Robots for Connection: A Co-Design Study with Adolescents

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***Abstract*— Adolescents isolated at home during the COVID-19 pandemic lockdown are more likely to feel lonely and in need of social connection. Social robots may provide a much needed social interaction without the risk of contracting an infection. In this paper, we detail our co-design process used to engage adolescents in the design of a social robot prototype intended to broadly support their mental health. Data gathered from our four week design study of nine remote sessions and interviews with 16 adolescents suggested the following design requirements for a home robot: (1) be able to enact a set of roles including a coach, companion, and confidant; (2) amplify human-to-human connection by supporting peer relationships; (3) account for data privacy and device ownership. Design materials are available in open-access, contributing to best practices for the field of Human-Robot Interaction.**

I. Introduction

Adolescents become less reliant on their parents for support and begin to turn to peer relationships, making peers the primary source of happiness. Supportive peer relationships positively influence adolescents' mental health and can be protective in terms of preventing suicide attempts, helping overcome depression and anxiety, and fostering a happy life [1], [2]. The Coronavirus-19 (COVID-19) pandemic has profoundly affected the way adolescents relate to each other [3]. One of the most abrupt shifts brought by COVID-19 for adolescents was the lockdown, where they were confined to their homes to safeguard health and safety [4]. This confinement —plus the 24/7 parental attention, supervision, and control that accompanied it—, imposed unique sources of stress on everyone, especially on adolescents, who were distanced from their main source of social connection and support: their group of peers [5].

Our work focused on engaging adolescents in the co-design of a social robot to determine appropriate form and behavior for a home mental health supportive robot. Bringing adolescents as collaborators of the design of their robot constitutes an essential first step towards understanding design requirements to build a robot that can support their mental health from home.

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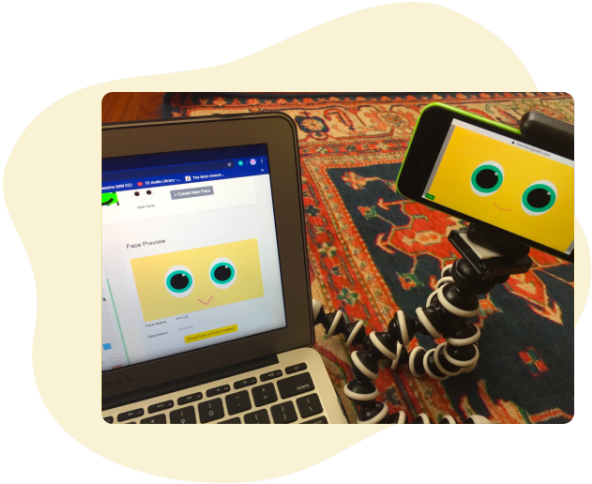

Fig. 1. Adolescent design of a home robot.

II. Background

A. COVID-19 Effects on Adolescents

The ongoing COVID-19 disease spread is a public health emergency and a global threat. Governments across the world, the U.S. included, have ordered citizens to stay at home as an emergency measure and implemented school closures to prevent further spread of the infection. As of March 2020, more than 150 million children and adolescents in 165 countries have been affected by the closures. Under such situations, physical and mental health problems are significant concerns, particularly related to adolescents' lifestyle behaviors, significantly impacting healthy behavior due to isolation [6], [4]. The pandemic is also exacerbating levels of anxiety and stress that are likely to persist long after shelter-in-place orders are lifted [7]. Social connections have been shown to be protective against adolescents experiencing the negative impacts of perceived stress during COVID-19 [8]. Therefore, finding ways to maintain social connections and support mental health in adolescents during COVID-19 may be imperative to their future mental health.

