Jun 8th, 9:00 AM - Jun 12th, 5:00 PM

Sketching Social Robots: Visualising Futures of Human–Robot Interaction through Participatory Imagination

Nicholas Vanderschantz
University of Waikato, New Zealand

Jessica Turner
University of Waikato, New Zealand

Jemma Konig
University of Waikato, New Zealand

Claire Timpany
University of Waikato, New Zealand

Rafeea Siddika
University of Waikato, New Zealand

See next page for additional authors

Citation

Vanderschantz, N., Turner, J., Konig, J., Timpany, C., Siddika, R., and Shakes, N. (2026) Sketching Social Robots: Visualising Futures of Human–Robot Interaction through Participatory Imagination, in Simeone, L., Gray, C. M., Verhoeven, A., de Götzen, A., Bakırlıoğlu, Y., Zohar, H., Stead, M., and Buwert, P. (eds.), *DRS2026: Edinburgh*, 8–12 June, Edinburgh, United Kingdom. https://doi.org/10.21606/drs.2026.2822

Authors
Nicholas Vanderschantz, Jessica Turner, Jemma Konig, Claire Timpany, Rafeea Siddika, and Nathan Shakes

Sketching Social Robots: Visualising Futures of Human-Robot Interaction through Participatory Imagination

Nicholas Vanderschantz*, Jessica Turner, Jemma König, Claire Timpany, Rafeea Siddika, and Nathan Shakes

School of Computing and Mathematical Sciences, University of Waikato, New Zealand

*Corresponding author email: nic.vanderschantz@waikato.ac.nz

doi.org/10.21606/drs.2026.2822

Abstract: In this paper, we explore sketching as a speculative and reflective practice for imagining social robots. Through a series of participatory design workshops, participants observed two prototype robots and then produced sketches and word maps envisioning possible appearances, behaviours, and social roles for robots in everyday life. Analysing the artefacts of these workshops reveals how non-expert human users perceive and imagine future robots in their worlds. We examine common themes of emotion, familiarity, discomfort, and relational values in the artefacts produced by the workshop participants. Our work highlights a way that sketching and written idea generation by non-designers can serve as a tool for thinking through affective, aesthetic, and relational possibilities in human-robot interaction. By situating sketching as a medium for speculative imagination rather than technical specification, our paper contributes to an emerging understanding of *Sketching Futures* as a relational, situated, and iterative process.

Keywords: Social Robots; HRI; Robot Aesthetics; Participatory Design; Research-Through-Design

1. Introduction

We invited participants to explore possible robot futures through a series of participatory design workshops developed within a speculative design framework. By robot futures we refer to imagined scenarios where robots are a part of everyday human environments, relationships, and practices. These speculative futures are not intended to be predictions of technological development. Instead, the use of speculative design practices can surface values, expectations, and concerns about how humans and robots may coexist. Speculative design is described as a critical design practice that uses imagined future scenarios to provoke reflection, critique, and dialogue about present conditions and assumptions (Auger, 2013; Dunne & Raby, 2013; Tsekleves et al., 2019; Lindley & Green, 2021). Positioned within the critical dimension of design, speculative design emphasises problem-finding over problem-solving. Speculative design encourages questioning assumptions, critical thinking, and designing for debate in the service of society (Dunne & Raby, 2013). Through these types of design practices, designers explore alternative possibilities that challenge existing norms and stimulate critical reflection (Mazé & Redström, 2009; Johannessen, Keitsch, & Pettersen, 2019; Bray & Harrington, 2021).

Building on this speculative framing, we approach sketching as both a reflective and imaginative method for engaging participants in the co-construction of robot futures. Rather than treating sketches as steps toward technical specification, we use them as artefacts of thought. These workshop artefacts provide visual and linguistic insights into how participants conceptualise social relationships, norms, and affect in their encounters with robotic systems. This study therefore investigates how participatory sketching activities can be used to explore how people imagine and make sense of future human–robot interactions. The purpose of this paper is not to report the full findings of our study, but to discuss how such participatory sketching can generate insights that support understanding between humans and future robotic systems. We present preliminary observations from our qualitative analysis of workshop artefacts, suggesting that this approach offers both practical and conceptual value for designers exploring human perceptions of emerging robotic and embodied artificial intelligence technologies. Finally, we argue that integrating a more-than-human orientation within the design research phase of human-robot interaction is essential to developing social robots that are relational, situated, and responsive to the complexities of human experience.

The remainder of this paper is structured as follows. Section 2 reviews related work on participatory approaches in human–robot interaction design, the role of sketching as a tool for ideation and inquiry in HRI and design research, and speculative futures and more-than-human perspectives in design. Section 3 describes the participatory workshop methodology and study design. Section 4 observations of the use of sketching during three workshop activities (brainstorming, designing, and storyboarding). Section 5 discusses these findings in relation to participants' limited prior experience with robots, the role of sketching as a speculative and relational practice, and the implications for participatory Human Robot Interaction (HRI) research. Finally, Section 6 concludes the paper and reflects on the contributions of participatory sketching for exploring human–robot futures.

2. Related Work

Our work builds on research in participatory design, sketching as a design reasoning tool, and methods for engaging with imagined and more-than-human futures. We use the remainder of this section to briefly describe the related work on these three concepts.

2.1 Participatory Approaches in Human-Robot Interaction Design

We reiterate Axelsson et al. (2021), who argue that the multidisciplinary nature of HRI necessitates tools and frameworks that foster dialogue across diverse levels of expertise. Such processes, frameworks, and methods help create a shared understanding and ensure that participatory approaches remain inclusive and grounded. This is particularly important given that HRI research frequently investigates constructs such as user perception, trust, and acceptance, which are shaped by both technical design decisions and human-centred interpretations (Onnasch et al., 2025; Rogers et al., 2022; Turner et al., 2026a). As a result, collaborative, inclusive, and participatory research methods are needed to meaningfully evaluate how robots are experienced and understood in social contexts(Ostrowski et al., 2020; Thompson et al., 2025).

Participatory design (PD) is becoming common in the development of social robots (e.g. Arnold et al., 2016; Azenkot et al., 2016; Rogers et al., 2022). Participatory methods can be a powerful way to ensure that robots are socially and contextually appropriate and likely to be accepted by end-users. PD methods have explored the use of brainstorming, card sorting, storyboarding, and interviewing techniques with a wide range of end-users, stakeholders, and HRI experts, as well as non-experts (e.g., Fraune et al., 2022; Sienkiewicz et al., 2024; Turner et al., 2026b; Winkle et al., 2021; Weiss & Spiel, 2022).

