Towards a Conceptual Model for HCI and Making

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ABSTRACT

With digital fabrication and the Maker movement increasingly gaining traction, interest in those developments in the HCI community is also rising. However, there is no extensive conceptual model to illustrate the intersections of HCI and making. Based on literature as well as our own research, we introduce such a model which revolves around five central points: *teaching and learning*, *research*, *region*, *global* aspects and *economic* issues. For each point, we introduce and discuss its relation with and potentials for HCI.

Author Keywords

Making; HCI, digital fabrication; Fab Lab; model;

ACM Classification Keywords

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

INTRODUCTION AND STATE OF THE ART

> "HCI is no longer simply happening in interaction-oriented research labs and HCI-centered academic programs, in user experience groups or at HCI conferences. It is also happening at emerging sites of technical invention – at hardware incubators, at hackathons, and in hackerspaces." [19]

Making, Do-It-Yourself (DIY) and hacking, backed by digital fabrication technologies such as 3D printing has seen a significant uprise in recent years. This is facilitated through advancements in technological capabilities for sharing and collaboration [29] and, of course, through cheaper and more approachable digital fabrication machinery – as of the time of writing, a consumer 3D printer can be bought for less than 300 USD. Those developments spark the formation of an increasing number of related communities which also build physical spaces to pursue Making: The number of Fabrication Laboratories (Fab Labs), hacker- or makerspaces [5] is steadily growing[1]. This *Maker movement* is a world-wide phenomenon and finds applications for their DIY-spirit in a huge variety of projects which range from the manufacturing of personal electronic devices [23] through the deployment of digital fabrication technologies in educational settings with children [2] up to Fab Labs as novel venues for bottom-up efforts in ICT for Development (ICT4D) [25].

Obviously, DIY itself is not new – people have been making things on their own since the dawn of humanity. In fact, for a long time, activities such as sewing clothes or fixing tools have been simple necessities of life. Modern society has done away with most of those necessities, instead emphasizing consumption and mass production. The recent maker movement often has aspects of a counterculture to those developments, emphasizing openness, empowerment and *in situ* access to production [29]. Evidence for those values can not only be found in the maker communities themselves but also in products such as open hardware platforms like the Arduino and in new financing models like crowdfunding to bring products to market in a bottom-up fashion. Based on this, digital fabrication and making is even hailed as the next stage in the digital revolution, opening up the production of physical goods in a similar fashion as the Personal Computer did for the digital domain and potentially disrupting existing socio-economic patterns [6].

HCI has always been a discipline interested in as well as producing disruptive and innovative technologies and their relation to society. This is why we also see increasing interest in Making in HCI communities, conferences and journals: There have, for example, been investigations into bringing together DIY electronics with other crafts [4], into how to facilitate the appropriation of 3D printing technology in different communites [20] or even into into DIY biology [16]. In a more macro sense, Kuznetsov & Paulos look at the "Rise of the Expert Amateur" and argue for more engagement between HCI practitioners and DIY expert amateurs [15]. Lindtner et al. [19] make a strong case for the relevance of maker practices and -sites for innovation and pose that HCI has a key position in making:

"We argue that HCI is positioned to provide critical reflection, paired with a sensibility for materials, tools and design methods" [19].

We fully agree with this sentiment. Given this position, we have been working in maker related settings for the last years, such as action research motivated ICT4D work with refugee children and 3D printing, inquiries into the appropriation of digital fabrication in academic communities or tying Maker-type projects into the curriculum of our HCI Master's program at our home university where we are also currently founding a Fab Lab. However, during the course of those

