Using Social Robots to Create Inclusive Classroom Experiences for Children with Mixed Visual Abilities

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Fig. 1. Inclusion in classrooms

Visually impaired children are increasingly educated in mainstream schools rather than special schools. However, even though being included with their sighted peers, previous research reveals concerns with classroom participation, lack of collaborative learning, reduced social engagement, and potential for isolation. My dissertation explores designing and building interactive social robots to promote inclusive classroom experiences and social engagement between children with mixed visual abilities. Social robots have the potential to foster engagement, participation, and collaboration due to their unique multi-sensory capabilities, actuators, and agency. Situated in a local mainstream school, I conducted extensive field work that involved engaging with the school community, including children, teachers, therapists, and parents through ethnographic observations, contextual inquiry, group interviews, and design activities. The identified challenges and opportunities will guide the design of social robots capable of supporting inclusive classroom experiences and sustaining long-term social engagement between mixed visual abilities' pupils. I will explore opportunities for off-the-shelf and custom-built robots to address existing challenges by following a user-centred methodology to design prototype, and evaluate solution with the school community.

CCS Concepts: • **Human-centered computing → Accessibility design and evaluation methods**; *Participatory design*; *Empirical studies in HCI*; • **Applied computing → Collaborative learning**; • **Computing methodologies → Cognitive robotics**.

Additional Key Words and Phrases: Inclusion; Accessibility, Human-Robot Interaction; Social Robots; Group Interaction

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1 INTRODUCTION

All children regardless of gender, age, disability or socio-economic status have the right to a quality and equitable education [12]. Prior research shows that pupils with disabilities, namely visually impaired children, are increasingly educated in mainstream schools [9, 11], demanding new types of support, learning experiences, and social activities.

Schools need to ensure that children fully participate in all activities, while feeling comfortable and secure [8, 18]. However, previous studies suggests that visually impaired pupils have a risk of exclusion from classroom dynamics due to the individual learning approach to their needs [19]. Moreover, current assistive technologies (e.g., braille typewriters, screen readers and enlargers) are specifically designed to be used by children with visually impairments alone, which can lead to learning in isolation and reduce opportunities for classroom participation, peer interaction, and engagement. Current technologies prioritize accessibility over inclusion, focusing on children's disabilities rather than on wide range of abilities present in mainstream classrooms [17, 20].

My research explores a complimentary approach that aims to augment classrooms with technologies that account for the mixture of visual abilities within group and individual learning activities. Particularly, I propose using social robots due to their inherently engaging nature, physical attributes, multi-sensory capabilities, and intelligent behaviours. Social robots have the potential to play a role in building social engagement and improving classroom participation, learning, and inclusion. The CREANOVA project [10] showed that inclusion and innovation could be driven from creative and collaborative activities that value the differences, openness to fail, co-creation, and joint knowledge production.

Recently, Human-Robot Interaction (HRI) studies showed that social robots have the ability to influence group dynamics [7, 15], and foster inclusion and engagement [23]. In schools, educational robots can play different roles such as social agents in learning activities [1, 3, 5, 6, 13, 16] , facilitators in assisted therapy [22, 24], or tools for learning [2, 14, 21]. Nevertheless, previous research on children-robot interaction are largely limited to single user activities, focusing on individual needs rather than group dynamics. Moreover, these studies focus on short-term evaluations, typically during one test session, preventing an accurate evaluation of robot influence in children behaviours.

In the Human-Computer Interaction (HCI) and accessible computing research fields, researchers have started to explore how to design for groups of children with mixed-visual abilities [17, 20] and investigate the potential of robots to drive inclusive play experiences [18] and learning activities [21]. However, to the best of our knowledge, the potential for inclusion of using social robots in mixed visual abilities classrooms deployments remain unexplored.

2 DISSERTATION RESEARCH

This research will explore the use of cost-effective robots to tackle inclusive long-term experiences in classrooms, enriching the robot with multiple-sensory interactions to allow access, manipulation and engagement within a group with sighted and visually impaired children. Our motivation is to extend educational robots to promote inclusion. This novel approach will help children have access to group activities, be more inclusive in their peers' relations, and overcome their challenges and differences. Our proposed research program aims to push forward the current state of the art in inclusive classrooms. It will explore different ways to promote inclusion between children with mixed visual abilities using social robots.

This work is at the crossroads of multiple research fields: accessible computing, human-robot interaction, and human-computer interaction. Therefore, the research goals and technical duties focus on the following : 1) Identify the needs of each stakeholder (children, teachers, therapists and parents) through **community engagement** activities in a mainstream school environment; 2) Design social robots for mixed visual abilities classrooms using **participatory**

design practices to explore appropriate robot characteristics, behaviours, interactions, and roles; 3) Create interactive modalities that are socially acceptable for the specific contexts, including verbal and non-verbal behaviours of the robot, allowing multiple types of interactions to adapt to each child needs; 4) **Build robot** experiences, using a **user-centred design** approach, based on cost-effective solutions (using off-the-shelf robots or DIY prototypes); 5) **Long-term evaluation** of the robot's influence on children inclusion at school;

To better understand inclusion challenges and opportunities, I conducted a six-month-long community engagement effort in a local school (from September 2019 to February 2020) using a multi-methods approach including ethnographic observations, contextual inquiry, group interviews, and design activities. By the end of February 2020, I recorded more than 40 hours of interviews and observation of classroom and therapy activities . In total, I engaged with 10 school teachers, therapists, and psychologists (two of them were visually impaired), and six parents. I observed multiple classes with children from different ages and school levels (N=91, Mean Age =10.6, SD=2.70). In this community, we had four children that experienced autism spectrum disorders and seven visually impaired children (blind N=2, low vision N=5).