A key challenge in applying PD to HRI is meaningfully involving stakeholders with limited technical expertise. At this early point in human-robot interaction, many participants' expectations of robots are likely to be shaped more by popular media than by lived experience (Sobolewska et al., 2021), which may lead to gaps between imagined and actual robotic capabilities. Weiss and Spiel (2022) highlight how these mismatches influence both user attitudes and design trajectories, and call for designers and developers to address both cultural and technical dimensions of robot design.

2.2 Sketching as a Tool for Ideation and Inquiry in HRI and Design

Leblanc (2015) argues that sketching is more than just drawing, they suggest it is a cognitive process that enables the creator to think through making. This perspective aligns with the broader design literature, which positions sketching as an important part of the Design Thinking process. Hoffman (2020) notes that sketching can serve different purposes at different stages of that process, while Aspelund (2014) reports that it is typically undertaken as part of the Exploration and Refinement phase of the design process. Sketching as an activity in the early stages of the design process is important, as it enhances creativity by supporting memory, lateral thinking, modelling, and enabling cyclical idea generation. The process of sketching functions as a thinking tool to enable the construction and development of ideas and functional elements (Suwa et al., 1998).

Bødker & Pedersen (1991) explain that sketching is a useful tool in a co-design process, allowing participants to generate scenarios. When sketching or drawing is used in a participatory design process, it functions as a tool to stimulate creativity and communication, and as a method to facilitate ongoing collaboration within the group (Craft & Cairns, 2006; Langford, 2002). This shared ideation is also effective for enhancing the quality of ideas (Sun et al., 2015). Van der Ludgt (2005) found that sketching in a group can help stimulate creativity in the idea generation phase and create a shared vision for the collaborative idea being developed. Sketching in collaborative tasks can also help ensure that participants focus on the same ideas and allow for information and ideas to be communicated more efficiently, rather than solely relying on language, especially when describing spatial information (Heiser et al., 2004).

Sturdee & Lindley (2019) propose that sketching, as a tool in HCI research, is not only a method for prototyping or ideation, but also assists with future inquiry, enabling both researchers and participants to explore and imagine solutions beyond their current known worlds. As a tool for future inquiry, Sturdee & Lindley (2019) explain that sketching or drawing can help to explore imagined future solutions with a lens of 'what might be'.

2.3 Speculative Futures and More-than-Human Perspectives in Design

Visual and conceptual sketches can be a valuable tool in articulating speculative futures by helping to shape perceptions of emerging robot technologies (Pentzold & Rothe, 2022). Methods to imagine future possibilities can include creating artefacts, scenarios, and installations to encourage both experts and non-experts to imagine possibilities, explore alternatives and envision futures beyond currently available technologies (Dunne & Raby, 2013).

A key concept in Geneinboeck's (2021) work is *Relational-Performative Aesthetics*, which focuses on the idea that aesthetics and function are co-created, with the robot playing a crucial role in developing its own form and function through interactions with the designer.

Non-humans can also play a role in speculating these future possibilities. The work of Nicenbiom et al. (2024) expands upon the concept of "designing-with," advocating for collaborations and alliances not only between humans but also between humans and nonhumans. Jensen et al. (2025) argue that adopting more-than-human perspectives in HCI challenges conventional approaches and advances richer, more inclusive, and sustainable digital futures.

3. Method

To explore possible robot futures, we conducted participatory design workshops with four groups of participants. Each workshop was run following identical protocols; however, the demographic sample of each workshop was unique.

3.1 Participant Recruitment & Ethical Approval

Participants were recruited using a convenience sampling method, as part of outreach activities at the university. We had the opportunity to recruit one workshop of secondary school students (52 participants), one workshop of tertiary students (25), one workshop of university staff (14), and one workshop from the community (13). We worked with a total of 104 participants across the four workshops. The average age of participants was 23 years ($\sigma=13$), with 62% ($n=65$) participants aged 16–19 years old, 15% ($n=16$) aged 20–29, and the remaining 23% ($n=23$) being 30–79 years old. The studies were run with approval from the Division of STEM Human Research Ethics Committee at the University of Waikato (Approval

No. STEM_HREC(2025)#33). Participation in the study was voluntary, and participants were able to withdraw from the study up to two weeks after they participated.

3.2 Workshop Protocols

As participants entered the workshop space, two robots were present, the *Roaming Roombas*, autonomously exploring a dedicated space (Figure 1).

Figure 1 Robots in the Workshop Space

Enclosures were created for each robot to ensure participant safety and to allow all participants the ability to see the robots clearly without others obstructing their view. Participants could freely move around the enclosure to view what the robots were doing from any angle they wished.

After participants spent some time observing the robots, the facilitators welcomed participants to the workshop, which was split into three distinct tasks: a brainstorming activity, a design activity, and a storyboarding activity. Each activity would take participants 10–20 minutes to complete for a total workshop run time of 45 minutes. Each activity had an associated A3 worksheet (see Figures 2–4), which participants could use to share their ideas with facilitators.

The brainstorming activity (Figure 2) was presented to participants first, and encouraged them to think about the robots in the workshop and possible robot futures for these or similar robots. The participants were informed they could generate word maps, word lists, brainstorms, and sketches to detail their ideation processes. The *Roaming Roombas* served as inspiration for participants, acting as two exemplars that demonstrated possible behaviours and forms. Next, participants were asked to select one idea from their brainstorming activity sheet and develop it further, using the design activity sheet depicted in Figure 3. They were encouraged to think about what types of tools or accessories their robot may need to fulfil their use case, how the robot might behave, and what the robot might achieve. Lastly, after they had designed their future robot, they were asked to storyboard the behaviours, movements, actions, and interactions between their robot and any end users they might have imagined (Figure 4). These three tasks enabled participants to envision a wide range of aspects of robot futures that they could perceive. The workshop facilitators, the exemplar robots, and the workshop activity sheets provided opportunities for the groups to discuss, write about, draw, and demonstrate possible use cases, key stakeholders, appearance, ability, capability, environment, and interaction.

