Review

Emerging Children Roles in Child-Computing Interaction Research: A Systematic Literature Review

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Posted Date: 7 August 2023

doi: 10.20944/preprints202308.0550.v1

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Emerging Children Roles in Child-Computing Interaction Research: A Systematic Literature Review

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Abstract: The framework proposed by Alison Druin about 20 years ago, which defined the roles children play in technology design, has been widely adopted by the Child-Computer Interaction (CCI) community. While some studies have adopted relevant roles as presented in the framework, others have argued for extending the framework to include newly identified roles. Still, other studies argue that Druin's framework failed to account for roles children may take up as they interact with peers or with tools. Consequently, this systematic literature review examines children's emerging and changing roles in the codesign of new technologies. Specifically, we answered the research question: What new roles emerge in research as children co-design new technologies? Our effort aims at providing evidence of new roles children have adopted in literature, which may help researchers in the CCI community make more informed decisions about participatory design approaches with children.

Keywords: participatory design; co-operative inquiry; design partners; co-design

1. Introduction

Children's participation in the design of technologies has been an area of growing interest in recent years. This is partly due to the increasing recognition of the importance of considering the perspectives and needs of children in developing technologies that will be used by them [1–4]. One approach that many researchers and designers have used to give children more voice in technology design has been through participatory design methods (PD) [4–6]. Participatory design (PD) emphasizes the active participation of end-users in the design process of technology and has been widely applied in the design of technologies for children [4,7]. PD approaches such as Cooperative Inquiry (CI) [23] has been lauded as a methodology particularly suited for children as it is uniquely designed to facilitate partnerships between adults and children at different stages of technology design by embracing children as full design partners, on par with the team's experienced adult designers.

Druin, a leading proponent of using PD and CI with children, argued that children need to have a voice in the design of child products because children see the world in a completely different way from adults [4,7]. Children have different perspectives on the world than adults do. This difference in view is not based on size or stature but on their cognitive, social, and emotional development stage, which is different from that of adults. This developmental stage comes with imagination and curiosity that allows them to engage their thoughts in unhindered and unrestricted ways, unlike adults who are more likely to be burdened by realities of what may be possible or not. Children's participation in PD has been found to be beneficial in several ways [8–11]. It can lead to the creation of technologies that are more appropriate for children's needs and abilities [12–15], and it can also increase children's ownership and engagement with the technology [16–19]. Additionally, children can be honest and open-minded [16]. They have been known to speak their minds and be open about what they think, feel, and observe without filters [17,19].

In the last two decades, researchers in the CCI community have explored various avenues through which adults can effectively partner with children to codesign technologies for kids. For example, Druin, in her widely cited framework, noted how children might act as users, testers, informants, and design partners depending on the context of the study and the goals researchers

intend to achieve for the co-design process. Druin's framework provides a broad model for the different roles adults might assign children during the co-design process. However, recent studies in CCI are starting to define and adopt newer roles that focus more on children's preferences, strengths, and interactions during the co-design process. For example, it was argued that children were beginning to take on new roles by themselves aside from those assigned by adults [20]. Similarly, Iversen and colleagues noted how children are starting to act as protagonists and take agency of their own co-design process [21]. Against this background, we conducted a systematic literature review that examines children's emerging and changing roles in the codesign of new technologies within the CCI community. Specifically, we answered the research question: What new roles emerge in research as children engage in the co-design of new technologies?

Why Druin's Framework?

The roles children play in technology design are defined by the extent of their involvement in the entire process. This level of involvement has been theorized by researchers in different ways and using different parameters. One of the foremost researchers in the Child-Computer Interaction community, Alison Druin, defined levels of participation based on the roles children are allowed to play in the design process. In her widely used model, the level of involvement depends on the child's function, with the level of involvement steadily increasing through the positions of User, Tester, Informant, and Design Partner. Druin identified four primary roles - user, tester, informant, and design partner- (see fig. 1) that children can play when engaged in technology design and creation with adults [7].

According to her model, these roles vary and are defined by three underlying dimensions; (1) the child's relationship to adults; (2) the child's relationship with technology; and (3) the goals researchers may have for inquiry with children [7]. As users, children participate in the research by using existing technologies while adults observe their patterns of engagement and interaction with the tool to understand the impact of the technology and to enhance future ones. When children function in the user role, they have an indirect relationship with adults as the adults merely observe how children use the technology to understand how the technology impacts the child and to improve future technologies or enhance future developments of the technology.

