

## The bizarre bazaar

FabLabs as hybrid hubs

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*Published in:*

CoDesign: International Journal of CoCreation in Design and the Arts

*DOI:*

[10.1080/15710882.2017.1378684](https://doi.org/10.1080/15710882.2017.1378684)

*Publication date:*

2018

*Document Version*

Peer reviewed version

*Citation for published version (APA):*

Pedersen, M. H., Hoby, M., & Padfield, N. (2018). The bizarre bazaar: FabLabs as hybrid hubs. *CoDesign: International Journal of CoCreation in Design and the Arts*, 14(4), 329-344. Advance online publication. <https://doi.org/10.1080/15710882.2017.1378684>

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## **The Bizarre Bazaar**

FabLabs as Hybrid Hubs

### **Abstract**

In this paper we consider the FabLab as an experimental facility for research, intervention and learning. By providing a space that affords close proximity between users, producers, technologies and materials, the FabLab affords a 'hybrid hub' for weaving relations between these. Borrowing the metaphor of 'the bazaar' from Raymond (2001), we argue that FabLabs, due to their open and nonregulated character, can be seen as offering what we call a 'bizarre bazaar' for exchange, fabrication and knowledge creation. Based on the background of our own experiences with establishing and running FabLab RUC as an experimental learning, innovation and research environment, we discuss how 'working through materials' enables new forms of learning and research. We do this firstly by considering lab-based learning in design in general, and design and anthropological theory around "Making" in particular. We then, secondly, move on to consider three cases for knowledge creation in a Fablab context, drawn from current work at FabLab RUC and demonstrating what we see as key potentials. Finally, and thirdly, we conclude emphasizing in particular the role of proximity between researchers, students and professionals in art, technology and entrepreneurship.

### **Introduction: FabLab RUC, its origin and principles**

*FabLab RUC* (<https://ruc.dk/fablab>) originally developed as an idea for bringing art, technology and hands-on 'Maker' approaches into academia not as an optional element in the academic program, but as a vital part of the skills and competences of future academics, whether training for a degree in technical science, natural science, the arts or social science. The Lab was formally established in autumn 2013 but draws on earlier experiences with integrating digital fabrication in research and learning. Since 2008

Roskilde University has provided digital and hands-on workshop facilities for students at the bachelor program in Humanities and Technology. This program was established as a new addition to Roskilde's three faculty-based bachelor programs, with the vision of integrating technical science, social science/humanities and design (Haldrup and Svabo 2012, see Blomhøj, Enevoldsen, Haldrup & Nielsen 2014 for an overview of this). As with all curriculum at RUC the main form of study relates to student-directed project work. While this model had its origins in the European architectural schools and later engineering colleges (Knoll 1997), its popularization in academia (at least in Europe) has largely been associated with the pedagogical philosophy of Dewey and critical Marxism, and it was in this version that it was introduced in Denmark with the establishment of Roskilde University in 1972 (The 'Roskilde Model', Andersen and Heilesen 2014). Hence, the establishment of the workshops at HumTek in 2008 reflects a return of craft and hands-on based methods to academia; an 'empowering of academia through modern fabrication practices' (see Padfield, Haldrup Hoby 2014). During the last five years this environment has functioned as an incubator for experiments with using design and digital fabrication as tools for learning and exploration in relation to a diverse range of academic fields and disciplines. It has functioned as test case for using digital technologies and rapid prototyping as a toolbox with a general usability, also in cultural and social sciences. Hence, the focus on problem *solving* rather than analysis has added new dimensions to the problem oriented learning approach traditionally used at RUC. Rather than providing suggestions for unequivocal solutions based on critical analysis, projects and course work have centered on the generation of multiple solutions and functional prototypes as well as experimentation in with these within real life user contexts.