Figure 2 Brainstorming Activity Sheet

Figure 3 Design Activity Sheet

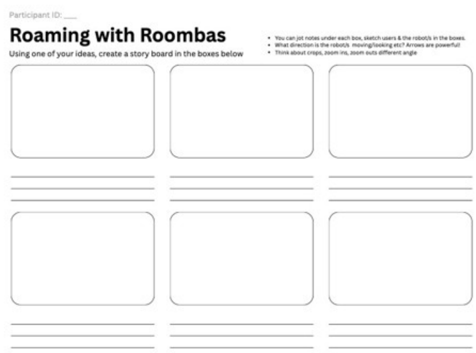

Figure 4 Storyboarding Activity Sheet

Participants worked in groups of 4 to 6 to complete these activities. Each group was provided with a range of mark-making tools, including a bucket of felt-tip pens, four ball-point pens (red, green, blue, and black), and a pencil, which they were free to use as they saw fit.

Each of the four workshops was facilitated by the same two researchers and followed a consistent structure.

3.3 Analysis

Data analysis was conducted using an approach built on grounded theory methods (Chun Tie et al., 2019). Three researchers reviewed the data from our workshop artefacts to identify meaningful segments for which we developed codes. These initial codes were grouped to provide higher-level categories. Through constant comparison and iterative analysis, relationships between codes and categories were explored. Using this process, our insights have emerged inductively from the data rather than from preconceived hypotheses.

4. Results

Here, we describe how participants used linguistic ideating and visual sketching in the three phases of our participatory design workshops.

4.1 Brainstorming Activity

While the brainstorming activity did not require participants to sketch or draw, we analyse here both the visual ideation and written ideation processes undertaken by participants. We considered whether more than one participant appeared to participate in the recording of group ideas, whether text and image were used, whether multiple coloured mark-making tools were used, and whether multiple types of mark-making tools were used. We also categorised the linguistic and visual ideations of the participants.

Tertiary student groups were the most likely to include multiple writers or illustrators during the brainstorming task (see Table 1). Six of the eight (6/8) tertiary groups appeared to have more than one writer, two of three (2/3) community groups, and three of ten (3/10) secondary student groups. None (0/3) of the university staff groups appeared to include more than one writer or illustrator during the brainstorming activity.

Table 1 Number of Writers (based on handwriting)

	Single Writer	Two or More Writers
Tertiary Student Groups	2	6
Secondary Student Groups	7	3
Community Groups	1	2
Staff Groups	3	0

Tertiary students used the widest range of colours, with not a single tertiary student group using only 1 colour in their brainstorm (Table 2). One (1/8) tertiary group used a total of 11 different colours. This is perhaps reflective of the indication that multiple writers were involved in the majority of these brainstorms. This, however, was less pronounced with the remaining groups, where the secondary student groups had equal numbers of groups using colour compared to not using colour, the community groups were slightly more likely to use colour, and the staff groups were slightly less likely to use colour in their brainstorm. We did not identify instances of the colour being used to portray a particular meaning or emphasis.

Table 2 Number of Colours Used

		Number of Colours Used							
		1	2	3	4	5	6	7	8+
Participants	Tertiary Student Groups	-	1	2	2	1	-	1	1
	Secondary Student Groups	5	2	-	1	2	-	-	-
	Community Groups	1	1	1	-	-	-	-	-
	Staff Groups	2	1	-	-	-	-	-	-

Similarly, when considering the number of mark-making tools used, tertiary students used the widest range of mark-making tools, with not a single tertiary student group using only a single tool in their brainstorm (Table 3). Again, secondary student groups had equal numbers of groups using multiple tools compared to single tools, the community groups were slightly more likely to use multiple tools, and the staff groups were slightly less likely to use multiple tools in their brainstorming. We did not identify different mark-making tools being used to portray particular meaning or emphasis, or for a specific illustrative purpose.

Table 3 Number of Mark-Making Tools Used

		Number of Mark-Making Tools Used								
		1	2	3	4	5	6	7	8	9+
Participants	Tertiary Student Groups	-	1	1	3	1	-	-	1	1
	Secondary Student Groups	5	2	-	-	2	1	-	-	-
	Community Groups	1	1	1	-	-	-	-	-	-
	Staff Groups	2	1	-	-	-	-	-	-	-

4.1.1 Sketch Ideation by Participants during Brainstorming Activity

No explicit instruction was given by the workshop facilitators regarding what type of content should be shared for the Brainstorming activity, we have analysed the use of sketching to understand the visual ideation that was present before it was prompted by facilitators in later tasks.

Seventeen (17/24) of the groups incorporated some form of sketching in their brainstorms. Of the seven groups that included no evidence of sketching in their brainstorms, two were Tertiary Student groups, four were Secondary Student groups, and one was a community group.

We identified three types of sketch artifact:

1. Lines and arrows that indicated connection of linguistic ideas and circling of central themes or important ideas (Figure 5). This use of mark making and sketching was used to clarify ideas, linkages, and patterns in the written material being produced by groups.
2. Cross hatching, smiley face emoji, and mark making often considered a “doodle” was also identified (Figure 6). This mark making was potentially created by group members who were disengaged in the process, or were visual or kinaesthetic learners who benefited from such sketching during creative idea generation exercises.
3. Scamps or sketches of elements related to the linguistic ideas being presented, such as initial robot designs, robot features such as faces or arms, and robots interacting with an environment, such as a fishing robot (Figure 7). These were often rudimentary visualisations of a linguistic note. However, it did appear that at times a sketch was drawn before labelling of the visual brainstorm idea.

