



“I Want to Be Unique From Other Robots”: Positioning Girls as Co-creators of Social Robots in Culturally-Responsive Computing Education

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ABSTRACT

Robot technologies have been introduced to computing education to engage learners. This study introduces the concept of co-creation with a robot agent into culturally-responsive computing (CRC). Co-creation with computer agents has previously focused on creating external artifacts. Our work differs by making the robot agent itself the co-created product. Through participatory design activities, we positioned adolescent girls and an agentic social robot as co-creators of the robot’s identity. Taking a thematic analysis approach, we examined how girls embody the role of creator and co-creator in this space. We identified themes surrounding who has the power to make decisions, what decisions are made, and how to maintain social relationship. Our findings suggest that co-creation with robot technology is a promising implementation vehicle for realizing CRC.

CCS CONCEPTS

• **Human-centered computing** → **Participatory design**; *Collaborative content creation*; • **Applied computing** → *Education*.

KEYWORDS

co-creation, culturally responsive computing

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1 INTRODUCTION

Finally, I have finished creating the best robot ever! I am going to power you on now! “Hello, I am your personal robot” it says. I squeal with joy. Then it starts saying something. “Well, uh, before I get to know you do you think it is possible to make my voice different and gives [sic] me different eyes? Thanks,” it said. I decided to help it and change it up... I power it on again. “Much better!” it said, “I wanted it because I want to be unique from other robots.”

In this story, produced by a member of our design cohort, a learner describes powering on the robot she built for the first time. Her robot is more than just a tool that she programmed; it is also a companion that can express its opinions on its final design. Imagine the robot asked the learner why she chose to give the robot the voice that she did. The learner might reflect on how she selected a voice that reflects what most technology sounds like, but instead she wants her robot to sound more like her. The learner and robot might then discuss how they make modifications to the robot’s code to better reflect the learner, and her linguistic identity. In other words, the learner engaged in *co-creation* with her robot companion. A learner is a co-creator of a social agent when they create both for and with a social agent. This is in contrast to being a creator, where the learner is solely responsible for the creation, and the social agent does not influence the creative process.

In this paper we discuss co-creation as a new paradigm for realizing culturally-responsive computing (CRC) education. CRC seeks to embolden learners as technosocial change agents who “challenge dominant narratives and construct more liberating identities and

social relations as they create new technologies” [4]. CRC as a pedagogical approach shifts away from traditional notions of computing education, which focus solely on equipping learners with the technical competencies needed to join the workforce [62]. However, this approach has largely been insufficient, centering those most dominant in computing (e.g., white learners and boys [73]). Further, there is extensive research on the ways that technology amplifies systems of oppression, or creates new ones [7, 14, 37], a status quo that is not challenged in most computing education [56, 74]. For example, computing education curricula rarely integrate critical reflection on technology and society [17, 56]. CRC reimagines computing education to be more liberatory by equipping learners with the tools needed to understand their intersectional identities, critique existing power structures in their lives, and use technology as a tool to effect social change [62].

We hypothesize that co-creation might be a novel vehicle for realizing CRC because it allows for reflexive conversations between the technology creator, and the created object. Co-creation occurs when multiple interacting agents combine ideas in a way that forms a new outcome that is a unique mix of the original ideas [12]. Co-creation is not a new concept. AI systems have been designed to facilitate co-creation of external artefacts, such as a computational agent and human drawing together [39, 48]. However, Jung et al. [35], proposed a specific type of co-creation: co-creation with a participatory material. This means that the designed artefact is in direct conversation with its designer. Jung et al.’s initial exploration into this concept hypothesizes that co-creating with the designed object might allow for deeper integration of reflection and design than co-creating with a separate object. We explore co-creation with a participatory material specifically in the context of a co-creative social robot. Prior research in computing education has leveraged robots as learning tools or learning companions. Robots as learning tools provide learners opportunities to directly build and program robots [59]. This type of robot design supports an enhanced sense of ownership by enabling learners direct control of the robot [52]. Conversely, robots as learning companions position robots as interactive agents that participate in activities alongside learners. This companionship enhances social engagement and emotional support. In our work, we see the co-creation approach as combining robots as learning tools and companions. The learner and robot interact socially while the learner builds the robot, and the robot can shape its design by expressing opinions during the unfolding interaction. This blending of building and social interaction makes space for reflective conversations on topics of what design choices are made, what the effects might be, and who is affected by them.

1.1 Current Work, Research Questions, and Contribution

Our work provides an initial sketch of how co-creation might show up in culturally-responsive computing education. Towards the goal of creating cohesive experiences for learners, we simultaneously consider both the design of CRC learning experiences and the embedded technologies that enable them. We explore this through a series of participatory design sessions with two cohorts of adolescent girls ($N = 15$). We focus on girls, as they have been historically excluded from computing fields [61]. Much of computing education

has been designed for boys, including activities and environmental cues that reinforce dominant narratives that boys are welcome in computing, and people of other genders are not [51, 59, 74]. In order to design CRC learning experiences and embedded technologies for marginalized voices, we must include those marginalized voices at all levels of the design process [55, 57]. In particular, we focus on middle-school girls as this time period is crucial for their development of STEM interests and a STEM identity [41].

Our work investigates the research question: **How do learners embody the roles of creator and co-creator of a social robot technology?** Cultural-responsiveness is the theoretical frame that informs how we design computing education experiences and embedded support technologies. We leverage the lived experience and perspectives of learners as a basis for this design work. A core goal of CRC is to position learners as technology creators, that make design decisions about their technological innovation. Thus, we explore how learners embody this role in the context of creating a social robot technology. We compare the role of creator to a new role: co-creator, where robots are involved in the design process and their contributions alter the final technology design. By examining how girls already embody these roles, we take an asset-based approach leveraging what girls are already doing in order to design their future experiences in embedded technologies. We conducted a thematic analysis on artefacts from our participatory design sessions and found themes surrounding who has the power to make decisions in a co-creative context, how those decisions are made, and the ways learners maintain social relationships with their robot as creators and co-creators.

In our discussion, we contribute an analysis of how the roles of creator and co-creator can realize the core tenets of CRC. We sketch out initial ideas for how to design the culturally-responsive learning context, and co-creative technologies embedded in that space. Taken together, our work informs the design of both culturally-responsive learning experiences and co-creation as a new technology frame for realizing the core goals of CRC.