While prevalent definitions of design tend to equate it with industrial design (in the US tradition) or the arts (in Europe), the FabLab ambition is to be able to make (almost) anything. Design has moved out of the specialist's arena and has increasingly been conceived of as tied into broader social and political spheres of society and everyday life (Ehn, Nielsson and Topgaard 2014). The mushrooming of FabLabs all over the globe (by November 2016: 1003 approved on <https://www.fablabs.io/>) reflects how 'fablabbing' has become a global social movement (Walter-Hermann 2013) in convergence with 'the Maker movement' (Hatch 2013) rather than 'just' another university outreach project creating new spaces for learning, innovation, research and self-actualization.

In design thinking, a host of approaches aiming at bringing design, user experience and idea generation in a closer dialogue has flourished in recent years. Calls for ‘research through design’ (Cross 2006; Zimmerman 2007; ), ‘constructive design research’ (Koskinen et al 2011) and ‘situated design methods’ (Simonsen et al 2014) all recognize the need for articulating design, user experience and research as part of the same process. In this context the FabLab concept with its focus on hands-on design practices, as a vehicle for exploration and experimentation, offers a radical new possibility for solving ‘the most practical of all questions we can ask of our civilization’ (Dewey quoted in Schelhowe (2013: 95): the integration of ‘the mind-body in action’ as a model for learning. The FabLab offers playful and explorative perspectives on design (Hoby 2014) that make it possible to engage in dialogues across social spheres and disciplinary boundaries. Hence, we contend that it contains potentials for redefining the role of universities as not only knowledge producers but transformative agents offering platforms for experimentation, exploration and re-imagination in relation to real-world technological, social, cultural and material futures (Haldrup, Hoby, Samson & Padfield 2015).

In that sense the FabLab is not merely *a workshop*, but rather an *experiment in how to run a workshop*. What emerges when students are given access to the latest in digital fabrication technology? How do people react when given a space with few rules and almost endless possibilities? Through the years a set of core pedagogical principles have materialized, challenging curriculum, as well as test and efficiency driven teaching strategies. The first and foremost principle is that the students do not have to justify their reason for using the lab. All students have access and are free to use the machines. There is not a complex, formal, test based certification system, but rather apprenticeship and learning by doing. Non-dangerous machines can be used after perusing guides on our online tutorials. Unlike most comparable workshops, there is no booking system. This deliberate ‘inefficiency’ is a central idea in providing the ‘bizarre bazaar’: we want to foster a vibrant, creative, and collaborative community. Users must just show up and cooperatively share machine time with the other members of our community, meaning that there is time to talk to other users, to learn by trial and error, to inspire each other, exchange ideas and experiences. It gives each student the freedom to learn, based on their own interests and curiosity, and to be inspired by others - who may be professionals from a completely different field. Every student has their own motivations for approaching

the lab. Some are motivated by an interest in exploring the possibilities that are present from having a large array of rapid prototyping technology available. They focus on questions like 'is it possible to make; can this machine be (mis)used to; what kind of materials is it possible to cut?' Others are driven by an external interest such as 'can I make a prototype that enables me to try out new recycling strategies for a typical home?'

Enabling students to engage based on their different motivations introduces a set of challenges. The space and the possibilities are daunting - we must actively and effectively lower barriers to entry and to engagement. For many students (and teachers) the use of hi-tech machinery for creating playful interactions and experiments is an unknown territory, and especially among teachers we have experienced a reluctance for using the environment. In the FabLab we have actively sought to bridge this gap between traditional academic cultures and the 'maker' ethos. Particular workshops and courses, directed towards 'humanistic' disciplines as well as plans to establish lab activities in relation to natural science has been devised. Still there is ongoing discussion in and around the FabLab on how to create comfortable environment for novice teachers as well as students.

We must facilitate users to be able to tap into their own curiosity and to daring to engage unknown territory. This we have sought to achieve by having multiple highly skilled experts employed, who together cover a wide array of substantial knowledge about solutions to the many different problems the students are interested in. The employees have used the title 'technology guru' - an intentional, if slightly provoking, title intended to highlight the unusual nature of the employees - while many technology experts are specialists, the gurus are multidisciplinary generalists, capable of getting students started on projects from programming to windmills to biotech. The guru is used as a concept to facilitate opening the mindset of the users in the Fablab to think of it as a space of exploration and wonder, where they can seek guidance on multiple levels from ideation, design iteration to concrete technical challenges. However, the novice-expert relations, and the hierarchies these produce within the highly informal and participation based milieu of the 'maker' movement and the FabLab, also creates a tension to the more meritocratic and formal relations of the university context. In that sense the FabLab offers a 'bizarre' space or 'bazaar' for interaction, knowledge creation and intervention on the borders between formal university education and the collaborative ethos of the maker movement.