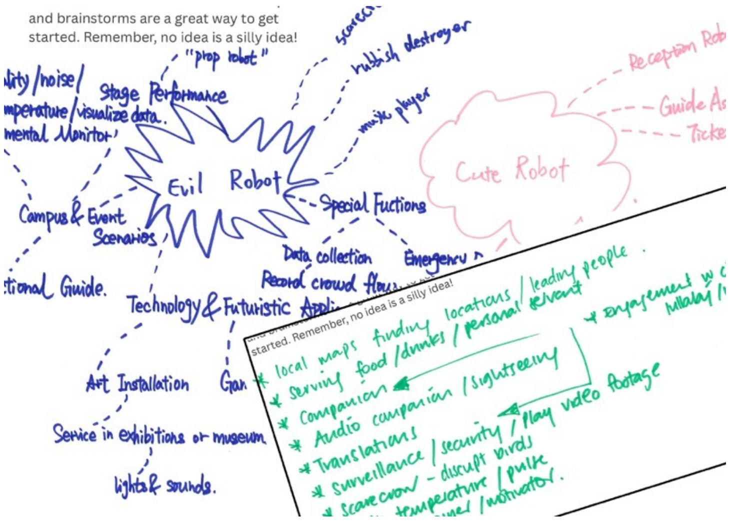

Figure 5 Lines & Arrows & Bubbles

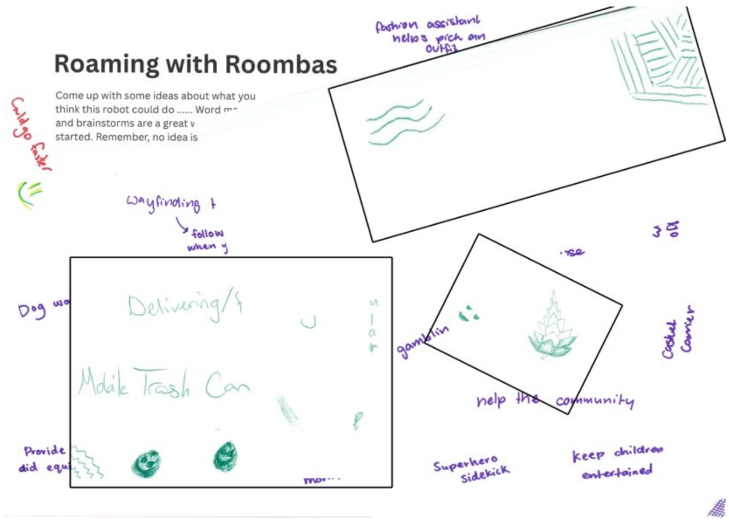

Figure 6 Doodles

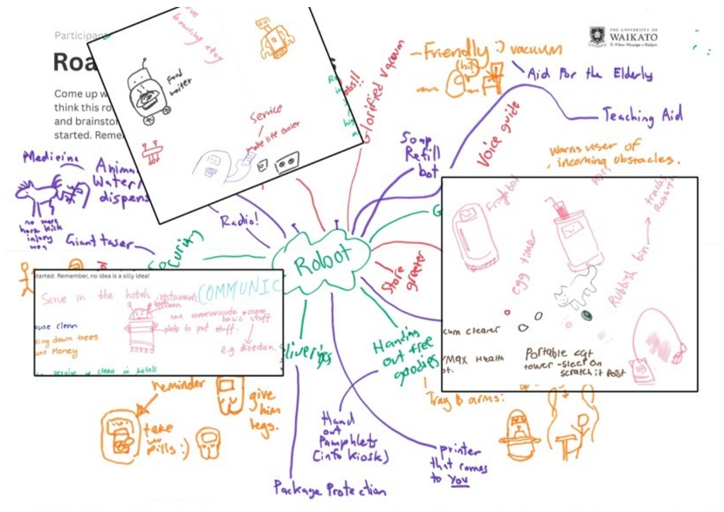

Figure 7 Robot Sketches

4.1.2 Linguistic Ideation by Participants during Brainstorming Activity

Table 4 Categories and Subcategories Developed During Axial Coding

Category	Subcategory	Definition
Service	Health & Safety	Robots supporting wellbeing or protecting humans from harm.
	Cleaning	Tasks involving hygiene, sanitation, or waste management.
	Security	Monitoring, protection, or enforcement functions.
	Entertainment	Activities providing amusement, play, or leisure engagement.
	Communication	Facilitating human interaction, translation, information search, information seeking, or information exchange.
	Caregiving	Providing physical or emotional assistance to people.
	Service	Providing task-based assistance or hospitality to meet human needs or requests.
Environment	Environment	The physical or social context where robots operate or interact.
Audience	User	End user identified or discussed.
	Engagement	Indication of nature of human interaction or attention directed toward the robot.
Characterisation	Intelligence	Perceived cognitive or emotional capacities of the robot.
	Role	Social identity ascribed to robots (e.g., teacher, helper, villain).
	Moral Alignment	The perceived ethical stance or intent of the robot, such as benevolent, neutral, or malevolent behaviour.
Appearance	Morphology	The robot's overall form, structure, and body shape.
	Zoomorphology	The degree to which a robot's physical form, features, or movement resemble those of animals.
	Accessories	Additional features or items that modify the robot's appearance or function.
Ability	Locomotion	The means by which a robot moves through its environment.
	Wayfinding	The capacity to assist users to navigate spaces & destinations.
	Object Manipulation	The ability to grasp, carry, or interact physically with objects.

Using the brainstorming activity data, we analysed the ideas that the participants generated to understand the diversity of their concepts and thinking. During axial coding, related open codes were grouped into higher-level categories to reflect the key dimensions by which participants conceptualised robot roles, environments, and behaviours. Table 4 presents these categories and subcategories, along with brief definitions that clarify their scope and meaning within the dataset. We identified 779 items to code in the brainstorm data. From these items, we were able to develop 18 themes (see Table 4 col. 2) that we classified as sub-categories of six key themes (see Table 4 col. 1) throughout the data.

The most common theme throughout the brainstorming activity was ideas involving service robots, with 410 identified. This included sub-themes such as health & safety services (44), where robots worked alongside medical professionals, or more comically, cleaning robots (49) for "dog poo collection". Similarly, there were robots which provided security (22), entertainment (27), communication (38), caregiving (26) services, with the remaining 204 services distinct to specific industries, like hotels or education.

This was followed by 88 concepts from the groups, which characterised robots either for a given job or with human-like qualities, such as an "evil robot". Additionally, groups commented on the intelligence levels of the robots they were designing and their perceived level of intelligence. Conversely, 86 concepts focused on different abilities of the robot itself, including key capabilities such as locomotion (57), wayfinding (12) or object manipulation (17). Similarly, 85 ideas also focused on the robot's appearance, listing morphological features or accessories that a robot may need to complete a task, such as an axe to chop trees or items to move, like food or library books.

70 concepts from the groups which mentioned the environment in which the robots should exist, such as libraries, at home, or in commercial settings such as shopping centres and grocery stores. Notably, one group suggested using robots in theme parks as mascots and marketing tools. Lastly, 40 concepts mentioned specific target audiences ranging from a variety of age groups, such as the elderly, babies, children or "students", to key engagement tasks such as operating as a tour guide for museum visitors.

4.2 Design Activity

The design activity explicitly encouraged participants to draw and describe their visions for how one of the robots they saw in the room could be developed, advanced, or improved to meet one of the needs they identified during their brainstorming activity. Across the workshops, the 104 participants developed 24 distinct robot designs, encompassing 21 unique robot use-case concepts.