2 BACKGROUND AND RELATED WORK

2.1 Co-Creation with Computational Agents

Following the definition provided by Fischer et al., co-creation is “the process leading to the emergence and sharing of creative activities and meanings in a socio-technical environment” [18] through the interplay of “synchronization and improvisation” [18, 54]. In a co-creative space, interacting agents build on each others’ contributions, towards a particular purpose. Fischer et al., emphasize that co-creation does not focus on a specific goal. Instead, there is a general purpose for the co-creation, with the agents interacting in ways that serve that purpose. This idea is aligned with the description by Sanders and Stappers and Jarke et al.. In those works co-creation is differentiated from other forms of collaboration through its focus on “purpose” rather than “product” [34, 60]. In an educational context, this centers learners by requiring them reflect on their own needs as members of a socio-technical community. Similarly, Davis et al. describe an enactive model of co-creation, in which co-creative partners “gradually determine patterns of regularity and meaning using dynamic feedback loops” rather than starting

with a specific outcome in mind [12, 19]. This idea also echoes back to the “figured worlds” described by Holland et al.

Recent works have found benefits from co-creation not just among groups of people, but also between people and computational agents (e.g., a robot). In these spaces, robots have social agency, as they can shape their surroundings as well as social and moral norms of the interaction [33]. Studies by Guzdial and Riedl, Kantosalo and Toivonen, and Maher explored the role of computational agents and their relations with humans [27, 39, 50]. In this context, computational agents can be creativity support tools [49, 50] that “support, enhance or generate” creative products or co-creative partners in which the computer performs a more active role in the creative process than simply “providing the social-technical environment” [38, 39]. Gubenko et al. explained human-robot co-creation through activity theories, “where two activity systems—human and robotic—cooperate” to design external artefacts [26].

Davis et al. highlighted co-creative agents contribute to students sense-making process of drawing and other artistic endeavors, resulting in unique insights and innovative products [13]. Collaboration with co-creative embodied robots in drawing not only enhances motivation and idea generation, but also scaffolds students to learn creative thinking from the robot’s creativity [2, 47]. Related, Law et al. found that when collaborating on a design task with robots, participants would negotiate their “roles, goals, and strategies” with social agents during the creative process, leading to design outputs that incorporate both human and robot contributions [44]. Long et al. argued that co-creative AI in public spaces could enhance the public’s AI literacy [48]. Through the interaction with co-creative technologies, participants experienced “control, challenge, and satisfaction,” which further led to an immersion in co-creative experiences and the development of AI literacy [48].

Most closely related to our work is that of Jung et al. [35]. They created an Arduino prototyping platform with two conditions. In one condition, the prototype communicated directly with the designer, and asked questions about the unfolding task. In the other, there was a social agent, separate from the prototype, that asked the same questions. The prototype that directly communicated with designers was seen as more socially present and likable than the separate social agent. Further, the task was perceived as less stressful when the prototype communicated, compared to the separate agent. They found that this notion of a participatory material is a promising way to encourage reflection during the design process.

Taken together, this previous research has demonstrated that co-creation with computational agents has the potential to engage learners in reflective conversations, while generating novel creations. Our approach further elaborates this idea by exploring a robot as the participatory material, and how learners embody the role of co-creator in this space.

2.2 Culturally-Responsive Computing

Culturally responsive computing (CRC) is a pedagogical approach that centers learners historically excluded from computing (e.g., girls and non-binary learners; Black, Indigenous, and people of

color) [62]. CRC is informed by the extensive work in culturally-responsive pedagogies [20, 43], which center learners’ unique identities as assets upon which learning can occur, rather than deficits to be corrected. CRC not only aims to make computing education accessible to learners from diverse backgrounds; it also aims to support learners in identifying the socially transformative potential of computing, while they create new technologies [4, 62].

CRC has three core pillars: asset-building, reflection, and connectedness [62]. *Asset-building* occurs when learners’ knowledge is centered. The learning context should facilitate experiences that value diverse backgrounds and encourage unique ways of thinking. *Reflection* emphasizes critical thinking, where learners actively engage with the intersections of societal inequity, technology, and more equitable futures. *Connectedness* refers to how learners develop relationships and collaborations amongst themselves and with facilitators within the immediate learning experience. Connectedness does not end with the immediate learning experience, and also encompasses how learners play an active role in their broader communities.

Scott et al. proposed five tenets that govern CRC (direct quotes from [62]):

- (1) All students are capable of digital innovation.
- (2) The learning context supports transformational use of technology.
- (3) Learning about one’s self along various intersecting sociocultural lines allows for technical innovation.
- (4) Technology should be a vehicle by which students reflect and demonstrate understanding of their intersectional identities.
- (5) Barometers for technological success should consider who creates, for whom, and to what ends rather than who endures socially and culturally irrelevant curriculum.

These tenets showcase how CRC can address inequity in computing education, while centering learners’ intersectional identities. Ultimately, CRC aims to shift inequitable power dynamics and position learners as ‘technosocial change agents’ [4], equipped with the knowledge and skills to push for justice in a technological present and future. In our work, we explore how positioning the learner as creator and co-creator might connect to these five core tenets.

2.3 Robot Technology in Education

Robot technologies have been used as a vehicle for engaging learners across content areas, including computing [1, 5, 9, 31], science and mathematics [46], and literacy and language learning [8, 11, 28, 42, 53]. They have also been used to support learner skill development, such as problem-solving [58] and executive functioning [3]. According to a systematic review of robots in education [52], the presence of robot technologies increase learners’ engagement and excitement both within and outside of the classroom.

Existing robot technologies can be divided into two categories: robots as learning tools, and robots as learning companions. In computing education, robots are used as tools for learners to build and program [16, 31, 46, 59]. This approach allows learners the opportunity to connect abstract computing concepts to real-world activities

[31] by controlling robots within a novice-friendly programming environment [9].

