The Future of Making:
Where Industrial and Personal Fabrication Meet

Verena Fuchsberger
Martin Murer
Manfred Tscheligi
Center for HCI
University of Salzburg, Austria
{firstname.lastname}@sbg.ac.at

Silvia Lindtner
University of Michigan,
School of Information
Ann Arbor, USA
lindtner@umich.edu

Andreas Reiter
Mixed Reality Laboratory,
School of Computer Science,
University of Nottingham
Nottingham, UK
andreas.reiter@nottingham.ac.uk

Shaowen Bardzell
Jeffrey Bardzell
Indiana University
Bloomington, USA
[selu; jbardzel]@indiana.edu

Pernille Bjørn
University of Copenhagen
Copenhagen, Denmark
pernille.bjorn@diku.dk

ABSTRACT

This one-day workshop seeks to reflect on the notion of fabrication in both personal and industrial contexts. Although these contexts are very distinct in their economical and political vision, they share important characteristics (e.g., users interacting with specific fabrication equipment and tools). The workshop topic spans from personal fabrication to (automated) production, from applied to theoretical considerations, from user requirements to design as a crafting practice. We will address changes in production that affect humans, e.g., from mass production to Do-It-Yourself (DIY) production, in order to discuss findings and lessons learned for individual and collective production workplaces of the future. We aim to explore the intersections between different dimensions and processes of production ranging all the way from hobbyist to professional making. Furthermore, the workshop will critically reflect on current developments and their consequences on personal, societal, and economical levels including questions of the reorganization of work and labor, innovation cultures, and politics of participation.

ACM Classification Keywords

H.5.m. Information Interfaces and Presentation (e.g. HCI): Miscellaneous

Author Keywords

Personal fabrication; industrial fabrication; production; manufacturing; DIY.

INTRODUCTION

In the production of goods, tremendous changes are on their way that affect how and where they are manufactured, and who is producing them, introducing critical alternatives to the field of fabrication. First, lowering costs of previously unaffordable manufacturing hardware have been accompanied by a rise of the so-called DIY maker movement – hardware enthusiasts committed to creating their own products, tools and machines (rather than purchasing them) (e.g., [1, 5, 6, 17]). Much of the scholarly discourse on makers argues that this will lead to a democratization of manufacturing and *personal fabrication* (e.g., [4, 6, 10, 11, 12, 13, 14]). These Do-It-Yourself (DIY) and maker cultures (e.g., [9, 18]) are currently much debated in the broader HCI and CSCW communities, as evident through CHI 2014 hosting a panel on "Making Cultures: Empowerment, Participation, and Democracy or Not?" [1], which aimed at unpacking the overly euphoric visions and promises of making as a "third industrial revolution". At CSCW 2014, a similar panel investigated "Making Cultures: Building Things & Building Communities" [17].

While maker cultures have garnered significant attention, recent changes in *industrial fabrication* are yet to be explored in HCI research. These transformations are driven by a desire to integrate smart computation into production facilities. For instance, in German speaking countries, "Industry 4.0" (e.g., [3]) has been coined as the term that indicates the efforts to computerize traditional manufacturing industries, also often called a "fourth industrial revolution" [3]. Adaptability, flexibility, and resource efficiency are anticipated to rise with the introduction of smart computation in production facilities. Furthermore, there are endeavors to individualize production in order to provide customized goods within mass production. Closely intertwined with these attempts are efforts around the "Internet of Things (IoT)", trying to turn visions of ubiquitous computing [20] into products [2] and standards [16].

Personal and industrial fabrication certainly differ in terms of political and strategic aims. While advocates of personal fabrication are envisioning a democratization of technology production (e.g., [17, 18]), those in industrial fabrication tend to make use of the economical potential that comes with individualized goods. However, this distinction is blurring, as personal fabrication is becoming an economic sector on its own, as visible in the rise of maker entrepreneurship [9]. Making, indeed, is envisioned as a return to the "made in America" brand [9] and the revamp of manufacturing in China as new site of innovation [7].

In this workshop, we seek to focus on characteristics that industrial and personal fabrication share. Fabrication – despite all automation efforts in production facilities – relies strongly on human labor and skills. Makers are envisioning to rework traditional processes of use and labor, enabling others to become producers not just of products, but also of new economic and political arrangements. In (western) factories, the humans' role turns from executors of tasks to coordinators and decision makers in order to account for customized goods and automated production [3]. In manufacturing in Southern China, on the other hand, we witness the rise of agile and rapid innovation processes rooted in an open source culture applied to industrial production [8]. These findings challenge traditional binaries that inherently associate western maker culture with creativity and innovation, and industrial production (in the so-called developing world) as numb execution. Taken together, both forces, grassroots making and industrial production, are continuing to drastically remake societal, economic, and political processes (see e.g., [19]), which influences how work force, innovation, and power are distributed.

