DIY Assistive Technology for Others: Considering Social Impacts and Opportunities to Leverage HCI Techniques

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ABSTRACT

One way to help address larger scale social and environmental challenges is to help individuals consider the social impacts of making alongside the technological aspects. We investigate the experiences of volunteers who 3D print prosthetic devices for children, focusing specifically on the way they discuss their relationship with the device recipients. We show that while the volunteers understand the social aspect of the experience, their focus is on the functionality. We suggest some techniques, methods, and principles from HCI that can enrich the experience for the volunteers and recipients by broadening the focus to include consideration of the complexities of the human and social experience.

CCS CONCEPTS

• **Human-centered computing → Human computer interaction (HCI)**;

KEYWORDS

DIY-AT, Assistive Technology, HCI, Maker

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1 INTRODUCTION

A common application of 3D printing technologies is prosthetic devices for people with limb differences, for example as described by Hurst and Tobias [7]. This type of activity has a close association with makerspaces and the broader maker movement, as several organizations and many communities have formed around fabricating and distributing these devices. This paper investigates member experiences in one such community, considering opportunities for enriched learning for the volunteers.

In particular, the learning we focus not on is not technical skills or knowledge, but rather on empathy and understanding of the complexities of the human experience of the people who receive the devices. The volunteers who print and distribute the devices have a lot of contact with the recipients, though as prior work has shown, the volunteers tend to have more technical interest and expertise, while clinicians have a deeper understanding of some of the challenges prosthetic-users face [10]. Additionally, while volunteers aim to distribute as many devices as possible and tend to be driven by "seeing smiling faces", the devices don't always work and are often abandoned [10].

In some cases the empowering aspect for a device recipient is not the device itself, but rather the supportive community they are introduced to [2]. While the devices themselves are one source of empowerment, it is not as simple as putting on a device and feeling empowered, rather there is a complex relationship that one has with their device as they navigate identity and normalcy [2]. Understanding the potential of these nuances requires not only a technical understanding, but also a human understanding and which is the type of sensitivity that we focus on in this paper.

The conference theme prompts us to consider "how the maker movement can respond to and help address social and environmental challenges that threaten to cause global chaos". One way is to ensure that the people who are participating in the maker movement have not only an understanding of the technology, but also an understanding of the social impact and how it relates to the complex human experience. We believe that the field of Human-Computer Interaction (HCI) is equipped with some methodologies, techniques, and principles such as Human-Centered Design (HCD), Participatory Design, and interview techniques that can help volunteers achieve a better understanding of people, devices, and the relationships between. Perhaps if volunteers making prosthetic devices integrate such human-centered, social perspectives as a first-order part of design and development, they might have not only a different understanding of the impact of their efforts for the device recipients, but a deeper understanding of the broader impact of maker-related technologies on the world.

In this paper, we begin to investigate the relationship between volunteers in a club for printing prosthetics and device recipients. We discuss ways in which club members engage with recipients and how their relationship with and understanding of the recipients could be deepened. Finally, we suggest some ways in which HCI offers processes and principles that would be worthwhile to teach volunteers engaged with recipients of 3D printed devices.

2 RELATED WORK

2.1 DIY Assistive Devices and Communities

Early on in the emergence of Makerspaces and availability of 3D printers, one of the promises of these technologies was for assistive

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devices of many different kinds. Commercial devices may not be the best alternative for some recipients, given considerations such as insurance and cost, younger recipients outgrowing devices, and not meeting specific nuances recipients would like them to address. At the same time, rapid prototyping technologies can enable people to participate in the fabrication of their own devices [7].

Communities have formed around DIY assistive devices, specifically 3D printed prosthetics, such as e-NABLE [3]. These communities and the people involved in them have been the subject of researchers, working to understand the motivations of the volunteers and challenges of the process. For example, Hofmann et al were interested the prototyping process that groups of researchers and recipients took part in [6]. They found the teams used common materials such as Legos, Styrofoam blocks, and clay to test aspects such as length, angle, and grip shape [6]. They suggest several mechanical devices that allow dynamic adjustment of these parameters to allow for an easier and more fluid prototyping process [6].

