3D Modeling and Printing with Vulnerable Adults

A Participant Observational Study with Immigrants and Low-Literate Older People

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ABSTRACT

3D Printing (3DP) has trending applications in many areas. 3DP has grown in popularity in recent years and it is also attracting significant research attention in Human-Computer Interaction. However, engaging in 3DP is not straightforward and not everyone participates or has the same opportunities to take part in it. Working towards making 3DP more democratic, and empowering vulnerable adults, this paper presents a participant observational study of the 3D modeling and printing experiences of (N=12) immigrants and low-literate older people. The study was conducted in two courses in an adult educational center in a working-class neighborhood in <blind review> over a 3-month period. The results show that the 3D modeling and printing experiences of a number of vulnerable people at risk of social exclusion can be both examined and facilitated, challenging stereotyped (mostly negative) views of these populations and digital technologies. The results have identified two key aspects to examine further to make 3DP more democratic and empower vulnerable adults: interaction issues and spatial visualization. Future and ongoing research perspectives are outlined.

CCS CONCEPTS

• Human computer interaction (HCI)~HCI design and evaluation methods~Field studies • Social and professional topics~User characteristics~Age

KEYWORDS

3D Printing, 3D Modeling, vulnerable adults, participant observation

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1 Introduction

Expiring patents have allowed fabrication technologies such as 3D printers and laser cutters to spill over into the realms of technology-enthusiastic makers [3]. Fabrication technologies are becoming very popular among the general public, e.g. "Every continent except Antarctica has a Fab Lab" [8]. We focus herein on 3D Printing (3DP), which has trending applications in many areas, from medicine and biomaterials to aerospace / aeronautics, automotive, construction, and food [17]. Within HCI, research on 3DP is burgeoning, with studies exploring the appropriation of 3DP among Palestinian children [25], the use of 3DP by teachers of the visually impaired [24], the design of tools that allow end-users to create functional objectives by eliminating the need for expert knowledge [14, 19], to name a few.

In light of the above, it might be argued that 3DP (and digital fabrication technologies, in general) promotes the democratization of computing, and fosters empowerment, two long-term HCI goals, as everybody can solve their own problems by producing the tools they need [10, 11], and non-professional people take control over product design and the manufacturing process [13]. Yet, engaging in 3DP is not straightforward [3]. Also, not everyone participates or has the same opportunities to take part in it [1, 15, 26]. Thus, an important question today is whether (and how) digital fabrication will transition not only from industry to technology enthusiasts but also to ordinary consumers.

We aim to address the following research question (RQ), which is broad so as not to limit the inquiry at the current emerging state of our qualitative research [5]: *How can we provide vulnerable adults at risk of social exclusion with positive and meaningful 3DP experiences?* By vulnerable we mean "(of a person) in need of special care, support, or protection because of age, disability, or risk of abuse or neglect" (Oxford English Dictionary). We focus on low-literate older people and immigrants. Research in HCI on 3DP with these populations is scant. To illustrate this fact briefly, in the ACM Digital Library, the advanced search *{AllField:("3D printing")* [1] *AND AllField:("immigrants") Publication Date: (01/01/2011 TO 12/31/2021), ACM Content: DL}* yielded 10 papers. From the title and abstract of these papers, which all of us read, none of them was related to this one, as they addressed other topics. One of the papers was about using 3DP for helping people living with Ataxia [21] and another about meaningful making with refugee children [20]. In the same academic database, the advanced search *{AllField:("3D printing") AND AllField:("older people") Publication Date: (01/01/2011 TO 12/31/2021), ACM Content: DL}* yielded 13 results[2]. The three authors of this paper read the title and abstract of these papers, and we came to the conclusion that none was related to this one, as they dealt with other (interesting) topics. Most of them were about assistive technology (e.g. [18]) and accessibility (e.g., people with dementia) [9].

We address the interplay of these populations and 3DP for three main reasons. Firstly, since 3DP has grown in popularity in recent years, engaging in 3DP can strengthen the social and digital inclusion of vulnerable people at risk of social exclusion. Secondly, most digital technologies have been designed without considering older people (60+), despite representing a large and fast-growing fraction of the global population. Thus, by addressing the 3DP experiences of these user groups, we can contribute to achieve the goals of empowerment and democratization, which current research is failing to attain.

To address RQ, we deemed it key to explore first-hand, and bottom-up, the 3DP experiences of those vulnerable people who are interested in 3DP. To do this, we conducted participant observation (PO), which is a method in which a researcher collects data in naturalistic settings by taking part in the common and uncommon activities of the people being studied over time [6].