[1] See also **`http://fablabs.io`** for a global overview

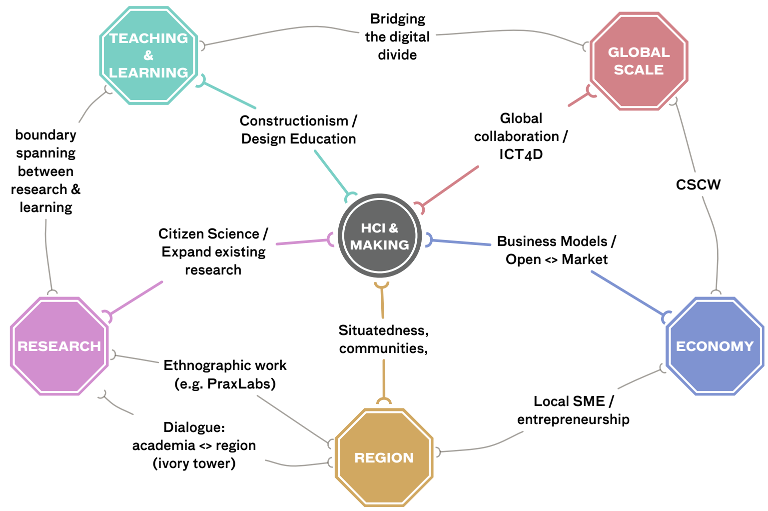

Figure 1. Model: HCI and Making

projects as well as the related literature reviews and fieldwork, we became aware that there is no real comprehensive conceptual model for the relationship of making and HCI. Given the growing interest and body of work (as indicated above) on making, we felt the need to develop such a model to facilitate understanding and meaningful conversation about the subject as well as to better seize potentials and directions for our work. In this contribution, we present our model in the hope to better represent and conceptualize what HCI is and can be to making and vice versa.

THE MODEL

Our conceptual model of making and HCI is depicted in fig. 1 and centers on five aspects which we believe to be the central points of synergy between both disciplines: Teaching and Learning, Research, Regional aspects, Global aspects and economic issues. The following sections describe and discuss each point in detail.

Teaching and Learning

There is a general trend in education away from teacher-focused to learner-centric approaches. HCI, especially CSCL has long been concerned with how to support such approaches with ICT, e.g. through multitouch systems or videogame inspired approaches (cf. e.g. [31]). A powerful perspective on such approaches is *Constructionism [7]* Seymour Papert's understanding of experiential learning holds that learning does not happen through instruction-based teaching but rather through the construction of individual mental models in the learner – a process facilitated through the actual construction of individually meaningful artifacts. The theory is associated with HCI in that ICT is viewed as the most potent tool to facilitate constructionist learning: There have been many long-running and very successful related projects such as Scratch [27] centering on constructionist approaches to programming. Digital fabrication and making offer potentially even more powerful avenues for constructionism in that it interconnects the physical and digital realms. This notion is also at the core of the Fab Lab movement [5] and there have been many successful projects with such approaches [2].

Makers are essentially amateur designers and producers. Design research and practice as well as innovative mental approaches to thinking about design such as Design Thinking [3] sit, of course, at the very heart of HCI [36] and there is already a wide body of work on how to bring this together with education (cf. e.g. [8, 22]). Hence HCI can offer a powerful grounding for educational (constructionist) maker projects.

Finally, it has to be noted that current hard- and software for digital fabrication usually are either highly professional and complex or still quite experimental and technical. HCI has to play a highly relevant role in facilitating the appropriation of maker technologies by working towards better interfaces as well as tighter integration of software, hardware and the human element [20, 33].

Research

Making and the associated spaces such as Fab Labs offer great avenues for applied research, especially research through design [36]. More specifically, due to making's focus on openness and democracy, new opportunities for citizen science and innovation arise (cf. [35]). HCI has already been concerned with facilitating collaboration between citizen and professional scientist communities [28] as well as maximizing the usefulness of the gathered data [12]. This in conjunction with the focus on local values and sensibilities HCI affords (see next section) also has the potential to help ameliorate the perception of academia as an ivory tower.