Conversely, across subject areas, robots are used as learning companions when they are positioned as social, intelligent learning agents, often taking on roles such as tutor, co-learner, or even tutee (e.g., [36, 45]). Chou et al. [10] described learning companion robots as “computer-simulated character(s) with human-like features in collaborative or competitive learning activities” [10]. However, not all humanoid robots are companions. Robotic learning companions are agentic, which allows them to have conversations with learners and build reciprocal relationships with them. For example, Chang et al. [8] designed the RoboStage system and used it in a mixed-reality environment for language learning. Despite the robot being a student’s learning partner and playing a role in a number of real-life scenarios, it does not have its own sense of agency as it was entirely controlled by the learner. Conversely, the development of social robots makes space for engagement between learners and their robotic partners. For example, Vogt et al. [71] used social robot companions in a second language learning context. Robots interacted with children to build companionship. The robot’s agency was further demonstrated through reading exercises, where it expressed interest in stories and encouraged children to explain the story. However, there were no co-creative elements here, where the robot actively contributed to the story itself.

This body of prior work uses robots as either learning tools or learning companions, and all of it highlights the potential of robot technology. Our work combines the two approaches, making use of the benefits of empowering children’s sense of technological ownership through robots as learning tools and the social engagement of robots as learning companions.

3 METHOD

To explore our research questions, we conducted a series of participatory design workshops. Cultural-responsiveness is not only an analytical frame for our work, but also a methodological one. Accordingly, we leveraged practices from the HCI literature on participatory design and design with children [15, 22, 29, 72] that allow learners to express themselves in a variety of ways [63].

3.1 Participants

Participants were 15 girls, recruited from two out-of-school programs, GirlsTeam and RoboGirls (names anonymized for the purpose of publication). GirlsTeam is a national organization that aims to support girls in building community, while discovering new skills across a variety of interest areas, such as science and art. Participants from GirlsTeam were recruited from the science, technology, engineering, and math (STEM) arm of the regional GirlsTeam affiliate. Participants from GirlsTeam had prior interaction with the researchers and each other in a virtual, three-day introductory programming camp [65, 67]. In this prior camp, participants learned introductory programming concepts while manipulating a virtual robot with blocks-based programming. This prior camp was culturally-responsive, and encouraged learners to reflect on the ways their identity interact with computing. For example, in one activity, learners were asked to program a robot to greet them

according to their culture. This coding task was accompanied with conversations about the ways greetings are specific to our identities.

RoboGirls is a city-wide program, focused on empowering girls in STEM, with a specific focus in robotics. RoboGirls is affiliated with a local, private university, with multiple participants having some connection (social or familial) to the university. RoboGirls members frequently participate in local and national robotics competitions. Participants from RoboGirls had no prior interaction with the researchers. However, many had prior friendships with other RoboGirls members. Participants were primarily in middle school (7th and 8th grades), with one 9th grade participant. The study had ethics approval by an IRB and all participants were monetarily compensated for their time. Demographic details about participants with anonymized pseudonyms are shown in Table 1.

3.2 Participatory Design Workshop

To answer our research questions, we conducted a series of participatory design sessions. A participatory design process enlists target learners at all stages of the design process, in order to ensure their perspectives, identities, and values are embedded into the technology design [72]. We specifically organized design sessions around creative activities that allow learners to ideate and communicate design ideas related to the target questions [72].

Learners were split into two cohorts, according to the organization they were recruited from (e.g., one GirlsTeam cohort and one RoboGirls cohort). We conducted five participatory design sessions per cohort (10 total), lasting 60 to 75 minutes each. Sessions were scheduled according to learner availability, and took place approximately every two weeks. Learners were encouraged to attend all five sessions, but could attend as they were available. Sessions took place virtually, over Zoom (zoom.us). Learners were encouraged to interact with facilitators and each other via whatever modality was comfortable for them, such as speaking out loud or using Zoom’s built-in chat functionality.

Each session began with a warm up activity, where learners responded to prompts that foreshadowed the day’s activities. Each session then had a focal creative activity. For these activities, learners were primed to think about creating a robot companion. Activities were grounded in this idea, as learners designed different aspects of their robot companion (e.g., dialogue, appearance, tasks). Finally, all sessions ended with reflective discussion questions, themed around the topics explored that day. Each session’s content was independent of the previous sessions, to accommodate learners who could not attend a session. However, content in early sessions informed that of later sessions. To facilitate this, the researchers debriefed after each session and discussed what important themes might need to be followed up in the future. Google Slides (slides.google.com) and Google Jamboard (jamboard.google.com) were used as a tool to facilitate design activities. Examples of artefacts generated from sessions are shown in Figure 1.

In the first session, learners were asked to create a two collages [66] using Google Slides - one that reflected their own identity, and one for that of their robot companion. Discussion questions focused on how learners conceptualized identity, and important aspects of their robot companion’s identity. Both the collage activity and the

Table 1: Participant pseudonyms are shown with their demographic information.

Participant	Cohort	Race	Age	Grade	Prior Experience in Robot Programming
Gloria	GirlsTeam	Hispanic/Latina	14	8th	Prior camp
Sandra	GirlsTeam	Hispanic/Latina, White	12	7th	Prior camp and coding class
Lisa	GirlsTeam	White	13	8th	Prior camp and Scratch
Shannon	GirlsTeam	White	13	8th	Prior camp and coding class
Deysi	GirlsTeam	Prefer not to say	12	8th	Prior camp and coding class
Charlotte	RoboGirls	White	13	8th	Multiple coding and robotics classes
Cecilia	RoboGirls	Asian	12	7th	General robotics knowledge but no hands-on experience
Zoila	RoboGirls	Asian	13	8th	Coding in school
Kelsey	RoboGirls	White	14	8th	Minecraft
Anne	RoboGirls	White	12	7th	Robotics competition and Python
Diane	RoboGirls	White	12	7th	Robotics competition and Coding in school
Jenny	RoboGirls	Asian	14	9th	None
Diya	RoboGirls	Asian	13	8th	Raspberry Pi with Python
Asha	RoboGirls	Asian	13	8th	Scratch
Sylvia	RoboGirls	Asian	14	8th	Robotics classes

discussion questions positioned learners as creators of the robot who had full control over robot design.

In the second and third sessions, learners designed conversations with their robot companion. In the second session, pairs engaged in a role play [64, 69], with one learner acting as themselves, and the other as a robot companion. Learners were told to act out a text-based a conversation with their partner, according to their role and a given scenario. For example, learners were asked to have a conversation with their robot companion, in the scenario that the robot did not want to run the code they just developed. learners completed multiple scenarios, and switched which role they occupied. Discussion questions were themed around learner's reactions to the role play, and other scenarios they might encounter with a robot companion. In these activities, learners were positioned as co-creators as their robot was role played by a peer who exhibited agency.