In the following we reflect on our experiences with regards to “empowering academia through modern fabrication practices” (see Padfield, Haldrup & Hoby 2014) in order to create an experimental learning space for design, research, education and innovation. We do this firstly by discussing the kinds of learning and design that take place in such an environment. Secondly we discuss in more detail three selected examples of projects that have taken place at FabLab RUC recently. Finally we discuss how we might think of the FabLab as a ‘bizarre bazaar’ enabling participatory, collaborative and often unpredictable design oriented learning processes to emerge.

### **The FabLab as a hybrid hub**

The ‘FabLab’ concept originated as an outreach project at MIT’s Center for Bits and Atoms in 2001, and has endured an intriguing success as a model for integrating hands-on learning, grass root movements and university research and teaching with a total of 1003 Fablabs scattered around the globe as of November 2016. While the exact context of these may differ substantially from being primarily grassroots based to being initiatives from public institutions (in particular in Europe), we contend that there are some basic features regarding this particular frame for knowledge creation that might be considered more carefully than they are today. Converging with the success of the ‘Maker movement’ and its association with what Gauntlett (2011: 8) identifies as a general shift from a ‘sit back and be told’ culture towards a ‘making and doing’ culture, the FabLab provides an astonishing prism for low-budget high-tech innovation, research and learning. Indeed, the prophecy of one of the key proponents of the FabLab movement Nick Gershenfeldt (2005) of it as an omen of the revolutionary times to come as digital fabrication would become accessible to all grassroot movements, inventors and households seems rather sober and realistic today as FabLabs, making and citizen science projects mushroom all over the globe. However, the benefits and particular contributions of the FabLab as a frame for knowledge creation, learning and innovation have only to a limited degree been reflected upon. Hence, this paper asks the question: how do we conceive the Fablab as a space for research, learning and innovation? What are the strengths and weaknesses of this particular type of knowledge creation?

In design publications there are a variety of metaphors regarding lab-based forms of learning. In his seminal manifesto 'The Cathedral and the Bazaar', Raymond (2001) reflected on the new and divergent mode of innovation exhibited by the emergence of Linux and other open-source software. He suggested 'the bazaar' as an alternate and advantageous model for innovation, as compared to more traditional commercial modes of innovation ('the cathedral'). More broadly, reflecting on the benefits for developing and exploring possible new design programs through concept design and prototyping experiments, Binder and Brandt (2008: 118) consider the lab, the workshop, the studio and the atelier as four different metaphors for design-based learning and research, each providing an opening for particular understandings of design exploration processes. Similar arguments were also proposed by Ehn (1998) in his vision for 'a digital Bauhaus' as a model for placing 'the development of new mediating technologies in their real everyday context of changes in lifestyle, work and leisure' and as a node in 'an international network for creative and socially useful Bauhaus design that embraces, penetrates and unites art, science and technology, and that influences research, study, and work' (p211, 214). Today we recognize this vision as very much coincident with the aims and scope of the FabLab movement.

'Being a global movement and part of a rising maker culture, FabLabs are central for an understanding of the present (and future) world. The democratization of production that comes along with a 'democratization of innovation' by various potential actors. That means that, in FabLabs, everybody can invent, create and modify things and everybody can become an artist. With relatively low constraints, people can design objects that are not only unique, but meet high design standards. Such an approach transforms the fields of arts and crafts, as FabLabs further promote an understanding of modern crafting, making, or DIY, as a response to mass culture.' (Walter-Hermann and Büching 2013: 14).