Analysing the design activity worksheets (see Figure 8), we were able to identify and code using the same themes identified from the brainstorming session. We found that sketching the robot made all the participants consider the appearance of the robot and what it could look like for a specific use case.

All 24 groups provided both visual and textual designs for this activity. Groups labelled features of the robot, named their robot, and included lines and arrows to embellish the robot visuals. Only four groups did not use the provided "Notes:" area on the design activity worksheet to add textual information about their robot. However, all of these four groups did use the space around their robot in some way to label features of their robot or provide a name. These four groups were part of the secondary school student workshop.

Almost all groups (23/24) listed or drew the abilities of their robot. We identified 117 distinct capabilities across the 23 robots, highlighting the benefits of sketching for robot futures. The ability to pick up, suck up, carry, manipulate, pass, and deliver objects was common in both illustrations of robot capabilities and in written annotations. Somewhat more obscure abilities were the provision of aromatherapy and pyrotechnics, arms that hugged, soothed, and swaddled crying babies, and a robot companion that appeared to be an entire kitchen of cooking and cooling appliances in a mobile unit with a form factor very similar to that provided as a starting point for this exercise. These abilities were often connected to the service aspects (22) or features that the participants had imagined for their robot. Services included cleaning, caregiving, health & safety, security, entertainment, and communication.

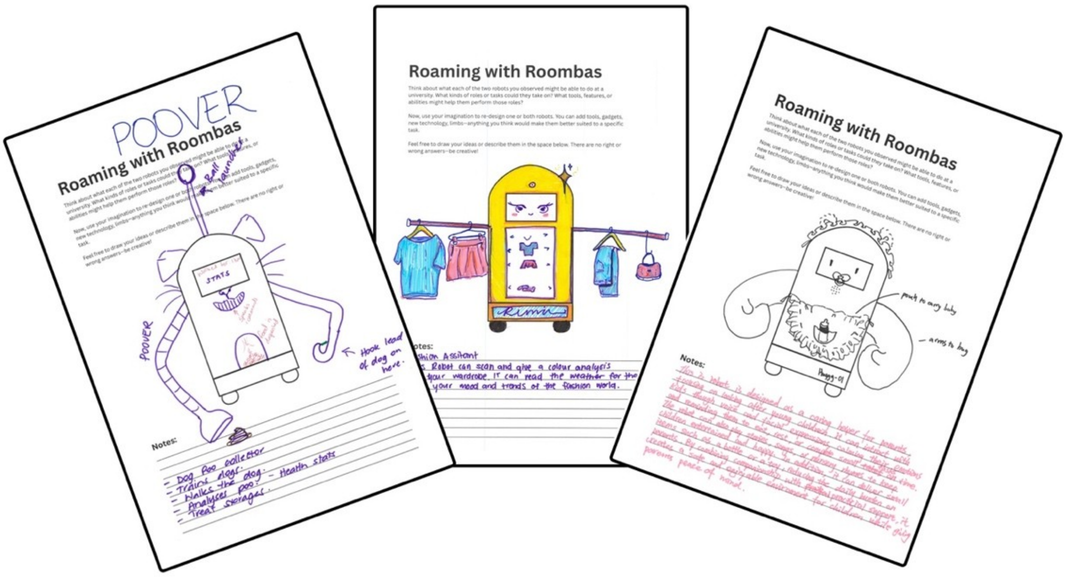

Figure 8 Sample of Design Activity Worksheets

Similarly, we identified 39 distinct accessories across the 24 groups, many of which were critical tools for completing the services these robots provide. These ranged from medicine and food to fishing rods, fireworks, and scents. These accessories were often easily identified in the sketches and labelled or described in writing.

17 of the robot sketches had specific characterisation aspects, including 3 robots that had been given specific names, such as “Bob - the children’s entertainment robot” [G20], “Speeder Sparker” [G21], used to assist people in shopping malls or theme parks, and “Poover” [G13], which was designed as a dog companion that collected dog poop and analysed it for pet health diagnostics. Characterisation was identified through visual indications as well as descriptions or labels of human or animal behaviours, written names or depictions of name tags sketched on the bot, and discussion of intelligence in the written descriptions. We identified sketch labels and descriptions that described the robot as a “teacher-bot” or an “Evil Destruction Robot”. Another example was the explicit description of a robot face that had a large smile; “the smily *[sic.]* face is to make people feel welcomed”.

Investigations into appearance and abilities revealed 60 distinct design features, including anthropomorphic concepts such as moustaches or mohawks, or zoomorphic features such as a cat’s ears and whiskers, a tail, and birds’ wings. When robot arms were sketched, we identified two different depictions of these appendages. Typically, arms were shown as mechanical tools designed for specific delivery, distribution, or industrial purposes. However, we also identified some depictions of arms that appeared human or humanoid with indications of skin and muscle. It was particularly common for robots that interacted with children to have human-like arms, used by a caregiving robot to hold a baby or by a crossing guard robot to guide a child across the road.

Notably, fewer of the design worksheets mentioned specific target audiences (9) or environments (7). We hypothesise this was because the activity naturally directed participants towards the appearance and capabilities of their future robots. Sketching in the design worksheets appeared to play an important mediating role between participants' initial vocabulary for describing robots and their emerging understanding of what those robots might *do.* As a visual thinking tool, sketching helped participants move ideas into visual representations. In this activity, that bridging function seemed to focus participants' attention on the physical characteristics and capabilities of their future robots, features that are more immediately expressible through drawing. Common examples of these physical characteristics were arms and appendages for sucking, holding, and carrying. This may explain why few worksheets referenced specific target audiences or contexts of use; the act of sketching naturally anchored participants' attention on form, features, and mechanics rather than on situational or user-centred considerations.

4.3 Storyboarding Activity

Participants were introduced to storyboarding as a tool for describing an experience, an interaction, or the use of a technology. The storyboarding activity encouraged participants to draw and describe how their imagined robot would interact with users, with their environments, and with other technologies to complete a task or perform a service. All 24 groups provided both visual and textual designs for this activity. Groups labelled features of the robot or interaction within the provided frames, including text as part of times on clocks, temperatures on thermostats, and used thought and speech bubbles provided by robots and users. Only three groups did not use the provided "Notes:" areas underneath each frame on the storyboarding activity worksheet to add textual information about their robot or the interaction. However, all three of these groups did use text in some way within the storyboard frames.