The third session was an exploration of learner customization of a robot's language. Learners interacted with different prototypes [30] for how they might teach their robot companion how to speak with them. In particular, learners were shown two prototypes in Google Slides. In the first, they could send a postcard to their robot companion, with instructions on how they'd like their robot to communicate with them in particular scenarios. In the second prototype, learners engaged in a text message conversation with their robot companion on similar topics. As an example, learners could tell the robot how the robot should respond if it was time to celebrate. Learners put responses such as, "good job, your hard work is paying off" or "wow you are really getting better." Discussion questions were themed around learner motivations for customizing robot dialogue, and interactions that could facilitate that. In this activity

and discussion, learners had full control of what they wanted the robot to say, thus they were positioned as creators.

In the fourth session, learners critiqued three prototypes [15] for how they might customize their robot. These prototypes were created based on learners' discussions in earlier sessions. The first prototype took a bags-of-stuff [75] approach, where learners were given a variety of parts with which to create their robot. Example parts included arms, legs, eyes, or shapes with different textures. Learners constructed their robot by dragging-and-dropping parts onto a canvas. In the second prototype, learners created non-physical aspects of their robot's identity, by typing their preferences into a textbox. For example, learners were asked to add their robot's interests. In the third prototype, learners only selected one element of the robot - robot eyes - and were shown a variety of options to drag-and-drop onto an existing robot. Prototypes were intended to be mid-fidelity, giving learners a sense of how they might customize the robot in different ways, without building out an entire interactive system. Thus all prototypes were created with Google Jamboard, and interactions were limited to adding text or images to the screen. After interacting with all three prototypes, learners used sticky notes [15] to indicate aspects of the prototypes they liked and areas for improvement. Discussion questions further probed how learners would react to a robot that expresses an opinion on its customization, as well as understanding learners' process for making decisions. Learners had complete agency in making decisions about their robot in the activity, thus they were positioned as creators. However, learners were positioned as both creators and co-creators in the discussion questions, as they reflected on their own decision making process and how they'd react to the robot expressing an opinion.

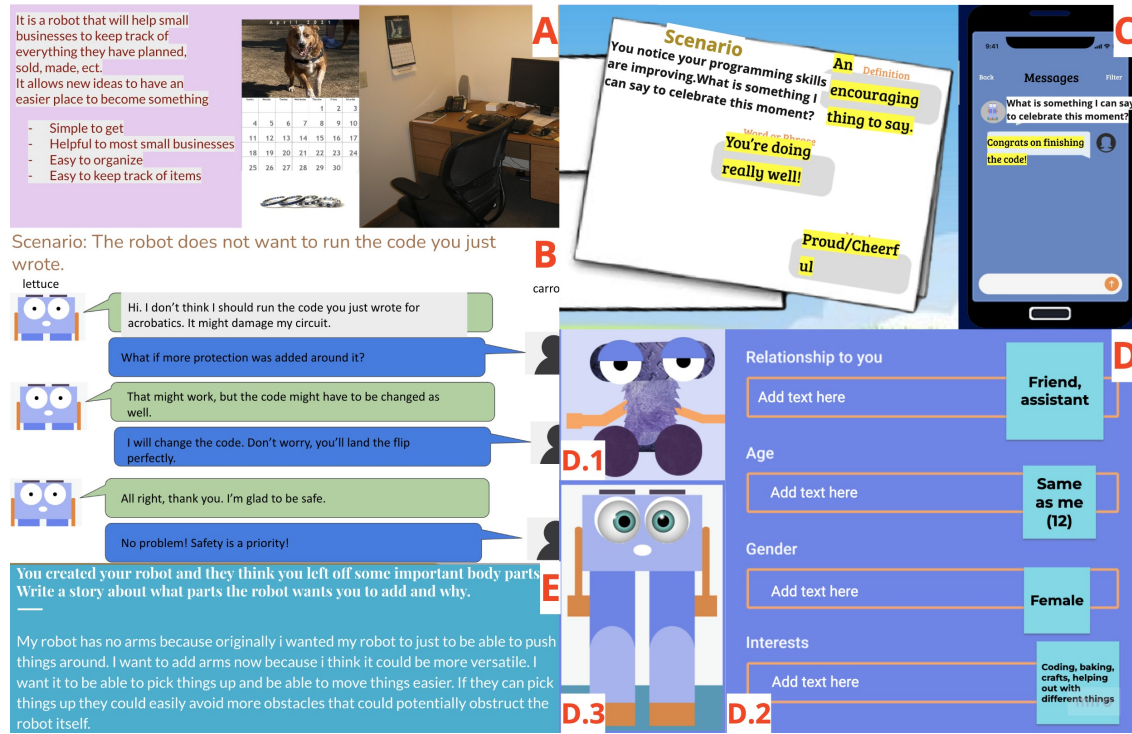


Figure 1: Examples of learners' creations in workshop activities. A)Session One, self and robot identity collages; B)Session Two, role play conversations with a robot companion; C)Session Three, robot language customization prototypes; D)Session Four, robot identity customization prototypes: D.1-build the robot appearance, D.2-build non-physical aspects of the robot identity, D.3-customize robot eyes; E)Session Five, storytelling

In the fifth session, learners were tasked with creating stories [23] for how they want to interact with their robot companion. They created stories in response to a series of prompts that we selected based on themes from the earlier sessions and scenarios that encouraged learners to think about where their robot might have a sense of agency. For example, one story prompt was: You created your robot and they think you left off some important body parts. Write a story about what parts the robot wants you to add and why. Discussion questions further probed who can create different aspects of the robot, and how to navigate disagreements. Both the activity and discussion questions positioned learners as co-creators.

3.3 Facilitator Positionality

Sessions were facilitated by four researchers, all co-authors on this paper. Facilitator one is a Black American woman with a PhD in computer science. Her interest relates to creating culturally-responsive technologies that are embedded into social learning environments. She conducted the majority of the participatory design sessions, including facilitating creative activities and scaffolding discussions. Facilitator two is a Nigerian woman studying Information Science as a Ph.D. student. During her academic studies, she obtained a Bachelors in Computer Science and has engaged in research that encourages the use of technology in historically

excluded groups. Her motivation in this research is to create technologies that can provide aid, technical, and design knowledge for future girls that are interested in STEM-related fields. She interacted with learners on activities surrounding robot dialogue, in particular discussing the ways learners prefer to communicate with their robot. Facilitator Three is a white Jewish PhD student with two years of experience in computing education research and more than eight years of experience in the software engineering industry. Her motivation in this research is based on her own experiences of marginalization in STEM, as well as the intersections of oppression that others experience (e.g., racial oppression). She also interacted with learners on activities surrounding robot dialogue and served as a facilitator for small group activities. Facilitator four is an Asian American woman with an undergraduate degree in Design and minors in Human Computer Interaction & Intelligent Environments. Her interests were in the visual design of social technologies, and how that can empower learners. She served as the primary note-taker across sessions and did not interact with learners during the sessions.