2 The study

From May to July 2018, we conducted two courses on 3DP in <blind review> (AG), an adult educational center in a working-class neighborhood in <blind review>. The study was conducted within the context of the <blind review> project, which was funded by the <blind review>. The project aimed to make digital fabrication technologies more democratic among vulnerable citizens at risk of social exclusion. AG has been operating since the 1980s and its main objective is to foster the social and digital inclusion of people who are, or might be, excluded from the <blind review> society, such as immigrants. The courses were run in weekly sessions of 2-hour long every Monday and Wednesday, respectively. Ethical approval was granted by the Council Center, which is the decision-making body of AG.

Twelve participants (Men: 7; Women: 5) took the courses. Six participants took part in each course. Four participants were unemployed adults (aged 40-50). Three were from South and Central America, and Africa; the other was Spanish. The remainder of the participants (8) were retired, aged 60+, from Spain, and with low levels of formal educational attainment. None of the participants had previous experience of 3DP. Seven participants (4 unemployed and 3 older adults) had very little experience of using computers and the Internet.

Members of the staff of AG, who were partners in the project, recruited the participants from AG and local associations. Inclusion / exclusion criteria were to belong to vulnerable populations at risk of social exclusion, and be interested in 3DP. An informed consent form, which was prepared by AG and us, was used during the recruitment. Participants granted us written consent to take notes of our observations and conversations, and pictures of themselves in the courses, and use this material freely and without any restriction in publications related to the project.

We provided the participants with an introduction to basic 3D aspects related to 3D modeling, such as the 3D space, to enable them to become familiar with the domain and design 3D objects on their own and also to understand their motivations for participating in the course (Figure 1). To cater for the participants' diversity, we encouraged the participants to design the objects they wanted to print and do so at their own pace. These objects were designed with Tinkercad[3] as it does not require installation and it is widely regarded in the 3DP community as easy-to-use. After applying the slicing process with CURA[4], which we used because of its adaptable interface to different complexity levels, the objects were printed in the BCN3D Sigma printer at the center. We also introduced participants to types of materials and printers, online repositories (e.g. Thingiverse[5] and 3Dhubs[6]), and fabrication

[1] We did not use "3D modelling" because this term is highly specific and became important in the study once we had analysed the results – not before, when we conducted the search. Also, much research on digital fabrication in HCI refers to 3DP. Thus, to keep the search as broad as possible, we used the keyword 3D printing. In future research we will include 3D modelling as a keyword in more systematic reviews of previous and related works.

[2] We also conducted searches with the keywords "older adult" and "elderly", as these terms are often used in the literature to refer to older people. From the title and abstract of these papers, none was related to this one. They focused more on assistive technology and accessibility.

[3] https://www.tinkercad.com/ (April 20, 2021)

[4] https://ultimaker.com/software/ultimaker-cura (April 20, 2021)

[5] https://www.thingiverse.com/ (April 20, 2021)

[6] https://www.3dhubs.com/ (April 20, 2021)

spaces in <blind review>, to provide them with a more complete and dynamic picture of 3DP.

One of us (the fieldworker, in PO terminology) ran the courses. Before the courses were due to begin, the fieldworker was trained by one of us, who has previous experience of conducting ethnographic research but could not participate in the fieldwork activities of this project, during three months. The training focused on the importance of developing key skills in PO [4], i.e., observation and recording. We focused on the habit of writing systematic notes and the ability to write and observe simultaneously. To do so, the fieldworker participated in some courses on computing in AG. The senior ethnographer also shared his/her own experiences and 'tricks' from the field, and other recommendations, such as those suggested in [2], e.g., recognize patterns, pay attention to proxemics, and write descriptions of people and objects as objectively as possible. This senior ethnographer also oversaw the fieldwork by meeting once a month with the fieldworker as the courses progressed.

The fieldworker jotted notes of his conversations with and observations of the participants immediately after the sessions, which were so active that they hindered in situ note-taking. We did not use video cameras, as they could have been highly disruptive.

Back at his desk, he wrote more descriptive notes, based on the ones he jotted in the field, which were shared in a Google Doc with the other authors, to combine different perspectives. We analyzed the notes by conducting reflexive thematic analysis, for its flexibility and importance in qualitative research [4]. All of us read the notes, generated initial codes, and searched for themes by collating codes into potential patterns. We wrote memos to discuss the potential patterns and check the codes worked in relation to them. We did so iteratively, until we shared similar, and more nuanced readings of the notes. This lead to a redefinition of the themes and the final ones, in **bold** in the results: s*elf-confidence*, *spatial visualization*, *interaction issues*, and *satisfaction*.

