Walk-Up-and-Use 3D Printing: Experiences of Casual Makers

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Abstract

Interest in understanding and facilitating 3D digital fabrication is growing in the HCI research community. However, most of our insights about end-user interaction with fabrication are currently based on interactions of professional users, makers, and technology enthusiasts. We are investigating the experiences of *casual makers,* users who have no prior experience with fabrication and mainly explore walk-up-and-use 3D printing services at public print centers, such as libraries, universities, and schools. We recently carried out 32 interviews with casual makers, print center operators, and fabrication experts to understand the motivations, workflows, and barriers in appropriating 3D printing technologies. Our results suggest that casual makers are deeply dependent on print center operators throughout the process—from bootstrapping their 3D printing workflow, to seeking help and troubleshooting, to verifying their outputs. However, print center operators are usually not trained domain experts in fabrication and cannot always address the nuanced needs of casual makers. Our findings have implications for optimizing 3D design tools and interactions that can better facilitate casual makers' workflows.

Figure 1: A casual maker passes through several steps when attempting to 3D model and print, and may have to return to earlier steps in response to some errors. Different parts of the workflow are associated with different user challenges.
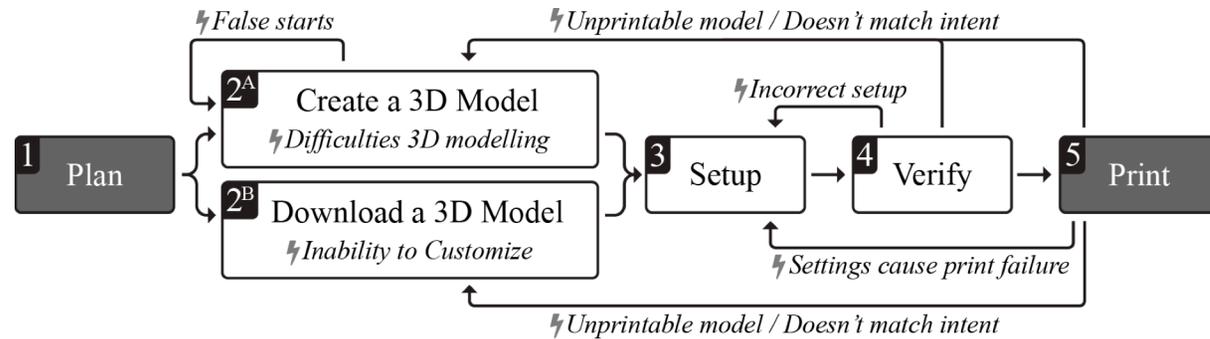
Introduction

The declining cost of fabrication hardware over the last few years has catalyzed the design of 'prosumer' machines and created new opportunities for consumers to make, create, and innovate [8]. This has led to the emergence of *makers*, a community of enthusiasts who focus on fabrication, invention and experience sharing, and who collaborate and learn in environments known as *makerspaces* [4]. Inspired by the makerspace concept, thousands of public institutions, such as schools [9], libraries [12], and universities [3], are now setting up print centers or creative hubs for end users to make use of digital fabrication technologies. However, unlike makerspaces that are often run by enthusiasts and have formal memberships that attract engineers, entrepreneurs, inventors, hackers, craftsmen, and artists [10], public print centers welcome users of all ages and skill levels [2] and offer 3D printing services for free or at nominal rates.

In our research [5], we use the term *casual makers* to describe users who have no prior experience with fabrication and mainly explore 3D printing at public print centers. Although focus on makers and enthusiasts [10], and professional users [6] is growing in human-computer interaction (HCI), we are only beginning to understand the emerging population of casual makers. This population is particularly interesting to study because casual makers can serve as a proxy for what it will be like for the general public to use 3D printing once this technology becomes even more economical and ubiquitous. We argue that if HCI is going to be at the forefront of inventing new fabrication design tools and interfaces [7], we need to look beyond enthusiasts and understand the challenges and opportunities that exist in facilitating the interactions of casual makers with fabrication technology.

In our recently study [5], we investigated how casual makers explore the world of walk-up-and-use 3D printing services, focusing on their motivations, workflows, and barriers that they face. We carried out semi-structured interviews with users who had little or no prior fabrication or 3D modelling experience, but had recently visited a print center to try out 3D printing. To understand the full spectrum of casual making, we also solicited perspectives of *print center operators* and experts in fabrication. Based on findings from 32 interviews, we carried out a comprehensive analysis of what it is like for casual makers to interact with complex 3D printing workflows at public print centers, the role of operators, and how casual makers' interactions differ from fabrication experts.

Our main findings indicate that there is a strong inter-dependency between the different stages of a casual

maker's fabrication workflow (Figure 1) that impacts the whole user experience. We further found that casual makers often struggle in every part of this workflow, from creating their 3D model to forming a mental model for 3D geometry to creating their final printed outputs. Although some of our participants avoided the difficulty of learning 3D modelling by turning to premade 3D models available through services such as *Thingiverse.com*, they were often deterred by the limited options to customize the models. We found that casual makers were successful only with the help of print center operators at every stage—from bootstrapping their 3D printing workflow, to seeking help and troubleshooting, to verifying their outputs. However, the operators could not always address the nuanced needs of casual makers as the operators were not formally trained in fabrication.

