Fostering Inclusive Activities in Mixed-visual Abilities Classrooms using Social Robots

ISABEL NETO, University of Lisbon, INESC-ID
HUGO NICOLAU, University of Lisbon, ITI/LARSyS
ANA PAIVA, University of Lisbon, INESC-ID

Visually impaired children are increasingly educated in mainstream schools following an inclusive educational approach. However, even though visually impaired (VI) and sighted peers are side by side in the classroom, previous research showed a lack of participation of VI children in classroom dynamics and group activities. That leads to a reduced engagement between VI children and their sighted peers and a missed opportunity to value and explore class members' differences. Robots due to their physicality, and ability to perceive the world, socially-behave and act in a wide range of interactive modalities, can leverage mixed-visual ability children access to group activities while fostering their mutual understanding and social engagement. With this work, we aim to use social robots, as facilitators, to booster inclusive activities in mixed-visual abilities classroom.

CCS Concepts: • **Human-centered computing → Accessibility**; • **Social and professional topics → People with disabilities**; • **Computing methodologies → Cognitive robotics**.

Additional Key Words and Phrases: Inclusion, Social robots, Visual impairment, Accessibility, Education, Children

ACM Reference Format:
Isabel Neto, Hugo Nicolau, and Ana Paiva. 2021. Fostering Inclusive Activities in Mixed-visual Abilities Classrooms using Social Robots. In *Companion of the 2021 ACM/IEEE International Conference on Human-Robot Interaction (HRI '21 Companion), March 8–11, 2021, Boulder, CO, USA.* ACM, New York, NY, USA, 5 pages. https://doi.org/10.1145/3434074.3446356

1 INTRODUCTION

Inclusive education is increasingly in mainstream schools [9], and demanding new types of support, learning experiences, and social activities [11]. There are benefits of inclusive learning, for both visually impaired and sighted children, such as higher achievement and gained skills [6, 11]. However, there are still challenges to overcome inside mixed-visual abilities classroom. Assistive technologies are for individual use (e.g., braille machines and enlargers) and teachers often prioritize accessibility, and learning achievements over inclusion and classroom participation [20]. Leading VI children to learn in isolation, in parallel with a classroom pace, and reducing their opportunities for group participation and peer interaction [18, 21]. Although this individual educational option intends to create a sameness (equality) and fair (equity) learning process, it creates silos and an inequality experience as VI children are excluded from group activities [10]. Technology, such as robots, can help create a more inclusive environment, by enriching VI children's perception of the activities, goals and surroundings allowing the access, participation and self-expression in-class activities.

2 BACKGROUND

Social robots have been used to interact with children, in single-user or pair tasks, [2, 31] in education [3, 14], such as learning [16, 23, 24, 28], foster creativity [1] or therapy [25]. The way they act in the physical world, talk [17], gesticulate [32], and manage proximity [30], influence robots' acceptance and perception by children. Research also showed that robots acting as an active member in a human-robot group, can influence group dynamics [4, 7, 15], and foster inclusion [27]. Tennent et al. [29], explored a different perspective, where robot was not a group-member. They used a peripheral robot, to increase social engagement and problem-solving performance in an adult group, by suggesting the next speaker and back-channelling the conversation. Nevertheless, these group dynamics research were limited to adults-robots interactions, and not adapted to children's activities, needs and behaviours. Only Gillet et al. [13], explored robots to promote inclusion in sighted groups between native and non-native children in a school. Researchers are also starting to identify barriers for inclusive activities in mixed-visual abilities groups and explore robots potential [18, 19, 21]. However, to the best of our knowledge, the use o social of robots to tackle participation in mixed-visual abilities classrooms group activities remains unexplored.

Robots hold promise to be used in an inclusive classroom context, namely as facilitators to boost inclusive-driven behaviours between peers by enabling access and participation in mixed-visual abilities group activities. Robots can provide a holistic interface with a wide range of interactive modalities, that can move around, be manipulated, behave and be perceived by all. However, to have broader use in schools, some additional challenges need also to be surpassed. Most social robots are cost-prohibitive and designed for general application settings by sighted adults, and they often overload users with information [8], making them complex to use. To tackle those challenges, we aim to explore simple, cost-effective robots (using off-the-shelf robots or DIY prototypes) following the universal design principles [26]. And study if affordable robots can positively affect children's, participation and ideas sharing in inclusive activities in classrooms and evaluate the impact of these experiences on their social engagement in a long-term.