One of the biggest challenges of the process involves the lack of knowledge of the volunteers. Hofmann et al interviewed professional clinicians who work with prosthetics and found that the "clinical process is fully led by the question 'will this do harm', while volunteers chaotically pursue the lofty goal of providing 'assistive technology to all"' [5]. The clinicians tend to approach new designs with caution and careful consideration for what could go wrong, while makers were optimistic they could solve problems. The clinicians pointed out how in many scenarios the devices could cause harm to the person wearing it such as getting stuck in a dangerous situation, irritating the skin, or introducing an injury over time from requiring an awkward motion to actuate the device [5].

Similarly, Parry-Hill et al interviewed both volunteers involved with making devices and professional clinicians [10]. They found that the motivations for participation matched Hustinx and Lammertyn's characterization of volunteerism, which includes a sense of obligation to the whole group or a sense of desire for personal fulfillment [8, 10]. Parry-Hill et al point out the complementary skillsets of the volunteers and clinicians, with the volunteers having a focus on engineering and prototyping of new solutions and the clinicians having a better understanding of how to work with the recipients and a more realistic understanding of the realities of living with an assistive device [10]. They suggest the clinicians and volunteers find ways to work together.

Proposed solutions to the distance in knowledge between the clinicians and makers include designing technologies that embed expert knowledge throughout the process or having makers focus more on devices for less risky situations [5]. These are all technical solutions, so additionally, in this paper we focus more on processes or mindsets that it might be beneficial for the Makers to have.

2.2 HCI and Making

Roedl et al have shown how rhetoric around Making tends to be optimistic [12]. Makerspaces are said to empower people to influence the world around them, Makers are viewed as more empowered than the average citizen, and all this is enabled directly by technologies that allow people to make things [12]. These authors have also pointed out critiques of this optimism, including work that has shown it is not the technology alone that drives empowerment, but rather technology can be leveraged in sociotechnical settings that take into account the complexities of being human [12].

Despite these critiques, the sentiment remains optimistic, not that Making itself will drive change, but that it can be leveraged to drive change. Bardzell et al also discuss how HCI is well-positioned to understand the effect of Making on the world since HCI is well-versed in understanding technical, social, and socio-techncial aspects of new technologies [1]. We use this insight to propose that HCI is an important perspective for people involved in Making things for other people to adopt of since it incorporates understanding of not only artifacts but also social aspects surrounding the artifacts and it has already helped deepen our understanding as researchers of the impact of making on the world.

Thanapornsangsuth presents two case studies in which Human-Centered Design was used as a tool to help people find purpose in Making [14]. However, to our knowledge, HCI design techniques and perspectives have not yet been used as a tool to train Makers to understand the impact or social aspects of their work.

3 STUDY

As prior work showed that there was a gap in knowledge between clinicians and volunteers, we investigate further ways in which volunteers' understanding might be enriched, specifically in terms of understanding complexities of the human experience. In this study, we investigate the relationship between the volunteers and the recipients as well as the extent to which the volunteers focus on the social aspects of the process compared to the technical. This is a step towards answering our larger research question of how adopting HCI methods or techniques might change the volunteer and recipients' experiences.

We conducted semi-structured, exploratory interviews, aimed at understanding motivations, goals, challenges, and process. Interviews lasted about 20 minutes and included questions such as:

- Why did you get involved with the club? What is your role?
- What are the steps in creating a prosthetic for someone?
- For someone who doesn't know, what is the club all about?
- Does what you are doing relate to anything you are doing in your classes? Or anything you have ever done before?

4 RESULTS

Recruitment took place locally via word of mouth. Study participants included 4 college-aged participants (2 male, 2 female) who had been active in clubs for 3D printing prosthetics ranging from 1 year to 3 years. Interviews were transcribed and coded for mentions of the device recipients, community, or other forms of social engagement. We discuss the participants' backgrounds and motivation for participating in the club for context and then we discuss the relationship between and perceptions of the interviewee and the recipients of the devices they have been creating.