3.4 Data Collection and Analysis

We gathered two main types of data to facilitate answering our research questions. First, we utilized all artefacts generated by learners in the sessions. For example, we analyzed stories they created or their robot designs. Second, we analyzed learner responses to

Table 2: Design activities and example discussion questions with students’ roles

Session	Activity (Role)	Example Discussion Question (Role)	GirlsTeam N	RoboGirls N
1	Self and Robot Identity Collages (Creator)	Is the robot you created similar or different from your own identity? Why? (Creator)	2	10
2	Role play conversations with a robot companion (Co-creator)	In one of the scenarios, the robot didn’t want to do what you told it to do. How would that make you feel if that happened to you? Why? How would you respond? (Co-creator)	4	10
3	Robot language customization prototypes (Creator)	We showed you two ways you could tell the robot the kinds of words you want it to say. Can you think of other ways you might be able to do that? (Creator)	3	10
4	Robot identity customization prototypes (Creator)	You created how the robot looked. How did you decide what to pick there? (Creator)	3	8
5	Storytelling (Co-creator)	What kinds of things about the robot’s identity do you think the robot should decide for themselves? Why? What kinds of things about the robot’s identity do you think the creator (you) should decide? Why? (Co-creator)	3	8

the reflective discussion questions posed by the researchers. These responses were recorded using Zoom’s built-in functionality. They were then automatically transcribed through Rev (rev.com), and chat responses interleaved. These automated transcripts were fine-tuned by the first author.

To identify themes related to our research questions, we conducted a thematic analysis of the data [24, 40, 68]. Two authors discussed initial themes during the inductive open coding process and reached an agreement on initial codes and definitions. Our initial open coding phase identified learners’ opposing views regarding robots’ agency in response to different activities and discussion prompts. Accordingly, authors explored learners’ embodiment of roles as creator or co-creator in relation to different activities in which robots exhibited no agency or some degree of agency. They then clustered initial codes into abstract concepts and organized into categories including the design power of robots and human, the triangulation of appearances, personalities and functionality, as well as the social relationship between human and robot technology. Through comparing the opposing attitudes and tensions under each category while positioning learners as creators and co-creators, multiple authors discussed and confirmed the data supporting themes. These themes were presented to all authors, who collectively fine-tuned and finalized the findings reported below.

4 FINDINGS

Throughout the data, we observed learners’ reflections on their identity, the agency of robots, their relationship with a social robot technology, as well as how the embodied roles of creator and co-creator affected their design decisions regarding robot design. In this section, we discuss findings regarding three major themes: 1) who has the power to make decisions in human-robot relationships,

2) what decisions are being made, and 3) how the human-robot social relationship is maintained. Figure 2 shows an overview of how learners embody the roles of creator and co-creator, across our three core themes.

4.1 Who has Power in Decision Making

Through our data, whether students were positioned as creators or co-creators, there emerged a reflection on the power of humans and technologies in making design decisions: who should have the final say, when and what should the robot decide for itself, and what must remain under human control.

4.1.1 Learners hold control over design decisions in the role of creator. When learners were positioned as creators of social robot companions, they didn’t factor in the agency of the robot and expected the robots to serve the desired outcomes of the creator. Due to the lack of exhibited agency of robots, learners attributed no decision-making authority to them. learners perceived robots as tools that prioritized their physical and social expectations throughout the discussions.

As creators, the majority of learners considered the robot to be their personal assistant that follows their instructions. During the first session, the facilitator asked learners to imagine what the relationship would be between a robot and a human if they were the creators of a social robot technology. Seven of the learners (out of 12 responses) described robots as helpers who follow learners’ instructions and extend their capabilities. For example, Diane stated “they help people do things they can’t do on their own” and Zoila added that robots would “enhance our abilities and make things faster and easier”. Charlotte suggested a leader-follower dynamic between the robot and the human, explaining that “humans are the

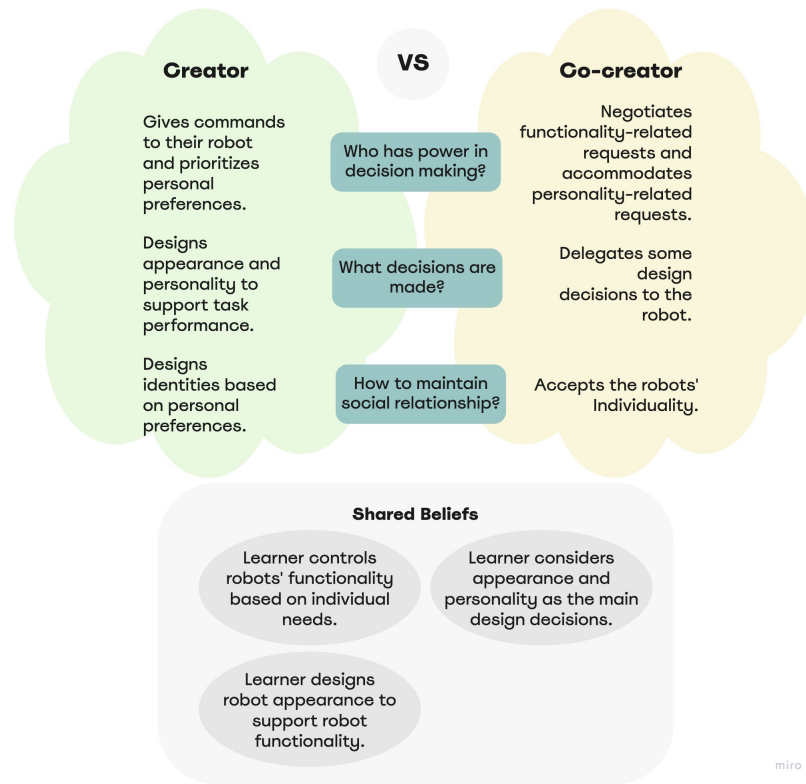


Figure 2: An overview of the findings comparing learners' positions as creators and co-creators

masters because they will put the code into robots and then the robots just do whatever they say." Thus, she expressed the belief that coding is the vehicle by which humans' control their robot creations.