Many promises are associated with maker movements, DIY and personal fabrication, such as a democratization of technology and increasing possibilities of participation. By the same token, industrial fabrication is anticipated to have a significant upturn enabled by increased automation and the production of individualized goods. Both augur paradigmatic changes in computing, one by focusing on making, the other one by upholding automation.

However, *are these euphoric visions of how fabrication changes desirable? If yes, how can they become reality? How can we, as a research community, help to achieve and sustain the potentials while being critical about undesirable consequences? How can we cross the boundaries between making and automation in order to facilitate collaboration and knowledge exchange?*

With this workshop, we aim to discuss these questions by reflecting on processes around hobbyist and professional production, their intersections as well as their social, economic, and technological consequences. These consequences are likely to affect humans and their quality of life in the next decades, in professional environments (e.g., factory workers), hobbyist settings (e.g., makers), or both. In line with the conference's scope, we attempt to establish a discourse that connects working life with civic life, which is nurtured by recent developments, changes, and promises in fabrication.

By focusing on intersections of personal and industrial fabrication, we aim to explore the opportunities and politics of the recent rise in smart computation, IoT, and maker entrepreneurship. Few efforts have investigated how processes of personal or industrial fabrication relate. We aim to discuss diverse perspectives, seeking to critically unpack who benefits from these changes in production, who gets to participate, and what sites of making, craftsmanship and production might be rendered invisible. In doing so, we question overly euphoric visions of individual empowerment and democratization of production.

Overview of the Workshop

The workshop will kick off by having the organizers provide an introduction to the topic, including their own perspectives, research and other engagements with personal and industrial fabrication. Participants will be invited to present their positions or projects on the topic, their experiences and reflections. We anticipate around 15 participants from diverse backgrounds (personal fabrication, industrial fabrication, or both).

In advance to the workshop, the organizers will group the participants for the break-out sessions to create heterogeneous subgroups in terms of backgrounds and experiences. The participants will be asked to bring artifacts with them that characterize their research contexts, for instance, objects that would contemporarily be difficult or impossible to fabricate in other realms (e.g., artifacts resulting from a maker, hacker, or DIY project, factory-made goods, etc.). In the break-out sessions, the subgroups will explore these artifacts and discuss whether, how, or why a specific artifact is characteristic to current industrial or personal fabrication in order to identify underlying dynamics and practices.

Time	Activity
09:00 - 09:30	Welcome and introduction to the workshop
09:30 - 10:30	Participants' statements
10:30 - 11:00	Break
11:00 - 12:30	Break-out session: Subgroups discussing objects they brought along (e.g., their characteristics, dynamics, and fabrication practices)
12:30 - 13:30	Lunch
13:30 - 15:00	Plenum session: Presentations of break-out sessions outcome and discussion
15:00 - 15:30	Break
15:30 - 17:00	Development of an (critical) agenda concerning the potential future interplay of personal and industrial fabrication

Table 1. Workshop Schedule.

Afterwards, we will reflect on how fabrication changed and changes, and how this will influence the future of fabrication and humans as innovators, workers, activists, etc. In particular, we will critically engage with larger social implications for workers, tech and venture labor [15]. Finally, our goal is to develop an agenda for how to shape the exchange between research on personal and industrial fabrication (e.g., the format of an ongoing discourse), while sustaining a critical perspective on consequences that these developments bring along. The organizers will actively participate in all sessions to foster discussions and reflection. Table 1 illustrates the overall schedule for the workshop.

Prior to the workshop, the participants' contributions will be posted on the website in order to allow preparation. We will take the workshop as an opportunity to explore future collaboration, e.g., a special issue, a mailing list, or collaborative research projects. Part of our goal is to build a community of scholars and practitioners concerned with both hobbyists and professional making cultures, as well as intersections thereof.

Organizers' Biographies

Verena Fuchsberger is postdoctoral research fellow at the Center for Human-Computer Interaction (University of Salzburg). She has done master degrees in Educational Sciences and Psychology and recently finished her PhD in HCI. In her research, she focuses on the agency of human and non-human actors in HCI and Interaction Design. In particular, she is interested in the materiality of interactions, which she investigated also in industrial contexts, such as a semiconductor factory. She co-organized workshops, for instance, at IDC2011 or NordiCHI2012.

