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Rethinking Technology Innovation

Factories, Fabrication & Design Research

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Rethinking technology innovation: Factories, Fabrication & Design Research

In September 2015, a summit on **Rethinking Technology Innovation** took place in Salzburg, Austria. Experts in the area of fabrication from Asia, Europe and the US came together to discuss factories, fabrication and design research in the light of Human-Computer Interaction.

This event had the mission of bridging single perspectives on fabrication by discussing its spectrum, including making, personal fabrication, do-it-yourself (DIY), manufacturing and industrial production in different cultures and countries. HCI has always been engaged with questions of fabrication, ranging from studying human factors, collaboration, or user experience in industrial settings (e.g., Carstensen et al., 1999, Wurhofer et al., 2015), to a rather modern emphasis on making and innovation of production (e.g., Lindtner, 2015). The summit not only built bridges between different notions of fabrication research, but also between research and practice, reflected by the expertise of the participants. Around 30 researchers and PhD students in HCI and Interaction Design, experts in industrial production (some of whom also representing a research expertise) and decision makers discussed cultures, regulations, and visions of fabrication.

The summit originated when we (Manfred Tscheligi, Verena Fuchsberger and Martin Murer from the University of Salzburg and Silvia Lindtner, University of Michigan) recognized a shared interest in fabrication, drawing from a variety of backgrounds, interest and methodological approaches. Silvia Lindtner focuses on the cultural politics and transnational processes of making, industrial production, and entrepreneurship in urban China and the United States (e.g., Lindtner et al., 2014; Lindtner 2015; Lindtner et al. 2015). Manfred Tscheligi, Verena Fuchsberger and Martin Murer research production and manufacturing in Austria, focusing on (third-wave HCI) themes such as user experience or materiality in factory environments (e.g., Fuchsberger et al., 2014). All of us have been centrally engaged in fabrication and prototyping as a means of conducting research, exploring avenues such as research through design and critical making (e.g., Murer et al., 2015; Lindtner et al. 2015 or as documented here: www.hackedmatter.com). Across our work, we have witnessed how approaches in making and industrial fabrication are increasingly intertwined; on the one hand, an expanding number of makers and open source hardware enthusiasts is moving into professional production and on the other hand, established manufacturing businesses envision to upgrade their production by incorporating making and open source approaches to retrain their workforces in creative and innovative thinking. Taken together, we argue that this intersection of making and professional production constitutes a unique opportunity to revisit concepts in interaction design, human-computer interaction, labor and work as well as shape new agendas for research and design. Our team came together around the shared interest to uncover diverse forms of making, from hobbyist tinkering over political intervention to industrial production. We began our collaboration with a workshop hosted at the 5th decennial Aarhus Conference on Critical Alternatives in 2015, focusing on intersections between personal and industrial fabrication (Fuchsberger et al., 2015). The conference with its commitment to a critical scholarship of computing constituted a unique moment to unpack what was at stake in contemporary shifts in production. The first workshop was a success opening up further avenues for research and debate, which led us to organize a summit in Salzburg, Austria, in September 2015, bringing together perspectives from research, industry and making.

Topics spanned a variety of themes, which we summarize in what follows, focusing specifically on the differences in perspectives, provocations, remaining questions and future directions. Our main questions centered around what and who makes fabrication today, what are the various visions of fabrication, and what does this all mean for fields like HCI and interaction design.



What is fabrication?

It's multiple.

Although on different scales and organized in different ecosystems, fabrication is not only relevant in professional and business terms (e.g., industries, innovation, economy, ...), but also for individuals, be it workers in factories, or makers, whose aims and motivations differ (e.g., hobby or doing a job; producing goods for one's own use or for others' use). It affects education by requiring specific knowledge, know-how and training to be able to work in those areas and it is a matter of policy, as regulations for specific products (e.g., for medical products), educational strategies, infrastructures (e.g., broadband, maker spaces) and funding for R&D are depending on the conditions provided by national and international policies.

The increasing availability and the decreasing costs of hardware has propelled forward different fabrication cultures. In Europe, industrial production is currently characterized by the term "industry 4.0", indicating significant changes in manufacturing towards smart production. Intelligent and connected production facilities, including robots as "workers," have already changed the way people work in production.