Unlike with the design worksheets, we saw a significant increase in the number of identifiable environments and specified target audiences in the storyboard worksheets (Figure 9). We identified 21 environments, such as libraries, wardrobes, malls, and grocery stores. In the illustrated storyboard frames, 18 target audience concepts were also noted, such as an elderly woman carrying groceries into the house, a mother and son at the doctor's reception, and a baby who needed soothing.

All of the robot futures in the storyboarding activity included clearly identified abilities for the robot they had designed during their earlier sketch. Similar to the previous activity, these were linked to specific service aspects (23). However, with the change in design focus, we saw less emphasis from groups on characterisation compared to the design activity. Seven groups added further characterisation elements to their robots in the storyboarding activity that were not present in the design activity. Likewise, only 14 of the storyboarding worksheets, compared to 24 of the design worksheets, add or further describe appearance elements.

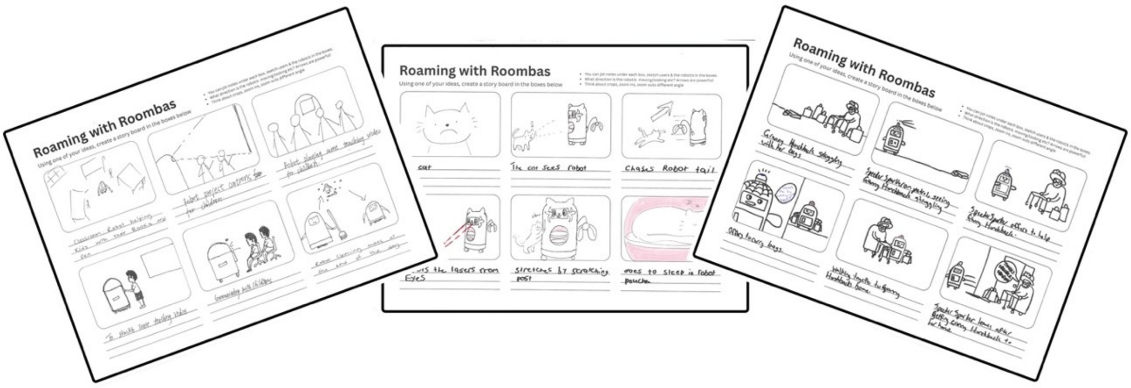

Figure 9   Sample of Storyboarding Activity Worksheets

Some of the storyboards were quite unconventional in their ideas, such as the fishing robot, which had lasers to defend itself from sea monsters, kill the monster and ultimately cook it for dinner [G4]. Similarly, the "poover", which was designed as a dog companion, depicted vacuuming up dog poop and analysing it to ensure the pet was healthy [G13]. However, others depicted robots which filled actual functions and needs, such as the robot which could scan rubble after an emergency to detect vital signs and rescue trapped people [G10].

Sketching with the use of storyboards assisted participants to translate an initial idea about a robot into a more concrete understanding of what the robot might do in practice. The storyboard process enabled participants to elaborate on features and functions of their envisioned robots. Appendages such as arms, vacuums, and lasers that were first illustrated in the design activity were elaborated on and further explained in the storyboard. For example, storyboards were used to show types of movement that was not visualised by participants when they worked on the single frame design activity. The storyboards also often depicted how the robots might interact with features of their environment. We identify these interactions as audio, visual, and physical communications as well as service provisions being conducted by the robots within their environments and with human and animal inhabitants of their world.

5. Discussion

Our participatory design workshops aimed to explore how non-experts imagine social robots. In this section, we highlight how participants used their cultural and everyday understandings to visualise plausible robot futures, how sketching functioned as a speculative and relational design, and what these insights imply for future human-robot interaction design.

5.1 Imagining Robots Without Experience

Even though participants had little or no direct experience of living or working with robots, their brainstorming, design, and storyboarding activities produced imaginative and socially coherent concepts for robot futures. Similar to Sobolewska et al. (2021), participants' ideas will have been shaped more by cultural narratives and media representations than interactions with robots, yet few of the results of these workshops showed influences of fear, dystopian futures, or negative perceptions of robots and their place in the world. The majority of robot concepts were grounded in everyday needs such as health, safety, caregiving, cleaning, communication, and companionship. We suggest that, generally, robot futures are considered positive by most participants. This aligns with Weiss and Spiel's (2022) observation that non-experts' expectations often diverge from the technical realities of robotics, but also suggests that such expectations can be productively harnessed in design contexts.

Participants developed robot concepts that were situated within human routines and environments. Robots were conceptualised as helping elderly people with groceries, soothing crying babies, providing entertainment, performing dangerous tasks, or assisting with navigation. These scenarios reflect what Dunne and Raby (2013) describe as *plausible futures,* futures that envision events which could occur, grounded in current understandings of science, technology, and social structures. Even the more humorous or fantastical designs, such as laser-equipped fishing robots or robots making pet health diagnoses by analysing dog poo, were grounded in recognisable human activities and could be considered feasible near futures.

From this, we posit that non-expert participants in speculative design activities do not require specialist knowledge to engage meaningfully in future-oriented robot design. Instead, their everyday cultural, social, and emotional assumptions provide a strong foundation for constructing meaningful futures. We expect the workshop contexts provided, particularly the included experience of observing the Roaming Roombas, helped ground participants' imaginations in tangible behaviours and capabilities, enabling them to extend from what robots *do* now to what robots *could do* in the near future.

5.2 Sketching as Speculative and Relational Practice

The three workshop activities provided opportunities for different types of imaginative engagement by participants. The brainstorming worksheets elicited breadth and spontaneity, revealing early conceptual associations around robot roles, environments, and abilities. The design activity prompted closer attention to appearance, capability, and characterisation, encouraging participants to refine their ideas through form-making. Storyboarding required participants to imagine robots within specific social scenarios and resulted in deeper insights into actions, interactions, users, and environments. Through these different sketching tasks, participants moved from high-level conceptualisation to detailed situational thinking. As identified in the related work (Section 2.2), sketching was used by participants not simply as an illustration tool but as a cognitive and generative practice and a way of thinking through making or doing (e.g. Leblanc, 2015; Suwa et al., 1998; Van der Lugt, 2005). Participants used sketches to communicate ideas, explore meaning, and imagine possibilities that were not fully formed at the outset of each task.