B. Robots for Connection

Socially assistive robots have been proposed in the past as a mechanism to support mental and physical health [9]. While many health-supporting functions for these robots were offered by going to clinics, hospitals, and schools, the demands of social isolation are placing restrictions on the population to use these care systems. Robots may be of help during these times by providing a safe way to

guarantee support services during times of isolation [10]. For example, prior to the COVID-19 outbreak, the robot Fribo was developed to connect groups of adult friends, promoting a cohabited experience even though friends were living in different houses [11]. In this paper, we gathered design requirements of adolescents for a home robot that would help them overcome isolation derived from a worldwide pandemic outbreak, which raised novel ways to consider the role and needs of robots for connection.

III. Robot Platform

The robot used in this study consisted of the participant's personal smartphone, which rendered the robot's customizable face, and a flexible tripod that can be shaped and covered in different ways to represent the robot's body (see Fig. 1). The robot was purposely kept simple and highly customizable to help adolescents express their preferences and generate novel design ideas while still getting a sense of how interactions with physical robots feel. The software for the system was designed in-house and consist of a web application that runs on a browser. Each user was given credentials to access their robot's content to ensure data privacy. The smartphone application renders the robot's face, while the desktop application displays the robot dashboard to help participants navigate different tools to interact with it. The dashboard has three tools: (1) Robot Face Editor, (2) Robot Diary, (3) and Stress & Mood Reporter.

IV. Methodology

We employed participatory design methods from human-centered design, as this is an appropriate way to engage vulnerable populations (such as adolescents) in the design of social robots [12]. We relied on a co-design approach where adolescents acted as collaborators in the process of designing the robot, side-by-side with researchers [13], [14]. This method prioritizes the perspective of adolescents by voicing their needs and concerns in the design requirements for a home robot [15]. Additionally, this study was conducted in situ to ensure ecological validity [16], [17].

A. Participants

Our sample consisted of 16 adolescents (9 females, 6 males, 1 non-binary) whose ages ranged from 14–18 years old (M=15.75, SD=1.34). Participants were recruited using an online flyer that was shared on social media websites accessible to parents. Only adolescents whose parents signed the consent form were included in the study, and this study was approved by the University of Washington Institutional Review Board (#STUDY00002822). As an inclusion criterion, adolescents needed to own a smartphone with internet access, as this was needed to run the robot software during the study. Self-reported ethnicity revealed that 43.8% of our participants identified as Asian, 18.8% identified as White, and the remaining as multiracial; they were from the states of Illinois, Kentucky, New York, Washington D.C., and Washington. Each adolescent received an Amazon gift card of $65 for the time spent on the study.

B. Materials in Open-Acess

A Design Kit that was shipped to adolescents' homes included (1) a tripod to place the personal smartphone, (2) instructions on how to use the robot platform, (3) prototyping materials to kick-off the design process, (4) and a checklist with details about the remote design sessions. In total, we shipped 16 individual Design Kits and offered them to the participants when the study ended [18].

C. Procedure

Our study started on May 23, 2020 and finished on June 20 of the same year, coinciding with the COVID-19 outbreak in the U.S. and a nationwide lockdown period to contain its effects. This lockdown included the closure of schools, which started to operate remotely. Severe social restrictions were in place, including the closure of all social spaces, such as coffee shops, parks, cinemas, theaters, etc. The population was allowed to leave the house exclusively to perform essential activities, such as grocery shopping. Physical contact was prohibited outside one's immediate social group, people were obliged to wear a mask, skin sanitize to prevent contagion, and keep a 6ft distance from others [19], [6]. Due to this, our recruitment process and co-design sessions were held online. Participants were randomly divided into three cohorts. Two cohorts had 6 participants, and the third had 4 participants.

Design challenge 1: Identity — During the first week, participants were asked to create an identity for their robot. First, participants accessed the robot's software and edited its face. Then, they built their robot by plugging their smartphone into the tripod and decorated the robot's outer shell using home materials, such as straws, cereal boxes, etc. Designs created by the participants are shown in Fig. 3.

Design challenge 2: Connection — During the second week, participants were asked to connect with other participants in their cohort and to connect with themselves. To connect with others, they shared designs in the Public Gallery. To connect with themselves, they used the Robot Diary. A second way to connect with themselves was to report their mood and stress levels.