Druin defined the role of the child tester as going a step further than the child user role. As testers, children engage with technology prototypes while adults observe their interactions and obtain direct feedback about their experiences with the technology. One difference between the child user and the child tester is the "stage of the technology" in the development process. The child user usually engages with a finished product in the market, while the child tester engages with prototypes that have not been released or circulated as a finished product. The child tester is said to have a slightly more direct relationship with adults as they are observed using the prototype technology, and the supervising adult asks for direct feedback about their testing experience.

Unlike the child tester, who engages with a prototype, the role of the child informant is described as more engaging, children have the opportunity to contribute in the technology design process. Their contribution in this role may require more detail, such as paper sketches and low-tech prototypes that adults incorporate in the design of the technology. The child informant has a more direct relationship with the adults and engages in dialogue during discussions, activities, and interviews that may have been designed to elicit design feedback. Druin describes the fourth role children play in the design of new technologies as design partners. According to Druin, children functioning in this role are equal stakeholders in the design of new technologies. While children might not be able to share equal responsibilities with adults, they have equal opportunities to contribute to the design in ways that are developmentally appropriate. In this role, the child is fully recognized as a member of the design team and is part of the design process throughout the research experience. The research team's activities are greatly moderated to accommodate the presence of the child as a design partner and encourage active participation of the child. Druin explains that while the roles may be distinct, there may be aspects of the less active roles being a part of the more active roles (see Figure 1). For

 doi:10.20944/preprints202308.0550.v1

example, aspects of the child as a user may be inherent in the child as a tester, and aspects of the user and tester may be inherent as the child takes up the informant role.

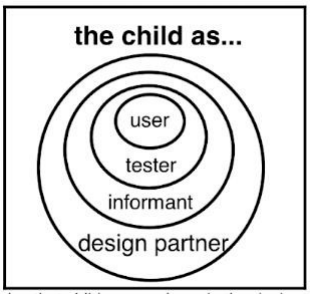

Figure 1. The four roles that children may have in the design of new technologies [4].

Since Druin's framework, several participatory design studies in the field of CCI have engaged children in diverse, multifaceted roles that are sometimes unaccounted for by Druin's work. For example, in a comparative study focused on the co-design of storytelling technologies, Ladoni and colleagues explained that children played the role of executors and managers as they engaged in the co-design process [24]. Other studies have broadened the conceptualization of roles to include the values children adopt and develop when designing technologies [20]. For example, while using a value creation lens to examine how children co-designed with peers and adults in the design of new technologies, Kinnula and colleagues identified unique roles like socializer, conformist, artist, and leader that children played, and they argued that these roles inform how they contributed to the co-design process. The study noted that children adopted roles not limited to those described by Druin [20]. A review of children's roles in PD or CI research will help examine what has previously been done in the field and, considering recent economic and global events, what is currently obtainable in the field. Furthermore, it will help us understand the changes in children's roles in PD and potentially make predictions for the future.

2. Review Methodology

A systematic literature search was done to summarize primary research previously conducted on children's roles in the co- design of new technologies. Following Page and colleagues' guidelines for reporting systematic reviews, a review protocol was created to outline search procedures [25]. Specifically, we used the updated Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines [25] (see Figure 2). The search was conducted using Google scholar, Worldcat. Through Clemson University Library: ACM Digital Library, Ebscohost: ERIC, dblp computer science bibliography, HCI Bibliography: Human-Computer Interaction Resources and https://arxiv.org/. The search parameters that were identified consisted of "Children in Participatory design," "Druin's framework," "using Druin's framework to understand children's role in technology design," "child computer interaction," "participatory design in child computer interaction," or "Codesign approach in Child Computer interaction research," and related terms. The scope of the search ranged from April 1999 until December 2022. The initial search yielded 495 results that combined the selected terms chosen after duplicate studies were removed. This literature review focused on the empirical research conducted to understand children's roles in co-designing new technologies.