When we consider the types of themes that these workshop sketches produced, it is interesting to see depictions of relational and affective dimensions of HRI that other methods might not have revealed. All groups imagined robots in broad social scenarios and working with diverse community groups, including guiding children, assisting elderly people, calming babies, and teaching. Robots were described and drawn with facial expressions, names, personalities, anthropomorphic and zoomorphic features, and moral alignments.

These depictions reflect a way of envisioning robots as actors operating in human worlds rather than merely tools or systems. This relational thinking is indicative of more-than-human orientation (Jensen et al., 2025), where meaning emerges through the entanglement of humans and nonhumans rather than from human experience alone (Nicenboim et al., 2024; Gemeinboeck, 2021).

Robots were imagined in ways that reflect human values, fears, and desires and in situations that will require humans to adapt or change in relation to these imagined robots. This further supports speculative and critical design approaches that emphasise relationality, accountability, and the co-production of futures (Mazé & Redström, 2009; Johannessen et al., 2019). Through sketching, participants visualised small speculative worlds in which they and we can explore what robots might look like, do, and how humans might feel alongside these robots. The workshop artefacts reveal an interplay of imagination, empathy, and anticipation that is rarely captured in traditional PD activities, which typically use interviews, card sorting, and feature wish lists to elicit requirements, preferences, and frustrations.

5.3 Implications for Participatory HRI Design

Our findings contribute insights into how participatory sketching methods can be used in HRI. As Axelsson et al. (2021) note, HRI design teams are typically multidisciplinary, and tools that support communication across varying levels of expertise are required. Sketching offers a tool for sharing ideas in ways that are accessible to both designers and engineers. Further, our findings indicate that sketch-based speculative exercises can aid in identifying user expectations, relational assumptions, and desired outcomes. Because sketching can surface what participants want robots to do, but also how participants expect to feel about robots, and how they imagine robots feeling and acting toward them. These insights will provide HRI designers with an understanding of perceived social norms and values, and areas where users' expectations may not align with technical feasibility.

The more-than-human orientation highlighted in participants' sketches suggests that early stages of the design process should consider robot capabilities in relation to the environments that robots operate within. Questions of how the robot and human will influence each other and the spaces and environments they cohabit require consideration. By embracing relationality and interdependence, design teams may better anticipate how meaning, trust, and social roles will emerge between humans and robots.

6. Conclusion

Through our participatory design workshops, participants developed a range of visual artefacts within a speculative design framework. Our findings demonstrate the value of incorporating speculative sketching methods into HRI design processes to foster future-oriented thinking. Non-expert participants imagined plausible, socially grounded robot futures that drew on everyday cultural and emotional understandings. Our linguistic and visual analysis revealed affective, social, and relational themes spanning empathy, care, morality, and personalisation. The use of three different sketching methods in these workshops resulted in different layers of imagination moving from broad ideation to visualisations of form and considerations of located scenarios with human and non-human actors. Our insights support the ongoing work that demonstrates how sketching helps multidisciplinary teams bridge communication gaps between stakeholders, designers, and engineers. Further, our work shows how sketching, when used in participatory design, can reveal aspects of human-robot interaction that traditional PD methods may not surface. Based on our work here, we recommend using sketching as a tool during early-stage robot design and development practices to reveal gaps in imagined and feasible robot behaviours and to offer insights into contextualised interactions, environments, and user groups. We believe that speculative sketching will enable design ideation to transcend technical limitations, yet remain grounded in scenarios that are analytically rich and support future HRI design decisions.

Acknowledgements: We would like to thank all the participants who generously gave their time, creativity and enthusiasm during the study. Their contributions were invaluable to the success of this research.

GenAI tools, ChatGPT, Grammarly, and MS Office were used to critique spelling and grammar, and to help improve the clarity of the writing.

7. References

Arnold, L., Lee, K. J., & Yip, J. C. (2016). Co-designing with children: An approach to social robot design. ACM Human-Robot Interaction (HRI).

Aspelund, K. (2014). The design process (Vol. 25). Bloomsbury Publishing.

Auger, J. (2013). Speculative design: crafting the speculation. Digital Creativity, 24(1), 11-35.

Axelsson, M., Oliveira, R., Racca, M., & Kyrki, V. (2021). Social robot co-design canvases: A participatory design framework. ACM Transactions on Human-Robot Interaction (THRI), 11(1), 1-39, doi:10.1145/3472225.

Azenkot, S., Feng, C., & Cakmak, M. (2016). Enabling building service robots to guide blind people a participatory design approach. In 2016 11th ACM/IEEE International Conference on Human-Robot Interaction (HRI) (pp. 3-10). IEEE.

Bray, K., & Harrington, C. (2021). Speculative blackness: considering Afrofuturism in the creation of inclusive speculative design probes. In Proceedings of the 2021 ACM Designing Interactive Systems Conference (pp. 1793-1806).

Chun Tie, Y., Birks, M., & Francis, K. (2019). Grounded theory research: A design framework for novice researchers. SAGE open medicine, 7, doi:10.1177/2050312118822927.

Craft, B., & Cairns, P. (2006). Using sketching to support visualisation design. British HCI-V&I.

Dunne, A., & Raby, F. (2013). Speculative everything: design, fiction, and social dreaming. The MIT Press.

Fraune, M. R., Komatsu, T., Preusse, H. R., Langlois, D. K., Au, R. H., Ling, K., Suda, S., Nakamura, K., & Tsui, K. M. (2022). Socially facilitative robots for older adults to alleviate social isolation: A participatory design workshop approach in the US and Japan. Frontiers in psychology, 13, doi:10.3389/fpsyg.2022.904019.

Gemeinboeck, P. (2021). The aesthetics of encounter: a relational-performative design approach to human-robot interaction. Frontiers in Robotics and AI, 7, doi:10.3389/frobt.2020.577900.

Heiser, J., Tversky, B., & Silverman, M. (2004). Sketches for and from collaboration. Visual and spatial reasoning in design III, 3, 69-78.

Hoffman, A. R. (2020). Sketching as design thinking. Routledge.

Jensen, R. H., Nilsson, E. M., Hansen, A. M., Yoo, D., & Eriksson, E. (2025). Provocations and More-Than-Human Perspectives in Human–Computer Interaction. Interacting with Computers, iwaf020, doi:10.1093/iwc/iwaf020.

Langford, J. (2002). Focus groups: Supporting effective product development. CRC press.