Design challenge 3: Futurizing — During the third week, participants were asked to 'futurize' interactions with the robot that would promote their well being. They created storyboards with desired interaction scenarios between a adolescent and a robot that would lead to mental health support (see Figure 2).

Throughout the study, participants sent us a daily picture of what they were doing with a robot. They could also contact us at any time to report issues with the robot software. At the end of the four weeks, we conducted an exit interview with adolescents to collect their general impressions of the study. Each adolescent spent approximately 6.5hrs (390 minutes) in total engaged in the study over the course of four weeks. Additionally, we measured the robot platform's usability using the System Usability Scale (SUS), which reported marginal to good levels of usability [20], which are comprehensive values given the simple robot prototype.

TABLE I

DESCRIPTION OF THE THREE ROLES FOR A HOME ROBOT CREATED BY ADOLESCENTS AFTER LIVING WITH A ROBOT.

Role	Robot as a Coach	Robot as a Companion	Robot as a Confidant
Definition	A robot that motivates you to perform activities or encourages learning of new ones.	A robot that is present and keeping you company.	A robot that can keep your secrets and be trusted with your emotions.
Metaphor	Problem solver, action-driven, inspirational robot.	Vessel for entertainment, decorative piece, a robot for a sense of togetherness.	Feeling good, feeling of belonging, and a comfort robot.
Activities	Motivates you to do homework, teaches a new skill, motivates you for physical activity, helps manage time, gives positive, uplifting messages.	Plays music, bakes together, goes for walks, keeps company while watching TV. Robot acts as an ice-breaker when making new friends.	Shares private conversations, journaling, daily life events; helps manage stress levels and negative emotions.
Location	House and outdoor spaces.	Different house spaces, such as the living room and the kitchen.	Confined to the bedroom or other personal spaces, such as the restroom.

D. Analysis

We comprehensively mapped the collected attitudes, concerns, and visual prototypes of adolescents towards a range of robot design requirements. We relied on thematic analysis to analyze the collected data since they are considered ideal for exploratory studies such as this one [21]. We specifically focused on co-design methods, including participatory design and interviews with adolescents. We used remote online tools, such as Zoom, a viable tool for collecting qualitative data [22], to conduct our remote design sessions due to the ongoing pandemic lockdown. We used thematic analysis to analyse data as this method is devoted to identify common themes that emerge by gathering similar emerging topics or patterns in the data by coders [23], [24]. Three coders listened to the recording of each of the design sessions, interviews, and collected visual data sent by the participants, to group the data. In total, we coded approximately 15h5min and more than 100 pieces of visual data, e.g., pictures of robots and storyboards.

V. DESIGN REQUIREMENTS

A. One Robot, Many Roles

Data revealed that adolescents conceived three main roles for a home robot that would help them overcome the effects of isolation and foster skill-building and well-being. These roles are robot *as a coach*, *as a companion*, and *as a confidant*. In Figure 2 we present a selection of three storyboards created by adolescents during a design session that illustrate interactions between adolescents and the robot. Additionally, Table I provides further definitions of these roles. Below, we articulate each social robot role in detail.

1) Robot as a Coach: A robot as a coach would motivate adolescents to acquire new skills, such as *"helping with sports"* (P4, Female, 16yo) or to complete unwanted tasks, such as homework. While acting as a coach, the robot would be outdoors, e.g., backyard or in nature. In this role, the robot could demonstrate the actual movements and techniques of a new sport, such as soccer (see Figure 2). A coach robot could also be responsible for motivating adolescents to perform activities that are beneficial for them, as illustrated by a participant, *"the robot provides motivation to have a good day"* (P12, Male, 17yo) and *"the robot gives a positive message at the beginning of the day"* (P10, Female, 18yo). Examples of activities that were envisioned with a coach robot are *"helping with homework"* (P14, Female, 14yo), *"giving tips to help prepare for school"*, (P2, Female, 14yo) and *"making life less stressful due to online classes"* (P16, Female, 14yo). adolescents imagined the robot to provide motivation *"by getting a better mood, you feel like doing the homework and the robot motivates for the hard part of homework"* (P12, Male, 17yo). They also desired personalization in a coach robot and one participant suggested the robot could do *"a survey about the activities so it can suggest them back when we are stressed or in the need of a good mood. The main idea is that the robot asks this survey over time because what we like to do can change"* (P9, Female, 17yo).