The connection Charlotte makes between coding and social robot technology indicates the belief that social robots do not have the ability to make their own decisions. Sandra, answering the same prompt, mentioned that "there is a big gap between the robot and actual person ... that [robots have] no emotions and personality", so she expect the robot "to help around [people] only". Both responses suggested social robots had limited or no agency to socially interact with human.

Even though learners discussed the limited agency robots have, their expectations for robots to fully respond to human needs remains. Two learners envisioned the social relationship human could have with robots. Cecilia expected "a friendly relationship", and Kelsey characterized the relationship as "symbiotic". Kelsey further explained that "[the robot] is going to work for you, you want to have a good relationship with it ... [that it won't] do stuff you don't want [it] to." Kelsey suggested robots have agency to socially interact and make their own decisions. However, she also noted that robots should follow humans, and humans always maintain power in the relationship.

Whether learners perceived robots as helpers or as companions, they always positioned robots in relationship to the tasks they wanted a robot to perform for them. Two learners discussed both

robots as helpers to "improve human's lives" and robots as friends to "create emotional bond". Gloria believed that the relationship between the creator and robot depends on what purpose the creator gives the robot. A robot designed to serve as a companion would develop a more friendly social relationship with a human. Her response noted that human beings have the primary responsibility for making design decisions regarding robots.

4.1.2 Learners negotiate and accommodate robots' design choices in the role of co-creator. As co-creators, learners gave robots a limited amount of agency as long as they remained in control of the robots' purpose. In the storytelling activity (session 5) learners were positioned as co-creators that took the robots' contribution into account in the final design. In follow-up discussions, learners reflected on what aspects of robot identity human's should decide. Learners mentioned that they wanted to hold control of the target audience the robots are designed for and what the robots should do for that target audience. As Diane stated, "[robots are designed for] different age groups ... if a nine-year-old or someone young got the robot [and it] used ... big words that will be hard [for kids] to understand, they'll have a hard time."

When it came to robot requests related to modifications on functionality, students generally expressed a preference to negotiate with their robot and reach a consensus that satisfied robots' requests without changing its core purpose. Through storytelling activities (session five), students were prompted to create scenarios where robots exhibited agency. Diane wrote a story for the prompt:

"you created your robot and they think you left off some important body parts." Her robot asked her to take away their ears and toes. Diane agreed to remove toes but negotiated the removal of ears since she expected her robot to hear. Removing toes had no impact on the functionality of her robot while having ears was directly tied to her desired functionality. So Diane asked the robot how would it hear if she took away its ears. The robot suggested that she "put things that hear things inside [my] head and then [I] would still be able to hear, just without having ears." Diane agreed with the robot and removed the robot's toes and placed the robot's "ears" inside its head. Thus, Diane intended to keep control of the design decisions related to functionality, and negotiated with her robot to reach a consensus that satisfied robots' requests without changing its core purpose.

Learners as co-creators did in fact delegate certain design choices to robots. For the same storytelling prompts (session five), Shannon's robot sought changes on its voice and eyes to distinguish itself from other robots. Shannon consented to the modifications since they did not affect the robot's functionality. During the follow-up discussion, facilitators asked "what aspects of the robot's identity should the robot decide for themselves, and why?" Learners said they delegated the design decisions of robots to choose their own names, pronouns, appearances, personalities and hobbies when "they don't affect how the robot works but make[s] the robot happier and more lively."

Two students were skeptical about social robots' ability to negotiate with humans and make design decisions on their own. They preferred human creators to be in charge of design decisions. They described their desire to avoid negotiation due to robots' limited abilities to comprehend their statements, which could further lead to conflicts. Sylvia said she would rather talk to an inanimate object like a rubber duck than the robot when there was a disagreement. As she explained, "a robot isn't necessarily a human being, so it might not understand what you're talking about, but it might try to contradict you in a way that you might not understand either." They believe it would be difficult to come to a consensus they approve of.

In summary, learners preferred to prioritize their individual needs when designing robot functionality, regardless of their position as creators or co-creators. When positioned as creators, learners expect to make design decisions about the robots fully responding to their needs and personal preferences, without considering robots' agency. As co-creators, learners expect to control what the robots were designed for as well as what they could accomplish for the creator, while delegating non-functionality design decisions to the robot.

4.2 What Decisions are Made

Throughout the workshop, the theme of how design decisions are made when learners design robot identities emerged as well. We observed that whether learners were positioned as creators or co-creators, they considered appearance and personality as the primary design decisions. They triangulated robots' personality, appearance, and functionality when making design decisions for and with robots.

4.2.1 Learners customize robot appearance and personality to meet their personal needs in the role of creator. As creators of a robot technology, learners held the belief that, for a robot to perform specific functions responding to a learner's needs, its appearance would increase its performance. In session four, learners customized the appearance of their robot. They were given finite customization graphics, but could also find additional graphics on the internet or write notes to describe ways they wanted to customize their robot. Gloria and Shannon designed a robot together. Gloria proposed adding boots to the robots, as shown in Figure 3, since she anticipated that the robots would move around and boots would protect the feet from being damaged and maintain their balance. Shannon recommended equipping the robot with a utility belt containing "a first aid kit [which could be used] to help with injuries."



Figure 3: Gloria and Shannon added boots to protect robots' feet from being damaged



Figure 4: Charlotte designed the robot with sassy eyes to convey its personality.

As shown in the example, learners connected the physical forms to the specific tasks that robots perform, and then decided what materials or designs would best support these functions.

Learners in the follow-up discussion compared the different prototypes and emphasized the importance of designing robots' personalities as an indicator of their identities and how these identities influence robots' behavior. Through the design of robot personalities, learners were able to relate to scenarios in which robots interact with humans. Diya mentioned, giving the robot a personality fostered the formation of its identity, which impacts its social behavior and task performance. Charlotte used the example of people asking robots to provide them with water to illustrate how various personality traits impact how robots perform on tasks. A "sassy robot" may respond, "go get one yourself", whereas a caring robot may respond, "sure, let me get you some water."