Leblanc, T. (2015). Sketching as a thinking process. InDS 82: Proceedings of the 17th International Conference on Engineering and Product Design Education (E&PDE15), Great Expectations: Design Teaching, Research & Enterprise, Loughborough, UK, 03-04.09. 2015 (pp. 606-611).

Lindley, J., & Green, D. P. (2021). The Ultimate Measure of Success for Speculative Design is to Disappear Completely. IxD&A, 51, 32-51, doi:10.55612/s-5002-051-002.

Johannessen, L. K., Keitsch, M. M., & Pettersen, I. N. (2019). Speculative and critical design—features, methods, and practices. In Proceedings of the design society: international conference on engineering design (Vol. 1, No. 1, pp. 1623-1632). Cambridge University Press, doi:10.1017/dsi.2019.168.

Mazé, R., & Redström, J. (2009). Difficult forms: Critical practices of design and research. Research Design Journal, 1, 28-39.

Nicenboim, I., Lindley, J., Zaga, C., Berger, A., Forlano, L., & Giaccardi, E. (2024). More-than-human design in practice. In Design Research Society, DRS 2024: Resistance, Recovery, Reflection, Reimagination. Design Research Society.

Onnasch, L., Roesler, E., Robert, L., & Visser, E. D. (2025). Trust (worthiness) Issues with Trust in Human-Robot Interaction. ACM Transactions on Human-Robot Interaction.

Ostrowski, A. K., Park, H. W., & Breazeal, C. (2020). Design research in hri: Roboticists, design features, and users as co-designers. In Workshop on Designerly HRI Knowledge.

Pentzold, C., & Rothe, I. (2022). Drawn into the future: The epistemic work of visual scenarios in the configuration of human–robot encounters. Visual Communication, 24(1), 67-89.

Rogers, W. A., Kadylak, T., & Bayles, M. A. (2022). Maximizing the benefits of participatory design for human–robot interaction research with older adults. Human factors, 64(3), 441-450.

Sienkiewicz, B., Radosz-Knawa, Z., & Indurkhya, B. (2024). A participatory design approach to using social robots for elderly care. In 2024 IEEE International Conference on Advanced Robotics and Its Social Impacts (ARSO). IEEE, 194–199.

Sobolewska, E., Vanderschantz, N., & Bitcon, F. (2021). “He’s adorable and I want to take him home”. Trust Perceptions Before and After First-Time Encounters with Social Robots. In 34th British HCI Conference (pp. 324-328). BCS Learning & Development.

Sturdee, M., & Lindley, J. (2019). Sketching & drawing as future inquiry in HCI. In Proceedings of the Halfway to the Future Symposium 2019 (pp. 1-10).

Sun, L., Xiang, W., Chen, S., & Yang, Z. (2015). Collaborative sketching in crowdsourcing design: a new method for idea generation. International Journal of Technology and Design Education, 25(3), 409-427.

Suwa, M., Gero, J. S., & Purcell, T. A. (1998). The Roles of Sketches in Early Conceptual Design Processes. In Proceedings of the Twentieth Annual Conference of the Cognitive Science Society (pp. 1043–1048). Routledge, doi:10.4324/9781315782416-188.

Tsekleves, E., Yong, M. H., Lee, C. A. L., Giga, S., Hwang, J. S., & Lau, S. L. (2019). Rethinking how healthcare is conceptualised and delivered through speculative design in the UK and Malaysia: A Comparative study. The Design Journal, 22(sup1), 429-444.

Thompson, S., Candon, K., & Vázquez, M. (2025). The social context of human–robot interactions. Annual Review of Control, Robotics, and Autonomous Systems, 9, doi:10.1146/annurev-control-030623-015506.

Turner, J., Vanderschantz, N., Bowen, J., König, J. L., & Carino, H. (2026a). Empowering Education: Student Perceptions and Attitudes to the Role of Social Robots in Learning Contexts. In Proceedings of the 21st ACM/IEEE International Conference on Human-Robot Interaction (pp. 913-917), doi:10.1145/3776734.3794527.

Turner, J., Vanderschantz, N., König, J. L., & Siddika, R. (2026b). "It Almost Wanted to Hurt Someone": The Impact of Intentional Creepiness on User Perceptions. In Proceedings of the 21st ACM/IEEE International Conference on Human-Robot Interaction (pp. 907-912), doi:10.1145/3776734.3794526.

Van der Lugt, R. (2005). How sketching can affect the idea generation process in design group meetings. Design studies, 26(2), 101-122, doi:10.1016/j.destud.2004.08.003.

Weiss, A., & Spiel, K. (2022). Robots beyond Science Fiction: mutual learning in human–robot interaction on the way to participatory approaches. AI & society, 37(2), 501-515, doi:10.1007/s00146-021-01209-w.

Winkle, K., Senft, E., & Lemaignan, S. (2021). LEADOR: A method for end-to-end participatory design of autonomous social robots. Frontiers in Robotics and AI, 8, 704119, doi:10.3389/frobt.2021.704119.

About the Authors:

Nicholas Vanderschantz is a Senior Lecturer at the University of Waikato whose research explores user-centred design approaches to information seeking, visualisation, and emerging technologies. His work spans human–robot interaction, robot perception, and participatory design methods that investigate how people imagine and engage with digital and analogue information systems.

Jessica Turner is a Senior Lecturer at the University of Waikato Tauranga campus focused on human-centred approaches to engineering interactive systems. She is a co-founder of the HRI@Waikato research group, advancing interdisciplinary research on social robots and emerging technologies.

Jemma König is a Senior Lecturer at the University of Waikato researching wearable, human-centred, ethical and culturally responsive technologies, and human–robot interaction. She co-founded Te Kura Rau Mahara (Waikato Wearables Research Lab) and contributes to MBIE and HRC-funded research.

Claire Timpany is a Senior Lecturer in Design at the University of Waikato. Claire's research focusses on the influence that typographic design decisions have on the ways we interact with our reading material and how design can improve our reading experiences.

Rafeea Siddika is a Software Engineer who completed her Bachelor of Software Engineering (Honours) at the University of Waikato, where she focused on human–robot interaction and perception of social robots. She works as an Implementation Consultant at FAST Enterprises helping maintain and improve large-scale government systems in a live environment.

Nathan Shakes is a Software Engineer who completed his Bachelor of Software Engineering (Honours) at the University of Waikato. His research interests include Human-Robot Interaction and leveraging low-cost, accessible tools such as 3D printing to make research prototyping more widely accessible.