By using high-tech design and manufacturing tools (3D Printing, CNC Milling, embedded microcontrollers etc.) the FabLab provides users not only with basic construction equipment but enables them to meet high design standards with their fabrications. In doing this sketching, prototyping and idea generating is not limited to the format of the traditional

academic (or design) workshop where loads of napkin drawings and post-it notes compete for attention. Instead users are able to fabricate truly functioning prototypes, artifacts and installations to be explored and examined in a diversity of use situations and contexts. Enabling users to experiment with fully functioning prototypes creates an explorative space for evaluating and reflecting on actual users' performances and interactions with technological installations and objects that moves beyond what may be anticipated from a purely conceptual design process. However, precisely because of the 'quick-and-dirty' approach and the scaffolding provided by the experts in the FabLab, users are enabled to focus on the *effects* of their prototypes rather than their technical detail.

Moreover, by being part of a global network the Fablab provides a porous global node or a hub, where ideas, competences, examples and knowledge can be drawn together with the energy generated from FabLabbing / Making as a social movement. As Dyvik (2013) remarks:

'FabLabs are social hubs that connect people and ideas. When a FabLab functions well, the accessibility, openness and freedom to try out new ideas brings out the best in people. This atmosphere becomes contagious and people willingly share ideas, techniques and knowledge with each other. It is as though a switch gets flipped in a visitor's head from a protecting to a sharing spirit. A user who comes to the lab with one specific goal might end up going home with a lot of unexpected inspiration and new collaboration partners. The space for failure is also very important. Unlike many traditional knowledge institutes, failure is welcome in a FabLab as long as you make sure you and others learn from it.' (p 153)

In this way it is not only by providing technical equipment and skills - or being a hub transmitting 'how-to' knowledge - that the FabLab has unique advantages. It is rather through the creation of a particular *hybrid* hub, enabling face-to-face interaction and 'creative entanglements' with materials (Ingold 2010); or rather entanglements and manipulations with hybrid associations of technologies, materials, bodies and minds (see also Latour 2005). In this way, the hybrid hub of the FabLab offers a space for material experimentation and engagements that exceed the emphasis on text and visual representation that normally forms the pivot of academic research.



This also explains why the practice of ‘making’ recently has found its way into a broad swathe of design literature. For instance, within the context of interaction design research Löwgren (2016) observes that there is a ‘growing recognition that making is seen as important in interaction design research.’ He also however notes it is ‘less clear exactly how and why making is seen as important in interaction research. One strategy, formerly quite dominant, is to black box making in favor of its outcome, the prototype’ (p. 27). Drawing attention to the making process formerly left invisible in the prototyping process can shed light on the sense of progression, rhythm and use that emerges in the process:

‘Making leads to artifacts, things that were made. In the design tradition, the artifacts are typically the final outcomes. (...) When I propose that making is significant in the interaction design research, the dilemma is right there: Making yields experiential knowledge embodied in artifacts, but the research tradition expects propositional knowledge embodied in academic writing.’ (ibid. p 31)

Interestingly, the interest in ‘making’ as a particular way of engaging with technologies and tools in the design process resonates with a general concern in contemporary ‘post-humanist’ thinking in re-valoring material engagements with the world, at the expense of concepts of cognition and intentionality. Acknowledging humans to be, not entangled with or confronted by, but embedded within a ‘universe of things’ (Shaviro 2014).

Acknowledging this also opens up for more intuitive and embodied understandings of knowledge creation and learning. As observed e.g. by Bennett in her book on ‘vibrant matter’, the mode of experience produced through engagement with the material is categorically different from the mode of experiences produced through science (or intentional-driven design models, one could add):

‘The desire of the craftsperson to see what a metal can *do* rather than the desire of the scientist to know what a metal *is*, enabled the former to discern a life in metal, and thus, eventually, to collaborate more productively with it.’ (2010: 69)

In line with this type of argumentation, anthropologist Tim Ingold has sought to demarcate 'making' ontologically as a departure from all sorts of intentional design, or what he terms 'hylomorphism' (after *hyle* [matter] and *morphe* [form]):