Furthermore, making has the potential to expand on existing research projects through integrating it the Fab Lab or makerspace infrastructure and the associated maker community. To give examples from our own work: We started to expand an existing research project which was centered around CSCL with children to digital fabrication (cf. [26]) and are currently working on expanding an ethnographic project on e-mobility by offering our participants the opportunity to self-repair their e-bikes in the Fab Lab. We believe that there are many more opportunities to expand ongoing research into making realms, similarly to the effects the PC and the Internet had.

Region

A grounded understanding of situated, local sensibilities, values and needs has always been at the very core of HCI (cf. e.g. [34]). Similarly, HCI offers powerful perspectives to understand the formation and behavior of communities (of practice) [32] and how to facilitate knowledge sharing and collaboration in such communities (cf e.g. [10]). This stream of thought and understanding is valuable for establishing and expanding making: Communities of makers often have certain entrance hurdles for newcomers, be it through a preconception as "nerdy", domain specific knowledge and vocabulary or the complexity of the machines (cf. [20]). Understanding and treating Fab Labs and makerspaces as boundary (negotiating) objects [17] also can help with those issues [21].

Tying locality to research, there are valuable scientific opportunities in treating makerspaces and the local maker communities as Living Labs [18], understanding them as locally grounded and embedded ecosystems in which innovation and co-creation happen.

Global

While maker communities are usually locally grounded and tied to a specific makerspace or Fab Lab, there is also a significant element of globality which condenses in collaborative international projects, an ever-increasing number of global maker conferences and gatherings as well as through knowledge sharing and communication via ICT [29, 15]. HCI, especially CSCW has always been concerned with the facilitation of such collaborative efforts which is much needed given the fact that there still are problems e.g. with the effective sharing of knowledge between maker communities (cf. [20]).

Another highly relevant global aspect is ICT4D: Making offers significant potential for aid, empowerment and help in developmental settings [25]. Projects such as DIY prosthesis which are orders of magnitude cheaper and can be manufactured by amateurs in the field [14] are already being deployed. There has been increasing interest in development issues in HCI in recent years [9] which needs to be expanded to making to develop better, affordable, human centered tools and machines ([26, 33]). Doing this with situated sensibility for issues such as illiteracy, vastly different ICT infrastructure, etc. is crucial for the advancement of making in ICT4D.

Furthermore, global aspects are connected to teaching and learning in that bottom-up constructionist education and empowerment via making and digital fabrication can help bridge the digital divide prevalent in development countries [11, 1].

Economy

Economic aspects are arguably the area where the worldwide maker and Fab Lab movement is least developed [24]. There are many opinions and predictions relating to economic disruption through digital fabrication, but setting aside the long-term vision of the Star Trek inspired replicator in every home and concentrating on the more graspable future, there is almost no work on actual business models and sustainability for Fab Labs and making – a notable exception being [30] who studied business ideas of Fab Labs worldwide and develop economically framed guideposts relating to openness, interdisciplinary collaboration, effectiveness and transferability, all focused on value propositions centered on innovation. We argue that a HCI perspective on economic issues can be very potent – especially CSCW has always been in the field of tension between leftist empowerment ideals (in this case personified by the open (source) maker movement) and work / economic context (here: business models and market sustainability) [13]. As such, a HCI lens and its traditions are well suited to conduct much needed research into economic aspects of Fab Labs and to facilitate the collaborative development of new business models to help make making more economically sustainable.

Through HCI's emphasis on local values and bridging different communities, there is also potential in bringing together local industry with maker communities in order to facilitate machine sharing, collaboration and co-innovation (cf. [19]).

CONCLUSION

We have showed that HCI and making have different areas of synergy and can benefit from each other. Those areas can be grouped in *teaching and learning*, *research*, *region*, *global* aspects and *economic* issues. For each area, we have given an insight in the pertaining work from HCI as well as chances, opportunities and directions for future work. Taken together, those dimensions form a conceptual model of HCI and making which will inform our future research as well as the advancement of our Fab Lab. We believe that the model also has the potential to help systematize the understanding of making and digital fabrication in the HCI community and encourage discussion and further work towards advancing both disciplines jointly.

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