2) Robot as a Companion: A robot as a companion was envisioned to be present and available to the adolescent. As expressed by one participant, *"A robot that can sit in the room and keep you company."* (P12, Male, 17yo) or that will *"keep you company for example when you walk your dog"* (P9, Female, 17yo). When illustrating the robot as a companion, adolescents placed the robot across different spaces in the house, e.g., living room, kitchen, and bedroom. A companion robot was not necessarily envisioned to have an active role in performing activities but could provide some guidance, such as *"help cooking, baking together"* (P5, Male, 16yo) and *"showing recepies"* (P6, Female, 18yo). adolescents conveyed the need to not feel isolated and alone and shared that they wanted a peer that would just be there for them: *"especially during quarantine, some adolescents don't have anyone else to talk to rather than their family. And you cannot talk with your family about everything."* (P10, Female, 18yo). They envisioned the robot to be a live presence for such moments and one participant explained this by saying that the robot *"would help even just like... being present. Even if the situation is hard, it will help you, like, get through it and encourage you to make it. Just to know that you have someone there would help."* (P15, Female, 15yo).

3) Robot as a Confidant: A robot as a confidant is desired to be trustworthy and a good active listener. For example, one teen said, *"now that we're in quarantine I don't have anyone to talk with"* (P15, Female, 15yo). The preferred locations for a confidant were personal and intimate home