3 RESEARCH PLAN

Our proposed research plan aims to extend the state of the art in inclusive classrooms. To meet the proposed goal a five-stage methodology was designed as follows (the first three were already done) : 1) a **user study** to investigate if activities with robots promoted participation; 2) a **School community engagement** phase to identify the challenges of inclusive activities; 3) **Co-designing robots** with children through a *participatory design process* to explore how robot can promote group work; 4) **Build robot experiences** exploring different interactive modalities; 5) **Long-term evaluation** of the robot's influence on children at school.

Initial user study. We conducted a user study in a school, [22] children (N=20, Mean age=6.6, SD=1.1, sighted=17, low vision=3), engaged in a collaborative activity, a pair quiz using a tabletop robot,[23] to draw and guess cursive letters and shapes. This initial study, had three main goals : analyse *children-robot interactions and responses*; look over to *children behaviours*, in an inclusive collaborative task; and evaluate the *group dynamics* after the study. From this initial study, we concluded that haptic feedback was more efficient, to perceive forms, than visual (even for sighted children). A blend of the four types of feedback (visual, haptic, audio-clues and back feedback) performed better (52% for sighted and 85% for VI) than using only one type of feedback. This finding suggests that using multiple modalities is a better design option. During the activity, they were very engaged, collaborative, and inclusive; however, that single experience did not impact children's social dynamics.

School community engagement. In the second phase, we conducted a school community engagement, including ethnographic observations, contextual inquiry and group interviews, to empathise and understand the inclusive activities' challenges. We engaged with ten school teachers, therapists, and psychologists (blind=2), six parents and children (N=90, Mean Age =10.6, SD=2.70, blind=2, low vision=5). From this phase, three barriers were highlighted: *VI Child participation* in class is more demanding as they do not perceive when to interact and are often disconnected from the group dynamic and working in isolation. *VI do not explore visually demanding tasks.* And *Access to visual information* such as materials, peers recognition, or perceived classroom environment.

Co-designing robots in a participatory design in-class activity. Children (N=54, Mean Age=10.8, SD=3.2, Low vision=4, Blind=1) had to work in groups, *building robots that promoted group activities and access to all.* Each class had at least one VI child, all materials were accessible, and all children had an active voice in the activity. Each group had to discuss potential reasons for child exclusion and how robots could overcome that, and discuss their ideas with the class. These co-design sessions resulted in 30 robots designs and role-plays. Through a thematic analyse approach [5], we found out that children did not include teachers' personas in the role-plays; robots played as facilitators (N=30), friends (N=21), teachers (N=18) or tools (N=10); the sound was the preferred communication channel in child-robot interactions (enriched by visual information such as lights, as some of the children with low vision perceived them); assistive technologies were in all designs; and different exclusion reasons appeared: shyness, knowledge, loneliness, and impairment; robots had different shapes, and all of them were at most 1m height. From this phase we narrow our research in four design principles: (1) explore *group activities* in classrooms without teacher intervention; (2) robot *do not have an active role* in the children relations, and will act as facilitators in autonomous work, by promoting equal participation of groups members; (3) use the *same robotic-device*, with multi-modal feedback for all children; and (4) the robot could *not be a distracting* factor from group activity.

Build robot experiences. We will follow a user-centred approach by involving children and other school stakeholders in the design process. We intend to prototype and test affordable robot in the context of autonomous work in classroom group activities. We will follow the approach proposed by [29] using a social robot as a peripheral object, adapted to mixed-visual abilities children. Children will focus on their group work instead of directing their attention to the robot dialogue or presence. Our robot's role will be to identify the current speaker and suggest the next speaker. From this phase, this work aims at delivering the **robot behaviours** to foster equal and fair participation of all children. We will use: *back-channelling* to promote ideas sharing. *robot movement, proximity and sound* to identify the speaker. *suggest a new speaker* each time the speaking child is uncomfortable or is talking too much. And children will *personalised their interactive robot's styles* by choosing lights and sound to identify themselves as speakers.

Long-term evaluation. With the refined prototypes, we intend to run a study, during a three-month-long period to measure and evaluate : (1) the impact of our robot on children participation and self-expression, measuring *number of times and duration* of interventions and *ideas shared.* (2) social dynamics of the class members, based on their *the strength of the relations, and inclusion-exclusion continuum classification* [12]. (3) *Robot utility and children responses* if they are not obliged to use the robot. (4) Explore the impact of *equality vs equity dilemma* by evaluating children engagement in a robot experience, providing the same access (equality) or a fair opportunity (equity, using robot back-channelling with a VI child). And (5) evaluate the impact of children personalisation of the robot.