A key focus in the HCI community has been on making the 3D modelling step easier for end users, which we observed was a key challenge for our participants. However, as discussed above, we observed a strong interdependency between the different stages of the 3D printing workflow in that casual makers often struggled not only in creating models, but also in understanding how the model geometry affected output, or how print settings affected output. There has been some exploratory work that uses real time interactive fabrication to help users better understand the relationship between their model and fabrication output [13], or uses interactive guided tools that help end users build more viable objects, such as structurally sound furniture [11]. There is potential in further exploring this space that can help casual makers better connect their design intent to output.

Additionally, one issue that we observed in the study was that almost all of our participants were deeply dependent on print center operators to bootstrap their 3D printing workflow and to troubleshoot. Given our observations, we believe that this dependency will not easily go away even if we improve the usability of fabrication tools because of the output-driven custom needs of casual makers and lack of interest and time in gaining expertise in the underlying domain. Therefore, we have to view 3D printing for casual makers as a highly social activity and there may be numerous opportunities along this path to support casual makers' workflows. For example, it may be possible to "weave in" expert tips, advice, and explanations throughout the printing workflow. Expertise-sharing systems have a long history in HCI [1] where information is shared in a way such that the expert is an "intangible" actor in the interaction.

Our work makes the following main contributions:

- Establishes an empirical understanding of casual makers' motivations, workflows and barriers in using 3D printing technologies and illustrates the role of print center operators in providing support throughout the process.

- Provides insights into public print centers and how they lower the barrier to access for 3D printing technologies, but currently lack the kind of community expertise and knowledge sharing that is the hallmark of makerspaces.

- Highlights the opportunities that exist in building the next generation of inter-connected fabrication tools with features for supporting expertise sharing.

References

1. Mark S. Ackerman, Juri Dachtera, Volkmar Pipek, and Volker Wulf. 2013. Sharing knowledge and expertise: The CSCW view of knowledge management. Computer Supported Cooperative Work (CSCW) 22, 4-6: 531–573.
2. Shannon Crawford Barniskis. 2014. Makerspaces and Teaching Artists. Teaching Artist Journal 12, 1: 6–14.
3. Michael Groenendyk and Riel Gallant. 2013. 3D printing and scanning at the Dalhousie University Libraries: a pilot project. Library Hi Tech 31, 1: 34–41.
4. John Hagel, John Seely Brown, and Duleesha Kulasooriya. 2014. A movement in the making. Deloitte University Press, Texas, United States.
5. Nathaniel Hudson, Celena Alcock, and Parmit K. Chilana. 2016. Understanding Newcomers to 3D Printing: Motivations, Workflows, and Barriers of Casual Makers. Proceedings of the SIGCHI Conference on Human Factors in Computing Systems. (To appear).
6. Ghang Lee, Charles M. Eastman, Tarang Taunk, and Chun-Heng Ho. 2010. Usability principles and best practices for the user interface design of complex 3D architectural design and engineering tools. International Journal of Human-Computer Studies 68, 1–2: 90–104.
7. David Mellis, Sean Follmer, Björn Hartmann, Leah Buechley, and Mark D. Gross. 2013. FAB at CHI: digital fabrication tools, design, and community. CHI'13 Extended Abstracts on Human Factors in Computing Systems, ACM, 3307–3310.
8. Catarina Mota. 2011. The rise of personal fabrication. Proceedings of the 8th ACM conference on Creativity and cognition, ACM, 279–288.
9. Mike Murphy. With the 3D printer revolution slow to reach the household market, MakerBot regroups. Quartz. Retrieved September 1, 2015 from http://qz.com/401569/makerbot-has-found-its-audience-and-its-not-you-or-me/
10. Kimberly Sheridan, Erica Rosenfeld Halverson, Breanne K Litts, Lisa Brahms, Lynette Jacobs-Piebe, and Trevor Owens. Learning in the Making: A Comparative Case Study of Three Makerspaces - ProQuest. Harvard Educational Review 84, 4.
11. Nobuyuki Umetani, Takeo Igarashi, and Niloy J. Mitra. 2012. Guided exploration of physically valid shapes for furniture design. ACM Trans. Graph. 31, 4: 86.
12. Charlie Wapner. 2013. Progress in the Making: 3D Printing Policy Considerations through the Library Lens. OITP Perspectives, 3.
13. Karl D.D. Willis, Cheng Xu, Kuan-Ju Wu, Golan Levin, and Mark D. Gross. 2011. Interactive Fabrication: New Interfaces for Digital Fabrication. Proceedings of the Fifth International Conference on Tangible, Embedded, and Embodied Interaction, ACM, 69–72.