"Industry 4.0 is a monster in complexity (...). At the moment, we need to find the right questions, not the right answers" (Michael Wiesmüller, Austrian Ministry for Transport, Innovation and Technology)

Manufacturing, as a central driver of European economy, is characterized by high-competence, innovative production in central Europe, and distribution of production facilities across lower-cost central and eastern European countries. It is, however, undergoing serious changes, e.g., output of services growing faster than that of goods, increasing high-tech manufacturing resulting in less available jobs, etc.¹

Innovation is considered key to industrial sustainability and competitiveness. The availability and accessibility of open technology, such as the Raspberry Pi, smart devices and sensors increasingly drive new forms of innovation within European industries, though the potential of open innovation is still to be explored and incorporated. Industry and research have become increasingly intertwined with the goal to sustain Europe as an innovative, stable, and competitive environment.

"There is a high potential for smarter products and new services" (Martin Zehnder, COO from Palfinger, an internationally operating crane producer with headquarter in Austria)

Similarly, politicians and corporates in Asia are promoting the upgrading of their industrial production sites. China, for instance, promotes making, Internet Plus and tech entrepreneurship as the means to transform from an image of "made in China" to "created in China". The vision is that making can cultivate an entrepreneurial spirit and micro-innovations that in part help to address a slow-down of the Chinese economy. The South of China has historically witnessed an informal manufacturing economy that unfolds through interpersonal relations, face-to-face networking and an open sharing mentality. It is this sociotechnical fabric of production in China that international makers and hardware entrepreneurs tab today to move products to the market quickly.

¹ See, e.g., Konstantin Pashev (ed), Paolo Casini, Neil Kay, Smaranda Pantea: EU Structural Change 2015. URL: http://ec.europa.eu/growth/industry/competitiveness/reports/eu-industrial-structure-report/index_en.htm



It's cohesive.

Making and industrial production do not exist in a dichotomy, but constitute different dimensions of fabrication. And yet, there are a variety of efforts streamlining hobbyist and professional production, making them seemingly more cohesive. A variety of infrastructures are being built and maintained to support hobbyist makers and entrepreneurs to move into mass production. Making, here, is envisioned to contribute to innovation and economic success.

"There are two different maker-related movements in China and Taiwan: one coming from maker spaces, tinkering around, making, hacking, financed, for instance, by crowd funding; the other one coming from incubators, young startups, trying to push innovative products and try to collect venture capital" (Terry Cheng, former President of China HP and TI Asia, former CEO of Foxconn International Holding; currently mentoring young makers on the startup journey at Terry & Friends, China)

Especially in the Chinese manufacturing ecosystem, innovation and production are merging, challenging any binary of design and production. Shenzhen, today often celebrated as the "Silicon valley for Hardware" or "Hollywood for makers", attracts makers because it has an already established social and technological ecosystem that enables professional production across various scales (from small- over mid- to large-size production). Corporate entities in the US and Europe, in particular, have taken notice and have already invested in China's design-maker-manufacturing ecosystem.

"It is important to not contrast existing companies and maker startups! More importantly, we need to connect both in order to transfer knowledge." (Suzanne L. Thomas, scientist at Intel Labs, USA)

The degrees of cohesiveness vary, though. One strategy of industry is to observe maker movements (e.g., to identify specialized interesting niches in the markets), another one is to consult makers (as ambassadors) to learn from them since they have a different approach, or to recruit makers as employees, becoming integral part of large scale industries. However, the culture of production is decisive; if an open design model is considered to characterize the future market, innovation might need to come from outside in order to be diversified and widely accessible. This would require a cultural shift, opening up in terms of products and skills; but what is the practice of economic change?

"In the realm of medical technology, which is very complex and costly, the maker movement paved the way for open prototyping workshops. Such open workshops allow to work interdisciplinary, requiring less efforts than traditional development processes for creating a novel product." (Georg Bauer, Vice President Engineering, STRATEC Consumables GmbH, Austria)

Interests in alternative forms of manufacturing and innovation are contributing to a variety of hopes associated with "making", e.g., towards its potential to support transformation and being a provocation to traditional industries.

It's diverse.

Talking about "the makers" and "the workers" does not do justice to the diversity of identities and motivations as well as cultures and ecosystems. Similarly, there is not one single homogenous "maker movement", but distinct and situated practices of making; making is heterogeneous, fragmented, and multiple. Making is often inherently associated with hobbyist production, creativity, design and craft; and yet many professional designers resist to be called a maker or distance themselves from the label.