4 CONTRIBUTION AND IMPACT

Our research envisions social robots as an inclusive technology that goes beyond responding to individual learning needs, to become a tool that can boost children's participation and self-expression in small group class activities. On a broader level, this research will contribute to the robot's integration in society, exploring group dynamics, personalisation, improving accessibility, and valuing the differences, creating more inclusive experiences. These contributions can enrich other researches in HRI with adults, or children with other challenges (e.g. gender, race, religion, bullying).

ACKNOWLEDGMENTS

We thank the staff and children of Centro Helen Keller. National funds have supported this work through FCT, Fundação para a Ciência e a Tecnologia, UIDB/50021/2020 and UIDB/50009/2020.

REFERENCES

[1] Patricia Alves-Oliveira. 2020. *Boosting Children's Creativity through Creative Interactions with Social Robots.* Ph.D. Dissertation. University Institute of Lisbon, School of Social Sciences and Humanities, Lisbon, Portugal. https://repositorio.iscte-iul.pt/handle/10071/20620

[2] Tony Belpaeme, Paul Baxter, Joachim De Greeff, James Kennedy, Robin Read, Rosemarijn Looije, Mark Neerincx, Ilaria Baroni, and Mattia Coti Zelati. 2013. Child-robot interaction: Perspectives and challenges. In *International Conference on Social Robotics*. Springer, 452–459.

[3] Tony Belpaeme, James Kennedy, Aditi Ramachandran, Brian Scassellati, and Fumihide Tanaka. 2018. Social robots for education: A review. *Science robotics* 3, 21 (2018).

[4] Cindy L Bethel, Merijn Bruijnes, Malte Jung, Christoforos Mavrogiannis, Simon Parsons, Catherine Pelachaud, Rui Prada, Laurel Riek, Sarah Strohkorb Sebo, Julie Shah, et al. 2020. 4.4 Working Group on Social Cognition for Robots and Virtual Agents. *Dagstuhl Reports, Vol. 9, Issue 10 ISSN 2192-5283* (2020), 21.

[5] Virginia Braun and Victoria Clarke. 2006. Using thematic analysis in psychology. *Qualitative research in psychology* 3, 2 (2006), 77–101.

[6] Xuan Bui, Carol Quirk, Selene Almazan, and Michele Valenti. 2010. Inclusive education research and practice. *Maryland Coalition for Inclusive Education* (2010), 1–14.

[7] Filipa Correia, Samuel Mascarenhas, Rui Prada, Francisco S Melo, and Ana Paiva. 2018. Group-based emotions in teams of humans and robots. In *Proceedings of the 2018 ACM/IEEE international conference on human-robot interaction*. 261–269.

[8] Luigi F Cuturi, Elena Aggius-Vella, Claudio Campus, Alberto Parmiggiani, and Monica Gori. 2016. From science to technology: Orientation and mobility in blind children and adults. *Neuroscience & Biobehavioral Reviews* 71 (2016), 240–251.

[9] Gareth Davies. 2019. Support for pupils with special educational needs and disabilities in England: report by the Comptroller and Auditor General. (2019).

[10] Oscar Espinoza. 2007. Solving the equity–equality conceptual dilemma: a new model for analysis of the educational process. *Educational Research* 49, 4 (2007), 343–363.

[11] Lani Florian. 2008. Inclusion: special or inclusive education: future trends. *British Journal of Special Education* 35, 4 (2008), 202–208.

[12] Donelson R Forsyth. 2018. *Group dynamics*. Cengage Learning.

[13] Sarah Gillet, Wouter van den Bos, and Iolanda Leite. 2020. A social robot mediator to foster collaboration and inclusion among children. (2020).

[14] Wafa Johal. 2020. Research Trends in Social Robots for Learning. *Current Robotics Reports* (2020), 1–9.

[15] Malte F Jung, Selma Šabanović, Friederike Eyssel, and Marlena Fraune. 2017. Robots in groups and teams. In *Companion of the 2017 ACM conference on computer supported cooperative work and social computing*. 401–407.

[16] Takayuki Kanda, Takayuki Hirano, Daniel Eaton, and Hiroshi Ishiguro. 2004. Interactive robots as social partners and peer tutors for children: A field trial. *Human–Computer Interaction* 19, 1-2 (2004), 61–84.