4.1 Motivation and Background

P1 (male) is a senior studying biomechanical engineering and has been printing devices with the club for 3 years. He came across the club as he was looking specifically for clubs related to BME. He has also created a prosthetic device in a formal engineering design class.

His role in the club involves printing and helping design solutions for some of the more complicated cases.

P2 (male) is a sophomore studying Mechanical engineering with a biomedical concentration. He has been part of the club for one year. Originally it did not relate to his career goals, but as a result of participating in the club, he considers going into orthotics after graduating. He says the club helps him build on skills he learns in classes, such as 3D modeling, and then incorporate those skills even more in later classes.

P3 and P4 (both female) joined together. They were students in the club's faculty mentor's class, who announced the interest meeting and encouraged them to come. They both started off helping with fundraising for the club and eventually started printing, saying it was scary at first and they had never even been near a 3D printer before. P3 and P4 are both biology majors and say the club has no relation to their classes and is very different to anything they had done before. They both reflect on how their confidence with 3D printing has grown. About her involvement in general, P3 says "The fact that we can take something that costs like 20 or 30 dollars maybe and just like completely change someone's life, that's amazing. And I'm really glad to be part of it honestly".

4.2 Relationships with the recipients

In general, the study participants recognized the importance of having a personal connection to the recipients and involving them in the creation of their devices. However, there is also evidence that they do not fully consider the experience of the recipients and that the social aspect is secondary to the technical.

For P2, working with the club incorporated far more human aspects than he had experienced in his engineering classes. He says, "In engineering we pretty much know if it works, then that is all you have to do. With an arm, you want it to tailor to the child and what they like. Like for the last one she likes Disney princesses, so we did princess theme with princess colors and gave her a wand and a matching tiara". He realized this as a result of his participation in the club since it made him "stop and think about what each person likes, not just what I could do, not just what would be cool". This is in line with a Human-centered approach to designing prosthetics. However, he then discusses the recipients as "customers", saying that "if you make something that just works but doesn't look good, the customer is not going to buy it". This shows that his eventual goal is to make *things that sell*, and not necessarily *good for people*.

P4 mentioned one delivery that did not go quite as planned: "delivering [anon's] arm was tough when it didn't work. Because everyone had built it up like ohh giving the arms to the kids is so awesome you get to see them pick things up and you get to see them smile and that was not what happened. I hadn't thought about what if it didn't work".

P4 was the only one who talked about creating community as central to what the club does, saying "we try to create a community for the children that they can feel welcomed in together and make relationships and not feel different". Other study participants only mentioned the club's activities in printing devices.

P3 discussed wanting to have more interactions with the recipient and "For her to be more involved in it". P4, working with the same recipient, mentioned this as well, saying that they were going to "have her come in and build another ... arm in color just so she can help with the process". P4 also expressed excitement that she would get to draw her own designs that would get screen printed onto the device. However, this was something they were trying to incorporate into the process after the fact and were doing it so the recipient could feel like she was part of the process, rather than being integral to it.

P1 had the lowest level of focus on the human aspects of the process. When asked about what he had learned about through this real-world design process, he mentioned that he realized there are a lot of other factors that need attention before one starts building, such as measurements, weight goals, and budget, but he doesn't mention anything that has to do with the personality or preferences of the recipient. When describing steps of creating a prosthetic, he considers factors such as "what this patient can and can't do, and so what are the limitations. What the patient has mobility wise, degrees of freedom wise, where he or she is the strongest." However, these are the only factors considered and no other interactions with the recipient are acknowledged. P1 also participated in making some devices as part of a class for the purpose of creating new solutions, but those were not intended for actual recipients. When asked if he approached those differently from real cases, he said there was no difference, since they are using actual measurements and use the same process and they "aligned for what they thought would be important".

5 DISCUSSION

In summary, we saw that our study participants all had some aspects of understanding the people they are working with, but only in small ways and it was always a secondary consideration.

We discuss now ways in which that understanding could be enriched, specifically drawing from HCI design techniques and principles. Because of the way in which HCI considers people holistically, it helps shed light on the complexities of the human experience and the need to focus not only on the functional, but also the social, which we believe is an important perspective from the volunteers can understand their work.