Martin Murer is interaction designer and researcher at the Center for Human-Computer Interaction (University of Salzburg), focusing on craft and technology. His research at the intersection of industrial and personal fabrication is concerned with the tangible practices that are relevant in both contexts, as even highly automated manufacturing processes are heavily depending on all sorts of embodied practices, mechanical skills and tacit knowledge. He co-organized workshops, for instance, at TEI (2014, 2015).

Manfred Tscheligi is professor for HCI & Usability at the University of Salzburg. He further is head of the business unit Technology Experience at the Austrian Institute of Technology. He leads a variety of research projects that investigate human-computer interaction in industry, e.g., the Christian-Doppler Laboratory on "Contextual Interfaces", a seven years industry-research cooperation. He was involved in a range of conference activities (e.g., co-chairing CHI2004 in Vienna, ACE 2007 or AUI 2011 in Salzburg) and co-organized several workshops and SIGs (CHI, Mobile HCI, AUI, CSCW).

Silvia Lindtner is an assistant professor at the University of Michigan in the School of Information. Her research investigates the role digital technologies play in global processes of innovation, work and labor, as sites of expressions of selfhood and collectivity, and in relation to political, social and economic processes of urban redesign. She explores these themes through a contemporary research project; DIY maker and hacker culture, with a particular focus on its intersections with manufacturing and creative industry development in China. She has published in various disciplines such as HCI, CSCW, STS, and China studies, and has organized workshops at Ubicomp and CHI in 2009, 2010 and 2011 as well as international workshops and conferences on making and manufacturing cultures 2011-2014 (see: www.hackedmatter.com).

Andreas Reiter is an early-stage PhD Student in the Mixed Reality Laboratory of the School of Computer Science and Horizon CDT at the University of Nottingham, UK. His research investigates the social organization of work practice within UK Hacker-/Maker Communities, with the intent of creating design to augment and facilitate innovation. He is one of the founding members of the OTELO Open Technology Laboratories (www.otelo.or.at) in Vorchdorf (Austria), which aims at enabling citizens with public and free access to rapid prototyping tools in rural Austria. He organized a RCUK Digital Economy Network Makers Workshop around MakerFaireUK 2014.

Shaowen Bardzell is an Associate Professor in the School of Informatics and Computing and the Affiliated Faculty of the Kinsey Institute at Indiana University. Bardzell leverages her background in the humanities to study technology in use, with an emphasis on participatory, intimate, and embodied experiences. One thread of her recent work has focused on how making and criticality intersect, especially in the context of national and cultural identity, local material resources, and community activism.

Jeffrey Bardzell is an Associate Professor of HCI/Design at Indiana University. He brings a humanist perspective to HCI and is best known for bringing critical perspectives into HCI, e.g., in his research on interaction criticism, aesthetics, and critical design. His interest in maker culture extends his prior research on the co-emergence of tools, communities of practice, and aesthetic vocabularies in amateur creative communities, ranging from traditional craft communities to online multimedia authoring communities.

Pernille Bjørn is Professor in CSCW at the Computer Science Department at University of Copenhagen, Denmark. She specializes in conceptualizing collaborative work arrangements and is mostly known for her CSCW work in healthcare and global software development. Currently, she is interested in unpacking the ways in which Makers engage and collaborate – shared knowledge and ideas – as prominent aspects of their work. In particular she is interested in exploring the opportunities for new born global companies arising out of the Maker communities, and how best practices for distributed work practices can be created based upon previous research on global software development, however particular adjusted to fit nature of the Maker communities.

REFERENCES

1. Morgan G. Ames, Jeffrey Bardzell, Shaowen Bardzell, Silvia Lindtner, David A. Mellis, and Daniela K. Rosner. 2014. Making Cultures: Empowerment, Participation, and Democracy - or Not?. In *Proceedings of the Extended Abstracts of the 32Nd Annual ACM Conference on Human Factors in Computing Systems (CHI EA '14)*. ACM, New York, NY, USA, 1087–1092. DOI:http://dx.doi.org/10.1145/2559206.2579405

2. Kevin Ashton. 2009. That 'internet of things' thing. *RFiD Journal* 22, 7 (2009), 97–114.

3. Malte Brettel, Niklas Friederichsen, Michael Keller, and Marius Rosenberg. 2014. How virtualization, decentralization and network building change the manufacturing landscape: An Industry 4.0 Perspective. *International Journal of Mechanical, Industrial Science and Engineering* 8, 1 (2014), 37–44.