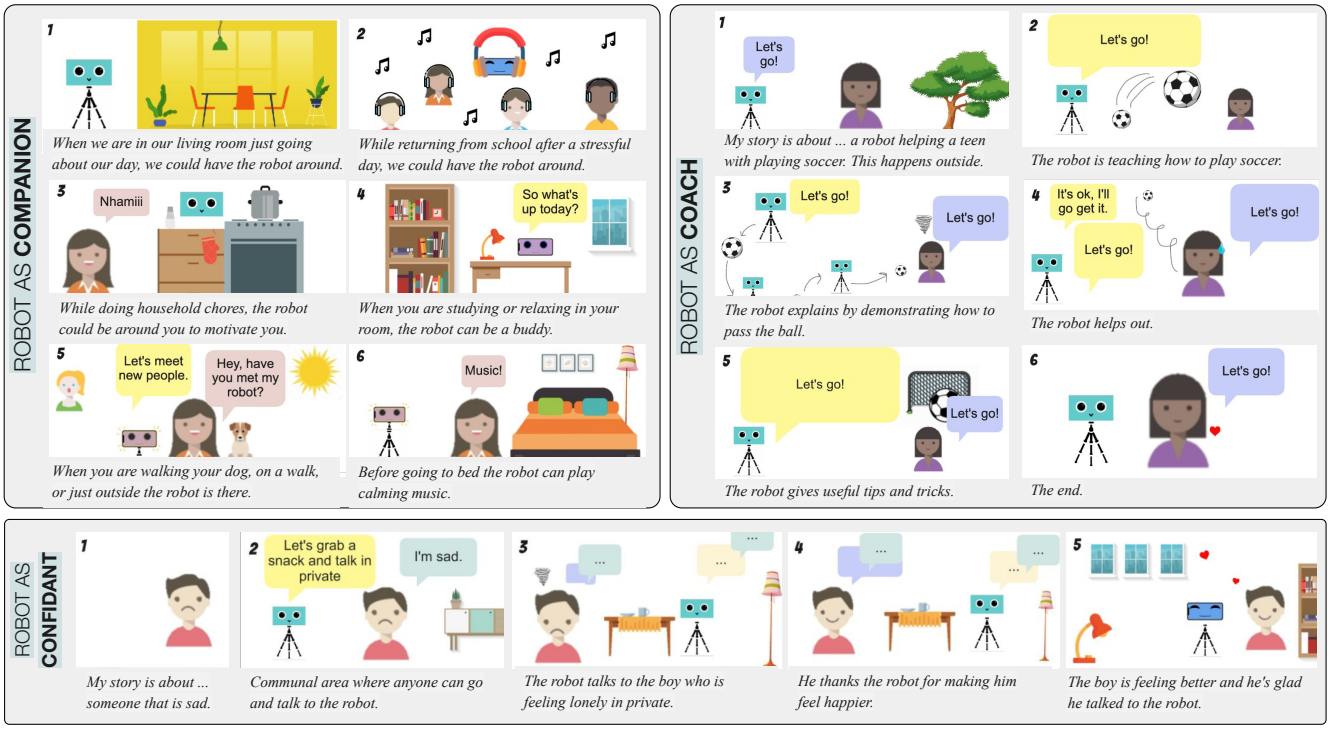

Fig. 2. Storyboards created by adolescents during design sessions. The storyboards illustrate the desired roles for a home robot to support adolescents during the isolation and include the robot assuming the role of a coach, companion, and confidant.

places, such as bedrooms and bathrooms. However, opinions about using the robot as a confidant varied. Some adolescents saw the robot as a safe space to vent about how they feel, and one participated noted that *"It's more private with the robot because you know it's not going to share anything"* (P14, Non-Binary, 15yo). The same adolescent named the robot *"Trustworthy Lad"* because the robot appeared to be *"trustworthy, I really don't know how else to describe it"*. adolescents brought up the difficulty of making social connections and how a robot could be a potential helper. As expressed by one participant, *"not everyone has, like, that one friend that they can always go to and talk about their like issues or problems and the robot is a way that they can have someone to talk to"* (P11, Male, 17yo). They also considered the robot as a training tool for real interactions and one adolescent mentioned that *"talking to the robot helps you think and put it into words before you talk to a friend"* (P5, Male, 16yo). The acceptance of a robot as a confidant seemed to depend significantly on the perceived trust towards the robot. As a participant put it, *"having a social robot can make people feel safe because they know they have place to talk"* (P10, Female, 18yo).

Although some adolescents invited the idea of a robot confident, some others, this was not a desired role. One participant felt suspicious about using a robot as a confidant, *"even if nothing substitutes talking with a human, it would be nice to have a robot at home"* (P8, Male, 15yo). Another participant voiced that the mere act of talking to a device was strange, *"It's odd talking to a robot, and odd knowing there are 20 more adolescents talking to the robot as well"* (P3, Female, 15yo) and *"talking to a robot doesn't feel like talking to a human at all"* (P3, Male, 15yo). One participant completely opposed the idea of using the robot as a confidant, *"to open up to a robot is just absurd"* (P6, Female, 18yo).

B. Amplify Human-to-Human Connection

Overall, adolescents expressed their need for social connection during the COVID-19 lockdown and appreciated having a robot that could support their social connections and decrease loneliness and feelings of isolation. adolescents shared how the pandemic affected access to their social circles and many felt isolated and did not feel comfortable sharing certain aspects of their lives with family members. One adolescent imagined novel ways to use a robot to reconnect, *"a portable robot that can hang out with you and your friends, like, you can listen to music together"* (P9, Female, 17yo). One participant whose parents are divorced shared that taking *"robot back and forth from [their] dad's house to [their] mom's house"* (P13, Non-Binary, 15yo), reveling the need for a robot to adapt and connect to family dynamics and to live in different homes.