Next, a hand search was conducted in the education policy journals of ACM/IEEE International Conference on Human- Robot Interaction, International Journal of Child-Computer Interaction Codesign, Proceedings of the 17th ACM Conference on Interaction Design and Children, AFFINE '10: Proceedings of the 3rd international workshop on Affective interaction in natural environments, CHI '19: Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems, WOCCI '09: Proceedings of the 2nd Workshop on Child, Computer and Interaction, IDC '21: Interaction Design and Children, DS 71: Proceedings of NordDesign 2012, the 9th NordDesign conference, ACM Conference on Interaction Design and Children, ECCE '15: Proceedings of the European Conference

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 7 August 2023 doi:10.20944/preprints202308.0550.v1

on Cognitive Ergonomics or ACM 2017 Conference on Computer Supported Cooperative Work and Social Computing.

This yielded N = 43 additional results that included child-computer interaction within the research. Then, ancestry and progeny searches were completed. The ancestry search was completed by investigating the reference section of each study that met the criteria. N = 10 studies were identified as potential articles.

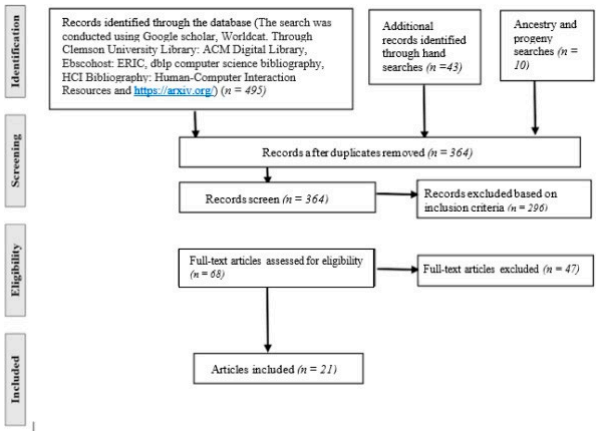

Figure 2. Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) [25].

The title, author, and abstract of each potential article (N = 364) were screened to see if they met the following criteria:

(a) an empirical study that consisted of quantitative, qualitative, or mixed methodology; (b) peer-reviewed; (c) included PD design techniques such as co-operative inquiry, co-design (d) children's roles in relation to Druin's framework; and (e) written in English. We also included empirical work where authors explained new roles children engage in during the co- design of new technologies. However, articles that were non-empirical were excluded. Additionally, studies without a clear role for children during the co-design process were not found eligible. This resulted in 296 articles being excluded because they did not meet the inclusion criteria. Finally, full-text articles (N = 68) were then screened using the same criteria. This led to the selection of 21 articles to be included in the data analysis.

Data Analysis

The A Priori codes for our first round of coding include methodology type, children's roles in co-design, material focus, and demography information. Three members of the research team independently conducted an intensive reading of the selected articles related to children's role in participatory research. Initial, broad patterns in data were discussed to guide a priori coding. Data was organized and analyzed in Maxqda (https://www.maxqda.com/). For our second round of coding, we used a thematic analysis to categorize all data. During the analysis, our team met several times to compare and winnow codes, discuss and form categories, and reach a consensus. The categories were then analyzed and developed into themes. Some of the themes include the extension of Druin's roles, Using Druin's roles as it is, and children's new roles.

3. Results

This section is focused on reporting the results of the review based on the presented research question. What new roles emerge in research as children engage in co-design of new technologies? To answer this research question, we coded the articles based on the description of the roles the children played in the research and connected this defined role with the evidence of the activities or tasks in which the children were involved. The literature review revealed that children played different roles when designing technologies in Participatory Design research.

3.1. Overlapping, Different and Extended roles

 doi:10.20944/preprints202308.0550.v1

In our review, children adopted a wide variety of roles as indicated in Druin's framework [26–31]. Although children's role represented in PD research is not new, we noticed certain themes that emerged as children adopted various roles in the literature we evaluated. The first emerging theme in the studies reveals points of overlap in the roles children played in technology design projects. In such studies, children take up multiple roles at different points in the studies, they can act as testers and informants in the same study. This is not surprising as Druin's framework indicates that each role incorporates elements of previous roles, with the design partner role being the deepest form of engagement children can have in the design process. This overlapping is experienced at the higher roles of "informant" and "design partners" While most of the studies reviewed did not fully use the "design partners" terminology as adopted by Druin, majority of the studies used phrases such as "co-designers" or "co-creators". The use of these terminologies helps to describe the level of engagement was more than testing the technology or merely informing the design process as the children appeared to be involved in moderate levels of ideation through prototyping. For example, children's contribution to design of an educational digital music game for primary school children [32]. Using PD principles, the researchers received feedback on the mock-up images of the first version of the music game and subsequently followed up with co- design sessions with the children that culminated in prototyping. Children were referred to as Referring to as "co-designers" in a study on the design and evaluation of an AR textbook for collaborative learning experience [33]. As co-designers, children engaged in low-tech prototyping and formative evaluation based on cooperative inquiry critiquing and layered elaboration.