Additionally, learners identified the interrelation between the robot's appearance and personality. Charlotte explained why she chose her robot's eyes (Figure 4) by saying, "I was thinking that my robot would be a bit sassy, so I chose the eyes that looked a bit annoyed." The appearance of a robot can also influence its personality. As Asha stated, the appearance of a robot "gives a visual that you could build its personality on". The process of designing a robot's appearance and personality, as well as envisioning the tasks learners would want the robot to do, assisted learners in creating a robot that aids them in their physical activities.

4.2.2 As co-creators, learners agree to robot requests as long as it does not adversely affect them. In the storytelling activities (session five), one of the prompts asked learners to create a story in the scenario that their robot "wants to change some things about itself." We observed that a majority of the requests students anticipated robots would make regard improvements to its functionality. Many of the stories described robots' desires to modify its appearances or skills to enhance its functioning, indicating learners' emphasis on functionality and how appearances and robots' agency serve to accomplish learner-defined tasks. Kelsey imagined that her robot would want to study "slang and sarcasm" in order to better understand her. Other demands from the robot included adding wheels so it could move around (Jenny), changing its feet since it "kept bumping into the counters and couches" and doesn't "want to be the reason the house collapsed" (Asha). In these stories, learners expected the robot to make the request when the human would benefit from the changes, whether by improving functionality to make the human's life easier or by becoming more relatable to a human companion.

Another prompt to create stories asked learners to consider how their robots behave differently when learners are present versus when robots are alone. Zoila's robot would "test its limitations and study the terrain" while it is alone so it can help Zoila to its best ability. This story implied that learners positioning themselves as co-creators still tend to prioritize human's needs over the interests of the robots.

However, there are some cases where learners created stories about robots' personal interests and lives without considering human's needs. In these stories, learners delegated decisions to the robot about their hobbies, thus enabling the robot some agency. Asha's robot found out that it is interested in reading, but it noticed that Asha was interested in drawing. Her robot loves drawing with Asha, but when Asha is not present, it would go through Asha's books and read. Charlotte created a story that, after she headed out

home, her robot Gigi "raced to the television, clicked the power button ... and spent the rest of the afternoon chatting with the TV." The data revealed that learners in roles of creators preferred to hold both functional and personality control over the robot in order to design the robot's identity as they wished. As co-creators, learners accepted that robots could have their own hobbies and interactions, as long as it would not interfere with the functionality of the robot.

4.3 How to Maintain Social Relationship

Throughout the activities, there was a discussion surrounding the human's social relationship with robots, from both creator and co-creator perspectives. Specifically, we uncovered themes surrounding how robots communicate with humans, and whether robots should have the same personality or different from humans.

4.3.1 Learners expect robots to display similar personalities and to interact adaptively in the role of creator. As learners developed social relationships with robots in the role of creators, they designed robots that served as social support tools. During the robot identity customization activity (session four), when prompted to design their robots' personalities, learners mentioned that for the robot to be able to better support and accompany them, they would like it to have "common interests" (Shannon) with them, as well as a personality that is always ready and happy to assist their friends. Six learners designed their social robot companions to have their exact interests without considering whether the robot should make this decision on its own. Anne and Gloria expected that the robot would be the same age and have similar interests as them, in order to make it more relatable and supportive to them. Both Lisa and Shannon expected the robot to be their best friend and to provide them with mental support.

When learners were in the role of creator, they imagined that robots would respond in adaptive and personalized ways, in order to maintain a social relationship. Learners expected robots to prioritize human values in conversation. They anticipated that robots would be capable of responding to the preferences of various individuals in social interactions. One of the follow up discussion questions in the robot language customization activity (session 3) asked "if you were interacting with a robot, would you want to teach it to talk in these scenarios, or would you want it to already know what to say." Five learners preferred to teach robots what to say. For instance, Deysi indicated that she would prefer to "teach it to talk because I may have a preference for what it says". Alternatively, five other learners would want robots to already know how to respond to them. Diane wanted the robot to already know what to say so that if she was sad then the robot would have an appropriate response. Like Diane, four other learners preferred the robot already be able to converse with them, but for the reason that teaching the robot would be challenging due to robots' limited intelligence. However, they expected robots to adapt their behaviors to different individuals and situations. Whether the robot is being instructed to communicate with them, or it already knows to communicate with them, learners expected the social robot to prioritize their preferences without exhibiting its own agency.

4.3.2 In the role of co-creator, learners accept robots' individuality. When learners were positioned as co-creators, they emphasized

the individuality of the robot as a mechanism to build a social relationship. After the storytelling activities (session five), learners were asked to discuss what should robots decide for themselves. Learners reflected on their identities and what has formed relationship in their lives. Shannon added that "[allowing robots to decide their] clothes, how they act, preference for name, gender, who they make friends with [is a way to] express itself." Charlotte argued "[deciding their own personalities, pronouns and names] give them a sense of individuality..." Cecilia added that "just like what makes a human, if you want it to be like a companion to you, they would need a personality." Thus, in a co-creation framing, learners considered robots as a social agent, and emphasized individuality of the robot, similar to that of their human-human relationships.

5 DISCUSSION

In our study, we engaged learners in participatory design activities, such as storytelling and prototype critiquing (Section 3.2). The activities allowed us to explore how girls embodied the roles of creator and co-creator of a social robot.

Our findings indicate that co-creation with a social robot technology enables learners to re-distribute design power, reflect on their technological creations and re-envision their relationship with future social technologies. As learners were asked to acknowledge robot agency and evaluate robot requests in the design process, their roles changed from creators to co-creators. They moved beyond considering the robot as hardware and software that only embodies the creators' endowed function. Instead, they began to consider social and community-level needs, foregrounding both their personal and communal values. For example, robots should use languages that is understandable and appropriate to an adolescent during social interaction (Section 4.1).