C. Privacy and Ownership

Several participants valued the option of having control over their own data to track personal progress, and as voiced by one participant, *"if it is a home robot then I would like to have access to my data"* (P8, Male, 15yo). Another participant mentioned wanting to have *"graphs of [their] individual stress and mood levels to look back at"* (P11,

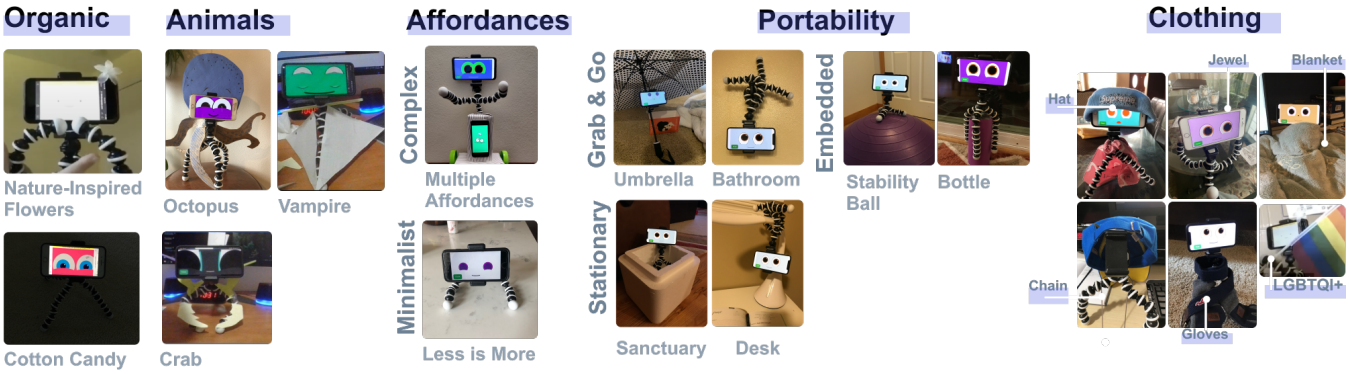

Fig. 3. Selection of home robots as conceptualized by adolescents. adolescents explored an organic-based outer form for the robot that integrated flowers; explored the robot inspired by animals; explored affordances from minimalistic to complex properties that defined the possible uses for the robot; explored different locations, such as the idea of the robot as a place where adolescents go to seek comfort; and explored the robot for self-expression by dressing it using personal fashion items, such as adding jewels for a chic robot, chains for a gangster-like robot, or an LGBTQI+ flag to express personal values.

Male, 17yo) and wanted *"to be able to look back at [their] journaling"* (P8, Male, 15yo). When asked if they also had interest in seeing the data from a group of adolescents using the robot (such as their friends), opinions were mixed. While some reported that wanted this option available, others shared that seeing group data would be beneficial under certain contexts such as the school as expressed by this participant *"it would be helpful to see where the rest of the class is in case [they] are seeing this data in school"* (P8, Male, 15yo). Another participant clarified that having a data sharing option for the robot is *"more useful in school than at home"* (P9, Female, 17yo) because *"in school you can compare stress levels and balance them with others"* (P8, Male, 15yo). This reveals that having a data sharing option can be important for personal tracking or as a way to balance their own emotions by looking at others. One participant expressed that group data *"didn't represent [her] stress level."* (P14, Female, 14yo) since the group showed high stress levels but she was less stressed overall, making her feel both invisible and unrepresented by the data. One of the most important themes for the adolescents, was their concerns about who can access their data. Envisioning the future of a home robot, one participants asked, *"can creators access my diary?"* (P6, Female, 18yo). One participant wanted a robot that would not *"share things that I am telling it"* (P14, Female, 14yo) and wanted to *"make sure no one else uses [the robot]"* (P12, Male, 17yo). Their sense of privacy was associated to the location of the robot in the house, such as expressed by this participant, *"I will want the robot in the bedroom, even when I am not in the bedroom"* (P8, Male, 15yo). Having a robot that was only for their personal use was an important sentiment with regards to data privacy, as expressed by this adolescent, *"every time someone else uses my robot it becomes less mine"* (P8, Male, 15yo). Another participant mentioned that *"confidentiality is important especially in these times when we're stuck like with the same people"* (P13, Non-Binary, 15yo), highlighting how isolation at home made privacy more prevalent in their lives. Another participant coupled the concept of privacy with ownership by expressing that *"even if the person is not looking at my data, I prefer them not to interact with my robot."* (P11, Male, 17yo). The same participant expressed various concerns for privacy, mentioning that *"the bedroom is in my space and if it leaves it, data will be shared"* (P11, Male, 17yo), which signifies that he prefer to be physically close to and in control of their robot. One adolescent reported she could use the robot for situations *"when you need to tell someone something but you don't want them to tell others"* (P15, Female, 15yo). When it comes to family dynamics, one participant expressed that *"it would be weird if a sibling would look on my robot if it has personal info"* (P10, Female, 18yo) and raised the idea of having *"passwords protection"* (P12, Male, 17yo).