From the qualitative data collected during the field work, I conducted a thematic analysis [4] to examine the stakeholders' needs, experienced challenges, and expectations. Interestingly, inclusion and social engagement were common themes that come up from children's', parents' and teachers' views, emphasizing the importance of social activities accessible to all pupils. Based on previous results, I developed five scenarios that explored the use of social robots in classroom activities: dance, friends, student helper, teacher assistant and storyteller.

In March 2020, I performed participatory design sessions with 54 children. These activities were embedded in school curricula and technology education classes, where the goal was to design robots for inclusion in school settings. Children were grouped based on their school level: one group from primary school (N=18, Mean Age =8.55, SD=1.29, Low vision N = 3); other group from the 5th grade (N=19, Mean Age = 10.78, SD=0.41, Low vision N= 1); and one group from the 8th grade (N=17, Mean Age = 13.23, SD=0.43, Blind N = 1). In each classroom, children organized in teams of three to four children, and shuffle scenarios between them. Due to COVID pandemic, the primary school group only had one session, while the other two had remotely three other PD sessions.

I am currently conducting a thematic analysis based on the transcripts and observations of the community engagement and participatory design sessions. Based on this fieldwork, I will continue to follow a user-centred approach by involving the school's stakeholders in all stages of the design process. In this iterative process, I intend to prototype and regularly test robot designs with children and other school stakeholders, exploring different robot roles and behaviors, multiple scenarios, and multi-sensory interfaces. Using the lessons learned from field studies and the refined prototypes, I aim to run an empirical study, during a six-month-long period to measure the impact of the robot on the social engagement and bonding of children with mixed visual abilities.

3 PRELIMINARY FINDINGS

The initial findings from observations and interviews highlighted that the fears, aims, and perspectives for inclusion are different between stakeholders. However, there is a common concern in creating healthy environments that value the differences and promote peer-engagement.

In the participatory design sessions, children worked in teams (each of them with one of the five scenarios) to build an inclusive robot that promoted group activities to all children. These sessions took place within classroom activities with the teachers' support. We followed a design thinking process approach with several phases : (1) Problem statement: they had to discuss how to use robots in group activities; (2) Problem specification: discuss challenges and opportunities in using a robot; (3) Research phase: we showcased several robots (illustrated in Figure 1), for children to explore and

Fig. 2. Five robots made by children, one per each scenario : Student Helper, Dance, Teacher Assistant, Friend, Story Teller

be inspired to the next phases; (4) Ideation: explore group ideas; (5) Team presentation to the class, which allowed classmates to critique initial designs and further refine ideas (6) Detailed robot design: each team had to prototype their robot using recycled materials and define several features; (7) Enacting: children role-played with their robot in a situated classroom context simulating how the robot and other users would behave within a group activity. These activities took place throughout 4 weeks and 4 sessions with 54 children (5 visually impaired).

These activities resulted in 30 robots designs. For each of robots, children had to define its features: (1) Physical components, (2) Appearance, (3) Communication channels, (4) Exclusion factor being addressed, (5) Role, (6) Accessibility features, (7) Senses, (8) Context, (9) Locomotion features and (10) Personality. Figure 2 illustrates examples of the robots; one common characteristic was the use of sound as a main communication modality, added by visual information (writing, colours and lights). The use of accessibility features were frequent in all scenarios, and different exclusion reasons appear: shyness, knowledge, loneliness and disability. The roles and traits of each robot were aligned with the scenario, (1) helping and calm (2) dance in groups, outgoing (3) repeat information, print in braille and engaged (4) Cheer-up, collect objects and playful and (5) read and write the story in groups and intelligent.

4 CONTRIBUTIONS

This research explores the use of social robots as agents in fostering inclusion and social engagement between children with mixed visual abilities. The long-term evaluation of different scenarios, robot roles, personality and interactive modalities will enrich classroom dynamics and advance knowledge in designing robots for inclusive experiences. On a broader level, I expect my dissertation research to contribute to finding novel approaches to integrating visually impaired children in society, exploring group dynamics within HRI, improving accessibility, and valuing individual abilities to create inclusive experiences. These contributions can inform research in HRI with adults or children with other inclusion challenges (e.g., gender, race, religion, bullying). I am in the second year of my PhD and looking forward to receive feedback from other accessible computing researchers about the fieldwork conducted in the past months to refine initial robot designs and group activities for children with mixed visual abilities as well as suggestions for the evaluation process.

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