"Stop talking about 'the maker culture'" (Anna Vallgård, Interaction Design Researcher at ITU Copenhagen, Denmark)

Disciplinary boundaries between designers, engineers, and hobbyist producers are often kept firmly intact, in order to legitimate their different efforts. What are the consequences of such boundary work? Those who advocate a maker approach often hope to break with such entrenched boundaries and established disciplines, envisioning the proliferation of production across differences in class, education, and region.

"Are we empowering individuals by making things more accessible?" (Seth Hunter, scientist at Intel Labs, USA)

In spite of making's utopian vision of individual empowerment and the hope in industrial production that instead of monotonous work individuals' expertise and skills will define their employment, participation remains somewhat exclusive and limited to availability of jobs, economic specifics, and pre-existing power relations. Digital fabrication, making, and industrial production cannot be seen in isolation from specific political processes, economic interests, local conditions, individual and societal value systems.

It's ideological.

Making has been mobilized for the furthering of different technological ideologies from promoting creativity and innovation thinking all the way to political intervention and critical reflection. The trope of a global maker movement is a powerful one, often assuming knowledge transfer across regions.

"Can we think about digital fabrication as a way to create digital proximity without physical proximity?" (Pernille Bjørn, Professor at the University of Copenhagen, Denmark)

However, the processes are still unclear on how to facilitate these transfers, but it is promising to think about making as a vehicle for questioning power and control, supporting activism and engagement.

"Making is something that unites people, it's cross culture" (Eric Pan, founder of Seeed Studio, China)

Making indeed promises to be a constructive site to envision alternatives. It can be the site for researchers, designers, and writers to support collaborations and partnerships across regions.

It's exclusive.

It is masculine. It is privilege. Although making is often related to visions of empowerment, as described above, there are several barriers that discourage people from taking part.

"Women often feel out of place" (Shaowen Bardzell, Assistant Professor at Indiana University, USA)

Certainly, it is a matter of interests, curiosity and skills, but it is also a matter of accessibility and inclusion. It seems that the current maker movement addresses only certain demographics, e.g., being male, having a specific mind-set. In the US, there are only few women participating; some are working in engineering, but they often come from Asia. The same can be observed in China, where both hobbyist making sites are predominantly male (this differs significantly when we turn to manufacturing, with a high percentage of female workers). However, there are also maker spaces specifically established for / by women, and more and more women are challenging established norms what counts as making and technology production. One way to further ad-



dress this issue might be to bring the maker movement to schools and the countryside, an effort that might also contribute to female students getting into engineering at all.

"Not everybody has a 'maker-mindset'; How can we 'explain' technologies to people without actual technological skills?" (Karin Slegers, Assistant Professor at the University Leuven, Belgium)

Consequently, there is an urging need for (research) initiatives that address questions of inclusion and equal treatment.

It's political.

The landscape of fabrication is also affected, driven, or constrained by political decisions. For instance, members of the Taiwanese maker scene propose a national project of making that challenges any prominence of Mainland China over the term or the approach. Making, here, is mobilized in a larger effort to articulate national and cultural identity. While governments across regions have become advocates of making, what they support in detail varies significantly and is often driven by national desires over global leadership. Governments increasingly facilitate innovation by allocating spaces for makers (e.g., at schools and universities), building infrastructures, and reducing taxes for startups. However, questions on how to encourage individuals to benefit from these infrastructures seem to be unsolved. Further, it remains yet to be seen how national and local governments will react if their maker policies do not lead to the expected growth in GDP or entrepreneurial expansion.

It's controversial.

While a variety of visions and hopes are attached to making and fabrication, there are several questions and concerns associated with these changes. For instance, a challenge that arises in Europe is how companies and industries will be able to transform in order to be competitive with new maker based start-ups. If this transformation fails, another solution on how to transform the job ecosystem will be required. This affects all levels of industrial production, observed, for instance, in North American companies whose managers on different levels struggle to connect innovative prototyping to larger batch production, being in-between tradition and innovation. Another concern is related to the gap between making infrastructures and actual usage thereof. The sole availability of maker spaces and fab labs will not be sufficient. For instance, in China and Taiwan, many maker spaces are pushed, some of which, however, lacking makers. Thus, people are needed who innervate these places, who are often hidden in the infrastructures of making and manufacturing.