3 Results

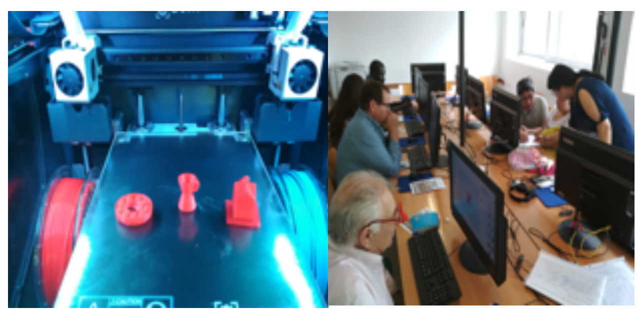
Self-confidence. We found that the popular motto in making, 'we are all makers', did not apply to our participants. They perceived 3DP as "*something for experts, not for us*" [P1]. They reported feeling outsiders in fabrication hubs. They also had very low levels of self-confidence in their abilities to engage in 3DP, and little previous experience of using computers, "*this is too much for us, I think*" [P2]. Still, they wanted to explore this new world for them, "*It's interesting to know these new modern technologies*" [P5].

Spatial visualization and interaction issues. Our participants wished to create mostly decorative – not functional – objects. They were working on 3D designs by thinking in 2D, something that came natural to them and, to their surprise, gave rise to unexpected behaviors of the objects on the screen, as they did not use camera control "*I want to widen this damn cube and what happens is this, you see, what the hell is the cube doing up there?!*" [P7]. Clicking on the desired point and modifying the object was another challenge. They often clicked on the wrong point, leading to undesired changes, low levels of self-esteem and complaints about their lack of ability. Over time, and with a lot of effort and determination, and support from the course instructor and other participants, they overcame these barriers. Yet, they had to overcome another one, printing, which was not straightforward, as they had to learn a new and difficult step for them in the 3DP workflow, i.e., slicing, "*It's a complex process, we need to follow a number of steps and it's hard to remember them.*" [P3]

Notwithstanding these challenges, participants finished the courses by being able to plan their designs, conceptualize the 3D space while designing, and use the camera, as well as a combination of several functions (e.g. Boolean unions and extrusion), to create and print their objects in a personalized manner.

Satisfaction. Participants were happy, proud of their new skills and of what they have learned and achieved, "*Look what I made! Do you like it? It's a doll face! I'll give it to my niece! I did not imagine I could do this, I'm really happy*" [P10]. The most motivated ones (older people) reported being willing to participate in Fab Labs and run courses on 3DP in the local center after the end of the project, "*I didn't know that there are places using 3DP in the city. Maybe it's worth going there and asking if we can see how people work there? We could also check if we can use it!*" [P12]

Figure 1: 3D objects printed (left) and participants in the course (right)



4 Conclusion

The initial results confirm the low levels of democratization and empowerment of 3DP discussed in the literature with a user group that has mostly been overlooked in HCI research on 3DP thus far. Regarding democratization, expecting our participants to take part in fabrication spaces without having partaken in our courses, or similar activities, is unrealistic. Regarding empowerment, the notions of empowerment that our participants attached to 3DP were beyond the instrumental, e.g. realizing they are able to do something they thought they could not do is what 3DP meant to them, failing behind the ideals of 'we are all makers'.

The results give support to our RQ and methodological approach, showing that the 3D modeling and printing experiences of a number of vulnerable people at risk of social exclusion can be both examined and facilitated. This challenges (mostly) stereotyped views, e.g., 'people belonging to marginalized groups have less ability' [12], and difficulties found in the study, such as 'this is for experts, not for us'.

The results have identified two key aspects to examine further while working towards addressing our RQ. We outline them next.

Most of the participants' difficulties were due to mouse accuracy, which might be expected in light of their profile. We plan to examine voice-driven interaction, as it might reduce considerably difficulties using the mouse amongst this population [23], and create a more natural way of engaging in 3D modeling, by using voice commands (e.g., 'move <object> to the right'). On the other hand, this interaction style might present some difficulties in a room full of people. This should also enable us to explore an emerging interaction style with 'extraordinary' users in a setting other than the home, where most voice assistants are used.

Our participants also found it difficult to conceptualize the 3D space. This refers to spatial visualization, i.e., the ability to mentally manipulate, rotate, twist, or invert a pictorially presented stimulus [16], typically 2D or 3D figures. Previous research shows that increased age is associated with lower levels of performance on several tests of spatial visualization [22]. Our results show that this holds true in 3D modeling too. How can we improve spatial visualization among our participants? We plan to adapt techniques and methods, such as video games and augmented reality [27], which are used satisfactorily in engineering graphics with students. By doing so, we expect to build more inclusive technologies that enable vulnerable people to better conceptualize the 3D space.

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Blind review.

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