would encourage learning. Though some participants prioritised task completion, so they preferred Furhat automatically assisting. When intervening, students preferred Furhat to give a verbal step-by-step instructions. Non-verbal behaviours and simple encouragement (e.g "Keep going") was deemed unhelpful when truly stuck. Furhat giving hints were seen as potentially useful for learning but could also be confusing if not specific enough.

- *Scenario 3 - Both humans have no issues:* The majority of participants preferred Furhat to do nothing when the task was progressing well, since any intervention was considered disruptive. Some suggested a quieter intervention if a potential error was detected but preferred it to be non-intrusive. Encouragement and praise from Furhat was seen as potentially distracting.

Furhat robot's contribution to the task
The participants generally highlighted that Furhat could contribute by:

- *Correcting Errors*: Providing feedback when the wrong piece or tool is selected.
- *Clarifying Instructions*: Using both verbal and non-verbal instructions to clarify instructions
- *Ensuring Engagement & Participation*: To check the team for engagement, fatigue, and participation during the task.
- *Learning tool & Practical tool*: For learning scenarios, participants suggested Furhat should take a more supportive role. Whereas, in a practical scenario (e.g. with a "deadline"), they suggested Furhat should be more directly helpful to ensure task completion. This influenced the participants' preferences for Furhat's level of intervention. It will be essential to incorporate and extend current pedagogical studies to address this for robots to be used in education.

Furhat robot's perception & behaviours
The students suggested the importance of Furhat having oracle-like knowledge and awareness of the task, to ensure the assistance is valuable Additionally, some participants suggested the value of Furhat being able to perceive the emotional state of the partner to "avoid stress" and "keep them engaged." Though some students debated about the role of this level of robot perception, feeling it was less relevant to the actual task.

Regarding the behaviours of Furhat, most participants preferred if Furhat directly communicated the correct step to guide the team. Some participants noted that the Furhat asking "Are you sure?", might be confusing during task completion though could encourage learning in an educational setting. Additionally, the participants noted the non-verbal behaviours of Furhat (e.g. facial expressions, gaze) and speech (e.g. tone, volume) could lead to prevent miscommunication during the task if poorly designed. However, the students did emphasize the importance of clear verbal instructions, along with appropriate non-verbal behaviours (e.g. pointing, gestures to show the pieces/tools).

Challenges of interacting with Furhat
The key challenges the participants identified in integrating Furhat for this group collaboration was the *competence* of Furhat; ensure Furhat's assistance is always accurate and relevant to the task's context. Secondly, the participants highlighted that Furhat's *communication had to be clear and noticeable*, especially since the users might be focused on the task or be under pressure. The students stressed the need for specific language ("Piece A and Piece B") rather than vague terms ("just screw the piece"). Finally, some students highlighted the potential of simply using existing voice assistant technology, characterising Furhat as basically "Alexa with a face." Though some students valued the physical embodiment and interaction of Furhat more.

4. Conclusion & Future Work

This participatory design study aimed to answer the research question 'how do secondary school students envision a robot as a social assistant improving a collaborative group interaction?' Given that PD is under explored with young people in group HRI settings for collaborative and education, this study hopes to provide a preliminary insight. This study involved conducting a focus group involving discussions, interactive sessions, and co-design stages with participants. The first part of the focus group was a exploration and co-design stage to encourage participants to discuss about and interact with social robots for group collaboration. This stage highlighted some of the challenges students face during group work and how they believe a social robot could assist them. The second part of the focus group involved getting the participants to discuss and co-design robot behaviours for a specific group collaborative task. This revealed the participants emphasis on the robot behaviours being clear, specific

and relevant for the task. These results should be considered when designing social robots for similar interactions with students.

The focus group provided general views into how students envision a social robot supporting collaborative tasks. Though this study does not reveal a critical insight, it could be a valuable preliminary study for researchers, to realise some of the challenges of this type of study and user group. A key limitation of this study is that it involved only a single focus group with a small number of participants. Future work should include more diverse groups of students and further interactions to explore this area of research. It would also be beneficial to consider interviewing classroom teachers and senior leadership team to explore the feasibility and utility of involving social robots, the current challenges students face during group work, and how teachers could also be involved in the co-design process.

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