Another theme that emerged shows two separate groups of children work on the same project while taking up different roles. For example, Keefe and Benyon describe how children became designers of their own mobile experiences by participating in four interaction design workshops. The children were tasked to design blended mobile experiences for other public school children and their prototypes were evaluated by another group of school children [34]. In another study, authors co-design an application that uses gestures and the Microsoft Kinect device to improve communication and interaction between autistic children with medium-low functioning and neurotypical individuals [35]. In the study, the authors engaged two high-functioning autistic children in the design of their technology, the final solution was evaluated with 10 autistic participants. Designing an educational interactive eBook for newly diagnosed children with type 1 diabetes, Tsvyatkova and Storni engaged two groups of children, one group was children with diabetes engaged as design partners and the second group was the children without diabetes engaged as informants in the study. While both groups provided iterative design insight into the technology to be developed the group of children with diabetes were more involved in cooperative inquiry activities and particularly the prototyping of the technology [36]. A slightly different approach was taken in a study that involved two groups of children that took on two different roles. One group is the role of designer/explorer, and the second group just designers. The authors examined how access to a Virtual Reality SandScape system allowed the first group of children to take turns being a designer and a user which influenced their choices of more user-friendly designs. In this study, the authors used the virtual immersive environment as concomitant to children taking turns as users and designers. They allowed for an open-ended design process where children could organically derive participation (i.e. designers or users) and design processes in their groups [37].

Thirdly, we observed studies that demonstrate children engaged in a specific role that needed to be enhanced due to the nature of the study. In her study with young deaf children, Korte defines the children's role as an "enhanced informant role". She describes this role as a slight step down from the design partner role because of the communication gap that existed between the hearing designer and non-fluent deaf children which did not allow for dialogue between the two groups. However, extensive elaboration that occurred during design sessions allowed children to take up more elaborate roles than is typically experienced from a "traditional informant" perspective [38].

3.2. Emerging Roles

This section describes roles we categorized as "emerging roles". We define emerging roles as roles not originally part of Druin's model but have emerged from the literature. The roles are discussed under two categories (1) Roles based on children's social interaction and values in the research process and (2) children as independent designers in the co-design process.

Roles based on children's social interactions and values

Based on our literature review, we identify an increasing number of studies that focus on the different roles children play based on organizational responsibilities and the social values exhibited during the co-design process. In contrast to Druin's framework which characterized children's roles based on the broader outcome and goal of the technology to be designed, these studies focused on the nuanced social interactions and behavior that children exhibit in relation to peers, adults, and technology. It was argued that children eventually take on diverse roles based on the goals and value expectations of a co-design project, and an attempt to force them into pre-defined roles might lead to disengagement from the project. However, when given the freedom to find and choose their own roles in the design process, children are successful in making valuable contributions to the technology design process [20].

Using a value creation lens, ten roles that children adopt during the codesign process were identified [20]. Children could take on the role of an *achiever, team worker, leader, artist, adventurer, inspired, pleasure seeker, socialized, conformist, or underachiever*. These roles were largely defined by socio-environmental factors that motivate how and to what extent children participate in the design process. For example, a child is considered to be a team worker when he or she derives satisfaction from helping others and making contributions that are valued and appreciated by others. Similarly, children who take the role of a *conformist* tend to avoid taking risk or trying out creative ideas during the design process. Instead, these individuals derive satisfaction by following established rules and patterns provided by adults in the design process. On the other hand, children who do not seem to be very interested in the design objective and process might act as *underachiever* who often fails to concentrate on activities while exhibiting some form of rebellious attitude. In their study on the roles children play in the design and evaluation of technologies, Ladoni and colleagues defined children's role based on their personalities and how they interacted with others during the co-design process. The authors noted that children acted as *searchers* and *executors* as they designed new technologies. As *searchers*, children define their own path in the codesign process by experimenting and exploring new ideas [24]. This is similar to Kinula and colleagues' designation of the child as an *adventurer* where children work on different new things to find what interests them when designing new technologies [20]. Similarly, we found that the role of a child as an *executor* mirrors that of the conformist role explained above. When acting as executors in the co-design of new technologies, children mainly followed the instructions laid down by the adult. Additionally, their design process and evaluation of the technology followed the predetermined workflow set by the adult.