4. Amber Ferger, Wai Fai Lau, Philipp Ross, Wyman Zhao, Hiroki Sayama, and Steen Rasmussen. 2013. Impact of Personal Fabrication Technology on Social Structure and Wealth Distribution: An Agent-Based Simulation Study. In *Advances in Artificial Life, ECAL*, Vol. 12. 521–522.

5. Neil Gershenfeld. 2008. *Fab: the coming revolution on your desktop–from personal computers to personal fabrication*. Basic Books.

6. Scott E. Hudson. 2014. Printing Teddy Bears: A Technique for 3D Printing of Soft Interactive Objects. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '14)*. ACM, New York, NY, USA, 459–468. DOI:http://dx.doi.org/10.1145/2556288.2557338

7. Silvia Lindtner. 2012. *Cultivating Creative China: Making and Remaking Cities, Citizens, Work and Innovation*. University of California, Irvine.

8. Silvia Lindtner, Anna Greenspan, and David Li. 2014a. Shanzhai: China's Collaborative Electronics-Design Ecosystem. (2014). http://www.theatlantic.com/technology/archive/2014/05/chinas-mass-production-system/370898/

9. Silvia Lindtner, Garnet D. Hertz, and Paul Dourish. 2014b. Emerging Sites of HCI Innovation: Hackerspaces, Hardware Startups & Incubators. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '14)*. ACM, New York, NY, USA, 439–448. DOI:http://dx.doi.org/10.1145/2556288.2557132

10. Hod Lipson and Melba Kurman. 2010. Factory@ home: The emerging economy of personal fabrication. *A report commissioned by the US Office of Science and Technology Policy* (2010).

11. David A. Mellis and Leah Buechley. 2012. Case Studies in the Personal Fabrication of Electronic Products. In *Proceedings of the Designing Interactive Systems Conference (DIS '12)*. ACM, New York, NY, USA, 268–277. DOI:http://dx.doi.org/10.1145/2317956.2317998

12. Catarina Mota. 2011. The Rise of Personal Fabrication. In *Proceedings of the 8th ACM Conference on Creativity and Cognition (C&C '11)*. ACM, New York, NY, USA, 279–288. DOI:http://dx.doi.org/10.1145/2069618.2069665

13. Stefanie Mueller, Pedro Lopes, and Patrick Baudisch. 2012. Interactive Construction: Interactive Fabrication of Functional Mechanical Devices. In *Proceedings of the 25th Annual ACM Symposium on User Interface Software and Technology (UIST '12)*. ACM, New York, NY, USA, 599–606. DOI:http://dx.doi.org/10.1145/2380116.2380191

14. Stefanie Mueller, Tobias Mohr, Kerstin Guenther, Johannes Frohnhofen, and Patrick Baudisch. 2014. faBrickation: Fast 3D Printing of Functional Objects by Integrating Construction Kit Building Blocks. In *CHI '14 Extended Abstracts on Human Factors in Computing Systems (CHI EA '14)*. ACM, New York, NY, USA, 187–188. DOI:http://dx.doi.org/10.1145/2559206.2582209

15. Gina Neff. 2012. *Venture labor: Work and the burden of risk in innovative industries*. MIT Press.

16. Huansheng Ning and Ziou Wang. 2011. Future Internet of things architecture: like mankind neural system or social organization framework? *Communications Letters, IEEE* 15, 4 (2011), 461–463.

17. Daniela K. Rosner, Silvia Lindtner, Ingrid Erickson, Laura Forlano, Steven J. Jackson, and Beth Kolko. 2014. Making Cultures: Building Things & Building Communities. In *Proceedings of the Companion Publication of the 17th ACM Conference on Computer Supported Cooperative Work & Social Computing (CSCW Companion '14)*. ACM, New York, NY, USA, 113–116. DOI:http://dx.doi.org/10.1145/2556420.2556852

18. Joshua G. Tanenbaum, Amanda M. Williams, Audrey Desjardins, and Karen Tanenbaum. 2013. Democratizing Technology: Pleasure, Utility and Expressiveness in DIY and Maker Practice. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '13)*. ACM, New York, NY, USA, 2603–2612. DOI:http://dx.doi.org/10.1145/2470654.2481360

19. Peter-Paul Verbeek. 2011. *Moralizing technology: Understanding and designing the morality of things*. University of Chicago Press.

20. Mark Weiser. 1993. Some Computer Science Issues in Ubiquitous Computing. *Commun. ACM* 36, 7 (July 1993), 75–84. DOI:http://dx.doi.org/10.1145/159544.159617