D. Robot Form Factor

When reflecting on the design of their robot, adolescents shared a positive impression of interacting with a simple robot as it gave them a creative space to futurize. As one teen summarized *"I thought [this study] was really creative and really made me think of how to design a robot that would fit our daily lives and how effective it can be"* (P12, Male, 17yo). Adolescents improved the robot form factor by decorating it with materials or with their own personal belongings. For example, one participant decided *"adding metals to make robot look tough"* (P5, Male, 16yo) (referring to the addition of a chain on the robot neck, see 3 for a design visual inspired by clothing), or by adding objects to the robot instead of clothes, *"I don't think of my robot as gender based because I didn't do clothes"* (P13, Non-Binary, 15yo).

While some adolescents decided for a minimalistic design, as explained by one *"[I] noticed that in cartoons, characters with minimalistic features are shown to be more cute"* (P13, Non-Binary, 15yo), others envisioned enhancements by adding a second screen near the belly that allows for more complex interactions as *"sometimes you want to use*

your phone when you have the robot and I find that it would be really hard to do both" (P14, Female, 14) (see Figure 3 for a visual comparison of minimalistic and complex designs affordances). One adolescent predomonlantly got inspiration in nature when designing the robot *"I generally go out every morning to get a flower to put in the robots hands"* (P13, Non-Binary, 15yo). Another participants shared an organic inspiration of the robot design, *"food is an inspiration to me"* (P14, F, 14yo) and designed a cotton-candy robot (see Fig. 3). Adolescents differed in their opinions about where the robot should be located. One adolescent offered the idea of portability, *"I want to attach the robot to the umbrella, it can go where you go"* (P8, Male, 15yo) or *"I thought it would be cool to attach the robot to the wall in my bathroom while I am getting ready. Maybe we can talk"* (P10, Female, 18yo). Opposite to this, a participant gave the idea of the robot as a 'space' (and not an 'object') where she would, similarly to a sanctuary, and saw advantages in this fixed location, *"by being not movable you need to go to that spot every time you want to interact with it"* (P10, Female, 18yo).

VI. Discussion and Conclusion

Throughout this study, adolescents shared their unique views of the ways in which a social robot could be supportive during isolation. This included having multiple roles, being customizable, and keeping their data personal. Additional contributions of this study are the *design of a robot based in needs*. By gathering design requirements for a home robot, we are laying the foundation for a more advanced and successful robot design and implementation in the future. Even with our small sample size, this study saw unique expectations, roles, and needs of individual adolescent users, suggesting that *customization may be an essential design principle* if we hope to benefit adolescents through social robot interactions. We share the *methods for the design in open-access* [18]. Finally, our study also show s*scalability of a virtual design study*, as we included adolescents across different U.S. locations; we developed an online, remote co-design methodology and shipped robot prototypes to participant homes.

We acknowledge several limitations of this study. In this work, only adolescents that owned a personal smartphone could be included. This inclusion criteria was set to ensure all adolescents could access the remote design sessions throughout the study. Although the majority of adolescents are reported to have access to personal computers and smartphones [25], we are aware that not all adolescents have access to a personal cell phone. In future work, we intend to move towards a more inclusive design by providing adolescents all materials required to engage in the study.

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