Table 1. Emerging themes from our analysis and the selected studies that fall under the emerging themes.

Category	Selected Studies
Overlapping, Different and Extended roles	[9,26–28,30–38]
Roles based on children's social interactions and values	[20,24,39–42]
Children as independent designers in the co-design process	[10,11,37–39,44–51]

Aside from the roles children adopt by themselves, they can also act in various capacities assigned by educators based on their cognitive and social skills. For instance, in a gamified co-design study teachers assigned children roles like secretary and silence-keeper within their design groups.

 doi:10.20944/preprints202308.0550.v1

The study argued that such roles allow children to apply a broad range of social skills during co-design [39]. A similar approach was used where children's roles within teams depended on the design activities, the child's personality, and the child's level of confidence in contributing and taking on responsibilities in a team [40]. Studies involving heterogeneous group of children are also beginning to redefine the diverse roles children might take during the codesign process based on their experience, age, abilities or disabilities, and socio- economic status. In a cooperative inquiry study involving children and young teenagers, Chimbo and Gelderblom described how younger children played the role of designers and evaluators while older kids acted as design facilitators as they worked together to codesign a web-based application. While the evaluator role shares some similarities with Druin's definition of the child as a tester, however, it is distinct in that children provide feedback on their own initial designs and prototypes [41]. In the study, adult designers iteratively created design prototypes based on children's initial design requirements, and the kids, in turn, test the system and identify areas that they would modify or change. This role of an evaluator also mirrors Ladoni's description of the child as a judge [24]. Ladoni and colleagues argued that children often play the role of judges when they assess the quality of their own design process or workflow and make necessary refinements to ensure it addresses the objectives of the design [24]. For example, when acting as judges, children in their study assessed the quality and relevance of materials they used for their design and decided whether they needed to acquire more materials or refine existing ones. The facilitator role, on the other hand, requires children to actively assist younger children in their construction of new ideas all the while making sure that they do not take over the design process. As facilitators, children might carry out tasks like recording the group's feedback, designing ideas, prodding for new ideas, or helping with presentations.

Finally, children can act as design proxies for another population of children with different needs and abilities. As design proxies, non-disabled children in the study partnered with adults to design, create and test various ideas and media that would appeal to their disabled friends. Garzotto and Gonella argued that this form of design by proxy leads to more holistic and inclusive technology design [42].

3.3. Children as independent designers in the co-design process

Our review shows that researchers have challenged existing roles children play in the co-design process and push for children to take up more active roles in participatory design research beyond providing feedback to existing technologies or contributing to the design of new technologies. In these studies, we identified that children are not merely engaged because of the need for their feedback or contributions to the design of technology but for the purpose of empowerment [10,11,37,39,43–51]. These studies create the opportunity for technology designs to be children driven, where a great deal of responsibility for successful design and implementation ultimately falls upon children. Therefore, with less adult hegemony, children design for children. As Palfrey and Gasser put it, "the age of gerontocracy is over" pp 228, that is; children are now potent drivers of innovation and creativity during PD [52].

Likewise, children understand how their peers live their lives in digitally mediated ways; therefore, researchers allow them to have greater self-expression and enjoy their creative ideas. Consequently, many researchers conducting PD research have captured these robust roles of children in different ways and described them as co-designers, technology designers, co-creators, process designers, protagonists, etc [53]. To empower children to make independent decisions and make notable changes as they ideate and design prototypes, these researchers leverage Druin's framework. The argument here is that children having a substantial role in the PD can help to address their needs effectively and build their understanding of current and future technologies [21]. Iverson and his colleagues addressed this in their study on expanding children's roles in PD. They argued that Druin's categorization of children's roles as users, testers, informants, and designer partners, as well as Doorn's and Mechelen's classification as co-researcher and designers, respectively, could be seen as "one dimensional in relation to the complex matter of child participation." pp 30 [49,50]. They conclude that children should be considered as protagonists in the co-design process, meaning they

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should be actively involved in developing technology that affects their lives [21]. Their active involvement includes a critical and reflective stance toward technology and its role in their everyday life and developing skills for designing technology. In the same manner, it was suggested that the hallmark of children as protagonists is to empower them in the co-design process; that is, children need to be allowed to play a variety of roles, including being active participants in the design process [24].