"How sustainable are maker spaces?" (Volker Wulf, Professor at the University of Siegen, Germany)

Maker spaces are scaling up, especially in China. In 2015, the national government has launched a new policy on building "Mass maker spaces," aimed at training workers, employees, and students to become entrepreneurs. The decreasing costs of digital fabrication tools (e.g., 3D printers) seem to provide an opportunity to democratize production and usher into a next industrial revolution. The vision, here, is one that appeals to corporates, venture capitalists, and governments alike: by turning many (and indeed masses of) people into self-made entrepreneurs, current economic and societal challenges can be addressed. A question remains on whether those places and infrastructures actually empower people and allow civic engagement, or whether it's the people that shape action; It remains unclear who is (and wants to be) empowered. Sometimes, making is associated with power and activism, which does not fit the vision of *being* empowered. It is, consequently, a



discussion about values (e.g., societal, economic, politic, individual, local or transnational) and about idealism, passion, and creativity facing the realities of industry, economy and politics.

Furthermore, there are gaps between making and producing, which are based on geographies, ideologies, and economies. And there are gaps in skills between professional makers and designers and hobbyist ones, resulting in the question of whether everyone *has to* be (or become) a maker or a designer.

"Not everyone has to jump up" (Aaron Quigley, Professor at the University of St Andrews, Scotland)

Learning programming and making does not result in everyone becoming a programmer or maker; rather, it has the potential to facilitate having a critical perspective and contribute to (fabrication) literacies. Similarly, making does not equal being creative; it can, but it not necessarily does. In any way, these movements lead to a blurring of established roles and practices, such as use, design, make, customize, personalize, etc. Additionally, self-conceptions of makers may differ to a large extent, indicating subtle and fragile differentiations, e.g., based on local values and practices. For instance, makers in Taiwan and China may have a different understanding of how making is related to creativity, manufacturing, and entrepreneurship.

"We want to acknowledge the heterogeneousness and fragmentedness of what can assemble in distinct ways to a 'maker'" (Jeffrey Bardzell, Assistant Professor at Indiana University, USA)

While linking makers and industries seems a promising approach towards innovation and new industries, it is not an easy way to go. It is depending on the willingness, need, and capability of industries and economies, which, in turn, depend on policies, skills, and infrastructures. Similarly, making does not equal entrepreneurship, there are practices and processes that may contribute to makers becoming entrepreneurs, but they are still vague and unstable.

It's open to discussion.

The summit that took place in Salzburg was initiated as a get-together of practice and research. It revealed the many faces of fabrication, which are to varying extents already visible in (HCI) research. Still, the question remains what roles researchers have, might have and should have, as well as how they are shaping the discourses. At the same time, research influences notions of production and making by coining terms, by posing specific question and by looking into particular situations and contexts. One related challenge is how research follows up on movements and changes in policies and industries, potentially requiring new research practices. HCI and Interaction Design research need to find their role in this field, facing several questions that still haven't been solved or that are just arising:

- Is making becoming a form of being human?
- What role does computation play in fabrication? How do artists, makers, designers, programmers, workers use computation and computers to fabricate things?
- When is a product actually finished, acknowledging that a product is more than its functions?
- How can we create visibility of practices, infrastructures, facilitators and facilities?
- Participation is an ideal, but what forms of participation should be enabled, allowed, supported?
- How do communities look like, what stages and elements do they have, and how can learning from each other be supported?
- How can makers be supported by means of tools and practices?



- How can knowledge be transferred between cultures, movements, economies, industries, policies, nations, and disciplines? And how are we going to deal with intellectual property and distributed knowledge?
- Open source software and hardware, prototyping and design are converging practices – how can those be rendered visible and anchored?
- How can we incorporate existing HCI knowledge (e.g., about User Experience) of organizations into currently prominent fabrication topics, such as maker spaces?
- What is the relation between making and traditional arts or crafts?

Additionally, research should be committed to change the situation for the better, for instance, by being in dialogue with governments and decision makers. Related to both the role of research as well as policies is how education might need to address fabrication, i.e., how active participation can be increased by means of teaching. How can arts, crafts, and programming be implemented in schools and universities to allow engagement? How can construction, tools, materials, collaboration, and sharing contribute to an increasingly necessary digital/physical literacy? Do we need fab labs and maker spaces in schools and if yes, how should they look like to keep them alive?

“Teach students a bit of programming and a bit of hardware!” (Torkil Clemmensen, Professor at Copenhagen Business School, Denmark)

With these questions and challenges, which were discussed at the summit, we do not aim to conclude on this topic; instead, they are an invitation to research and practice to participate in the discourse on fabrication.

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