[17] T. Kanda, M. Shimada, and S. Koizumi. 2012. Children learning with a social robot. In *2012 7th ACM/IEEE International Conference on Human-Robot Interaction (HRI)*. 351–358. https://doi.org/10.1145/2157689.2157809

[18] Oussama Metatla. 2017. Uncovering challenges and opportunities of including children with visual impairments in mainstream schools. *Electronic Visualisation and the Arts (EVA 2017)* (2017), 1–6.

[19] Oussama Metatla, Sandra Bardot, Clare Cullen, Marcos Serrano, and Christophe Jouffrais. 2020. Robots for Inclusive Play: Co-designing an Educational Game With Visually Impaired and sighted Children. In *Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems*. 1–13.

[20] Oussama Metatla and Clare Cullen. 2018. "Bursting the Assistance Bubble" Designing Inclusive Technology with Children with Mixed Visual Abilities. In *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems*. 1–14.

[21] Oussama Metatla, Marcos Serrano, Christophe Jouffrais, Anja Thieme, Shaun Kane, Stacy Branham, Émeline Brulé, and Cynthia L Bennett. 2018. Inclusive education technologies: Emerging opportunities for people with visual impairments. In *Extended Abstracts of the 2018 CHI Conference on*

Human Factors in Computing Systems. 1–8.

[22] Isabel Neto, Wafa Johal, Marta Couto, Hugo Nicolau, Ana Paiva, and Arzu Guneysu. 2020. Using tabletop robots to promote inclusive classroom experiences. In *Proceedings of the Interaction Design and Children Conference*. 281–292.

[23] Ayberk Özgür, Séverin Lemaignan, Wafa Johal, Maria Beltran, Manon Briod, Léa Pereyre, Francesco Mondada, and Pierre Dillenbourg. 2017. Cellulo: Versatile handheld robots for education. In *2017 12th ACM/IEEE International Conference on Human-Robot Interaction (HRI*. IEEE, 119–127.

[24] Peter Reid and Beryl Plimmer. 2008. A collaborative multimodal handwriting training environment for visually impaired students. In *Proceedings of the 20th Australasian Conference on Computer-Human Interaction: Designing for Habitus and Habitat*. 195–202.

[25] Brian Scassellati, Laura Boccanfuso, Chien-Ming Huang, Marilena Mademtzi, Meiying Qin, Nicole Salomons, Pamela Ventola, and Frederick Shic. 2018. Improving social skills in children with ASD using a long-term, in-home social robot. *Science Robotics* 3, 21 (2018).

[26] Molly Follette Story. 2001. Principles of universal design. *Universal design handbook* (2001).

[27] Sarah Strohkorb Sebo, Ling Liang Dong, Nicholas Chang, and Brian Scassellati. 2020. Strategies for the Inclusion of Human Members within Human-Robot Teams. In *Proceedings of the 2020 ACM/IEEE International Conference on Human-Robot Interaction*. 309–317.

[28] Fumihide Tanaka and Shizuko Matsuzoe. 2012. Children Teach a Care-Receiving Robot to Promote Their Learning: Field Experiments in a Classroom for Vocabulary Learning. *J. Hum.-Robot Interact.* 1, 1 (July 2012), 78–95. https://doi.org/10.5898/JHRI.1.1.Tanaka

[29] Hamish Tennent, Solace Shen, and Malte Jung. 2019. Micbot: A peripheral robotic object to shape conversational dynamics and team performance. In *2019 14th ACM/IEEE International Conference on Human-Robot Interaction (HRI)*. IEEE, 133–142.

[30] Dana Tokmurzina, Nurbolat Sagitzhan, Abzal Nurgaliyev, and Anara Sandygulova. 2018. Exploring Child-Robot Proxemics. In *Companion of the 2018 ACM/IEEE International Conference on Human-Robot Interaction*. 257–258.

[31] Caroline L van Straten, Jochen Peter, and Rinaldo Kühne. 2020. Child–robot relationship formation: A narrative review of empirical research. *International Journal of Social Robotics* 12, 2 (2020), 325–344.

[32] Elmira Yadollahi, Wafa Johal, Ana Paiva, and Pierre Dillenbourg. 2018. When Deictic Gestures in a Robot Can Harm Child-Robot Collaboration. In *Proceedings of the 17th ACM Conference on Interaction Design and Children* (Trondheim, Norway) *(IDC '18)*. Association for Computing Machinery, New York, NY, USA, 195–206. https://doi.org/10.1145/3202185.3202743