Other research that seek to empower and recognize that children have valuable perspectives in PD includes a study by Vartianen and colleagues [46]. They broadly refer to children as co-designers. In their study, children become makers and designers of their own machine-learning applications. They developed machine learning design ideas that harnessed face recognition, gestures, or sound recognition to help people; the ideas were refined, prototyped, and tested. These activities allowed the children to build data agency and be more aware as daily users of machine learning-driven applications. Similarly, Mechelen and colleagues describe children as designers in their study [51], while in another study, researchers demonstrate how through "play activities," children are given opportunities to (co-)define the PD process and methods used. They argue for collaboration with children to (co-)design PD processes instead of merely participating in PD studies [11]. In the same vein, in the study where children were referred to as "technology designers," a group of children engaged in various activities, such as roleplay and designing low prototype artifacts. During activity sessions, the researchers provided support that enabled children to design conversations between humans and robots [47]. Also, Children were referred to as happiness inventors in a study on teaching well-being skills drawn from positive psychology while designing technologies [48].

4. Discussion and Conclusion

In this paper, we conducted a systematic literature review to examine the emerging roles of children in the co-design of new technologies. Our final corpus consisted of 21 empirical papers. For all the reviewed studies, we analyzed the roles children play in them in relation to Druin [12] framework. Particularly, we identified how these roles redefine or expand on Druin's categorization in the order to answer our initial research question: w*hat new roles emerge in research as children engage in the co-design of new technologies?* Based on our analysis, we developed an understanding of the recent roles children play in CCI studies. Our results indicate a move towards greater fluidity of roles where children take on different and multiple roles at different stages of the design process. In many studies, children acted in two or more roles as they co-designed with peers, adults, and technologies. This corroborates Druin's submission that although the roles may be distinct, there are aspects of the less engaging roles (user, tester) that can occur as children take up more active roles (informant and design partner).

Furthermore, we observed an increase in studies focusing on the roles children adopt by themselves and identified a preference for defining roles based on children's personalities and their motivation to participate and contribute to the co- design process [55]. This increasing focus on the motivation and interpersonal behavior of children during codesign indicates how recent CCI studies show more interest in the social interactions and organizational behaviors that lead to the design of new technologies and not just the final product. Children are becoming the center of attention in PD processes rather than the technologies designed. We argue that the freedom to discover their own roles in the co-design process facilitates inclusion and allows children to bring in unrestricted and unique perspectives to the design process. Some questions we pose here are how much freedom children can be entitled to during the codesign process, and how does this freedom impact the outcomes of the design process? How does the child's role change in relation to the amount of freedom they are allowed during the creative process? More freedom might lead children to take on a more active role in the design process, while less freedom might amount to limited roles.

An intentional effort to give students more autonomy in the co-design process is also apparent, especially when considering how recent studies move towards giving children opportunities to iteratively design and evaluate their own ideas as against engaging as users or testers of existing prototypes or technology. Several studies broadly referred to children as "co-designers" or "co-

creators," explicating the increasing involvement of children and also amplifying children's design ideas and voices [10,37,39,43–45]. In these studies, children are challenged to solve real-life issues by designing new technologies or redesigning existing ones. They go through different stages of ideation, develop prototypes with the goal of solving problems posed by the researcher, and acquire content knowledge or learn technical skills. We describe this category of children as "independent designers" in the co-design process. As independent designers, children are engaged in the codesign process with the sole objective of empowering them and helping them develop certain technical or design skills. This trend is desirable as it allows children to freely develop ideas, have a sense of ownership, and feel empowered during the co-design process. However, we would like to draw attention to the need to establish how these changing roles of children impact the co-design outcomes and how it affects the roles researchers and adults play during codesign [54].

Selection and Participation of Children: No children participated in this work.

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