5.1 Optimism

Other authors have already pointed out how volunteers tend not to have as many concerns for the safety of the devices as professional clinicians [10]. Additionally, one of our study participants expressed that volunteers sometimes do not realize that devices might not work for everyone. This shows that she and possibly others have underlying assumptions that what they are doing is positive without thinking about negative aspects or complications. Just as Roedl et al pointed out how the optimism in much of the rhetoric that surrounds Making assumes that it is the technology itself that brings empowerment, volunteers have a similar optimism about the impact of the devices and 3D printing technology more generally [12].

HCI interview techniques might help mitigate this optimism. HCI design researchers are familiar with potential "please the researcher" bias in usability studies. They are also familiar with the danger of asking leading questions such as "Do you like this?" and have techniques for helping understand a spectrum of reactions. Perhaps understanding these interview and user evaluation

techniques might turn volunteers' optimism into a more realistic understanding of the recipients' experience.

Additionally, reflexive ethnography is an HCI technique for qualitative research that involves iteratively reflecting on one's stance and breaking down why one might perceive things in a certain way [11]. Adopting this reflexivity might help volunteers understand some of the ways in which their perceptions of the recipients' experience might be biased as the result of their own background.

5.2 Functional vs Social Goals

All our participants put an emphasis on the technical endeavors of the club, focusing on the mechanical devices and physical modifications or improvements they could make. P4 was the only one who mentioned building community as one of the goals of the club, but this was secondary. This is interesting given the results of Bennett [2], who when interviewing recipients of the devices found that the main benefit lay in the empowering community.

An important part of Human-Centered Design is articulating user experience design goals and evaluating the extent to which an experience meets those goals. Perhaps participating in the process of outlining goals and evaluating how device recipients feel those goals are being met might help volunteers recognize other sources of value in what they are doing.

5.3 Participation

While P3 mentioned wanting the recipient to feel like she was more involved, none of the study participants articulated a goal of having the recipients participating fully in the fabrication of the devices. There is no reason why the recipients can't have more control of modifications, experimental techniques, or the aesthetic design.

A design technique from HCI, Participatory Design, includes strategies for shifting some of the work of the designers into the hands of the users [9]. This involves breaking down barriers between designers and users and attempting to further empower users by accounting for ways designers are inherently biased and have power over individuals when they are the ones designing. Perhaps understanding Participatory Design (even if they don't practice it regularly) might help volunteers realize some of the assumptions they make about device recipients and what they think they want.

5.4 Empathy and Complexity

Our study participants seemed to have a limited ability to empathize with the recipients. Some participants understood the importance of customization, however, this was limited to things like color or theme. Humans are more complex than these surface level aesthetic choices. Hawthorn and Ashbrook report exploring these aspects for their own device, but admits that they would be hesitant to ever ask someone else to explore those aspects since they feel that would be a burden [4]. Similarly, Hawthorn says that they view their device as an extension of themselves, both a work in progress. This shows that recipients have different benefits when participating fully [4].

Human-Centered design might lead the volunteers to delve deeper into aspects of the recipient that might influence the design of the device and develop a sense of empathy that goes beyond feeling bad for someone because they can't pick things up in the same way as other people. The first step of some Human-Centered Design processes is "Empathize" [13]. Focusing on this step, even before measuring, might open up new possibilities for volunteers.

6 CONCLUSION

The human experience is complex. It is particularly important in the case of 3D printed prosthetics to consider the complex social aspect of the experience as well as the technological one. If we can use HCI in this specific scenario of 3D printed prosthetics to guide engineering-minded volunteers towards a more social understanding of what they are doing, perhaps we can also use HCI to instill these same sensitivities in other Making-related scenarios. The result would hopefully be one step closer to a mindful, empathetic, thoughtful, critical future, where people not only solve technical challenges, but can also consider the human aspect.

Future work includes developing metrics to measure volunteers' understanding of the complex social experiences of designing for and with recipients. We can then use these metrics to provide practical HCI-based guidelines for volunteers to apply in working together with recipients.

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