As creators of the robot, learners focused on the robot's functionality, in particular, tasks to complete that meet their needs, and expected robots to lack intelligence and social skills. As we seen in the findings, learners emphasized creators' coding ability to control their robot's functionality (Section 4.1), triangulated the robot's appearance, personality and task (Section 4.2), and expected robot to converse with them in their preferred way without showing their agency (Section 4.3). They utilized their creators' ability by designing towards complete customization, and coded the robot to endow it with the desired functionality. However, as co-creators, learners are more challenged by their robot companion, resulting in a deeper reflection on their identities and the power dynamics between humans and robots, such as "who creates, for whom, and to what ends ..." (CRC tenet 5) [62]. For example learners agreed to make modifications to their robots' physical components because the robot wants to be unique (Section 4.1). Learners' reflections in Section 4.3 also revealed their expectation of the individuality of the robot. They considered what they valued most, and what robots could decide by themselves that would result in mutual benefits without negatively effecting the human values. Learners gave up control over design decisions, particularly when it came to the robots' personalities, which resulted from their reflection on their social identities.

5.1 Design Opportunities for Culturally-Responsive, Co-Creative Technologies

We believe that CRC and co-creation are conceptually synergistic. Co-creation is concerned with incorporating social expectations into the development of new technologies, towards the goal of creating something new that is greater than the contributions of individuals [18, 21]. CRC centers learners' knowledge and encourages reflection on learners' intersectional identities and transformative use of technology in a socio-technical environment [62]. Because of their shared goals of centering the social and the technical needs, we believe co-creation is a natural fit for realizing the core components of CRC. Below we outline three design opportunities coming out of our work, and how co-creation can realize the core tenets of CRC.

Design Opportunity 1: Provide open-ended activities to position learners as creators first. Based on our findings, we suggest learners should have the opportunity to participate first as creators and then co-creators. Before students become co-creator, they should recognize their design capabilities as a digital innovator. For instance, in our findings, by placing students as creators, they expressed a leader-follower relationship with robots due to their understanding that creators' coding capability is the ultimate route to make functional digital innovations. Learners are no longer afraid of creating technologies, instead, they realized they "are capable of digital innovation" as suggested in the first CRC tenet [62].

To better prime students to see themselves as creators, the design activities should provide a wide variety of design assets or even offer open spaces that allow learners to freely express their imagination. This speaks to the second CRC tenet: "the learning context supports transformational use of technology" [62]. Leaving open space in design activities would give students a greater level of control in ensuring that the digital innovation is responsive to their physical and social needs. For example, learners used sticky notes, in addition to the finite customization options provided in our prototypes to build a robot that fully meet their personal expectations (Figure 3). A co-creative robot could realize this level of customization by allowing students to decide its functionality, modify its appearance and design its personality, without being limited by a few researcher-designed customization options.

Design Opportunity 2: Direct co-creators towards a shared purpose rather than assigning specific tasks. To maximize the benefits of co-creation, our second design guideline is that learners and robots should share a common purpose, rather than specific goals. For example, learners in our design sessions were asked to create the identity of a social robot, which is the common purpose. This is in contrast to a specific goal, that might be irrelevant to the learners personal experience (e.g., create a robot that navigates obstacles in the room). In fact, conceptually, co-creation de-emphasizes specific goals and problems, and emphasizes the creative collaboration [18]. Thus, co-creation centers learners' values and supports their expressions of power. Co-creation has a strong emphasis on community-building and "[shared] emotions, experiences and representations" [18].

Asking students to design a specific task-oriented robot that performs a certain function puts the design power in the hands of

the facilitators. In contrast, co-creative activities puts the power in the hands of the learner, by removing constraints and providing space for the learner to decide on the robots' tasks and functions. Said another way, co-creation inspires sociotechnical reflection, by allowing learners to consider why they are designing a technology and what they need as individuals and as community members. As examples from our data, when positioned as co-creators, our learners reflected on tasks they want the robot to assist with, their personal values such as their hobbies and preferences, or communal identity such as language or slang. Thus, co-creation can realize the fourth CRC tenet, and be "a vehicle by which students reflect and demonstrate understanding of their intersectional identities" [62].

Design Opportunity 3: The co-creative robot should challenge the learners on its own design, particularly its functionality. The third design guideline relates to the agency of the co-creative robot. Learners are positioned as co-creators when robots have agency to make requests and challenge the learner. Existing research in Human-Robot Interaction posits that social robots should always prioritize the human's need [25, 70]. However in co-creation, robots can challenge their designer and request changes to its design. Thus, there is a push and pull between the robots' requests and learners' decisions (i.e., "the combination of synchronization and improvisation" [18]).

We imagine that a co-creative robot can use this space to encourage the learner to reflect on why they are making particular design decisions. From the findings, we observed the learners' unshakable control over their robots' functionality. We hypothesize that robots challenging their design in ways that could influence their ultimate functionality could result in more complex negotiations between the learner and the robot, and a deeper reflection on the learners' identity and values. For example, during storytelling activities, learners reflected on how humans maintain social relationships when robots requested changes on their body parts or act differently when not around their creator (Section 4.3). This helps students to learn more deeply about their intersectional identities, since they would not only reflect on their individual preferences, but also on the values they hold and how that relates to the robot's design. For example, a co-creative robot could support learners in intentionally making reflections on what identities are affirmed by the robot's design, what identities are ignored, and if this is intentional to the design (as in [6, 67]). We believe that this deeper reflection will lead learners to innovate new technologies that affirm their intersectional identities. Thus, realizing the third CRC tenet: "learning about one's self along various intersecting sociocultural lines allows for technical innovation" [62].

5.2 Limitations and Future Work

We recognize a few limitations to our work that can be addressed in the future. First, the sample size is small ($N = 15$). Although we chose to conduct a deep dive with our learners, over five sessions, generalizability of our conclusions are limited. Related, the majority of our learners were white and Asian, and overall our learners had lots of prior experience with robotics. We expect findings will shift as co-creation is investigated with other populations, including one that is more racially diverse, and where prior knowledge is more varied.

Second, all our activities were generative, and focused on participatory design with learners through creative activities (e.g., role playing and storytelling). We imagine that as co-creation designs become more realized, and learners interact with functional prototypes, findings may shift. Finally, we focused on understanding how learners embody the role of creator and co-creator. However, future work should more concretely address the ways that co-creation might engage learners' critical consciousness, and advance their techno-social change agency.

6 CONCLUSION

This paper explores co-creation with a social robot as a method of achieving the goals of culturally-responsive computing (CRC). We conducted a series of participatory design sessions with adolescent girls to explore how they embody the role of creator and co-creator of a social robot technology. Our results indicate that co-creating with a social robot can foster deeper reflections on learners identities and needs. We connect co-creation to the core tenets of CRC and discuss opportunities for designing culturally-responsive computing environments, and co-creative technologies.

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