'Whenever we read that in the making of artefacts, practitioners impose forms internal to the mind upon a material world 'out there', hylomorphism is at work. I want to think of making, instead as a process of *growth*. This is to place the maker from the outset as a participant in amongst a world of active materials. These materials are what he has to work with, and in the process of making he 'joins forces' with them, bringing them together or splitting them apart, synthesizing and distilling, in anticipation of what might emerge.' (Ingold 2013:21)

According to Ingold, whose thoughts, particularly in relation to design, have been elaborated in Gatt and Ingold (2013), it is through the material engagement and practicing of skills that knowledge is built up - not as a blueprint for shaping materials, but as a collaborative and participatory 'growth process' in which skills and artefacts are simultaneously built. In this sense we might say the design model enabled by the the model of Fablabbing and Making can be seen as a radicalization of what Donald Schön once coined 'a reflective conversation with materials' (1992). By experimenting with a multitude of materials, technologies and knowledges, exploring their possibilities and constraints, the Fablabber/Maker draws these heterogeneous elements together to learn-through-making. It is through these hybrid collaborations between people, knowledge and materials that the FabLab obtains its quality as an explorative space for learning, design and research.

By providing a 'bizarre bazaar' of materials, technologies, knowledge, conversation pieces, throwaway prototypes, procedures and people, the FabLab functions as a learning space that enables participation and cross-pollination of ideas and procedures. In the bizarre bazaar we are all makers - but some more than others, or perhaps, put in slightly another way, we all bring different skills to the table. In the following we want to address three issues in particular:

- The relation between product and process
- The relations between experts and novices

- The relation between knowledge and design

In the following we discuss, three examples - exhibits - from the FabLab. Each example exhibits the particular form of design and learning that unfolds in the Lab and how making and hacking in the FabLab context can push the possibilities of the field forward by providing an experimental 'bazaar bazaar' in which the experiment functions as an outlier of potentials for future projects and experiments.

## **Exhibit #1**

### **Industrial robotics for the people: Creating conversation pieces**

<Insert fig 1>

*Exhibit #1*

*Kid exploring the industrial robot, showcased at a science fair in Copenhagen*

Robotics has until recently been the purview of industrial fields with a high level of automation, technical skills and the resources to invest. One could even argue that the replacement of manual labour along the factory assembly lines with the mechanical movements of industrial robots has been emblematic for imaginations of post-WW2 industrial society. Apart from its cultural effects, the use of this sort of automated machinery has also been exclusive. The technology has not been affordable for smaller companies like the local bakery or mechanic - and even less attainable for private use.

The scope of the Open Source robot arm project was to open up the potential of industrial robotics for a wider array of users. Specifically, small to medium sized companies, entrepreneurs, hackers, other FabLabs and students. The robot was initially created by three of the technological experts at FabLab RUC Nikolaj Møbius, Mads Hoby & Nicolas Padfield and is intended to do the same as the Volkswagen did for cars. It allows normal people to be able to gain access to new technology. To solve this challenge, we designed an affordable and hackable industrial robot arm which could lift 5 kilos and had a action radius of a meter. The arm was specifically designed to be built on Fablab machinery: a CNC mill was used to cut the plywood for the frame, and the control system is based on the Arduino open source hardware project. An arm that would normally cost 15000 dollars could thus be produced for 900 dollars in materials and one day in labour, at

a Fablab anywhere in the world. Everything is open source and the drawings can be downloaded online.

FabLab RUC have until now produced five of the robots, and already, people at FabLabs elsewhere are replicating the robot from the drawings online. Our five robot arms were used to hold a workshop for students. They had two weeks to hack and modify the robot arms and explore possibilities. Among many things they built a waffle maker, automated ping-pong shooting turret and an augmented reality full body controller.

One particular advantage of this project was that the low price and costs of the robots gave the students the freedom to hack them in whatever way they wanted. They could even use basic tools like a hacksaw to modify the arm to their requirements. Because they were easily reproducible, each group of students could have their own robot to hack, instead of having to book time on a single shared robot for the whole class. The teachers did not need to make sure robots were returned in the same state as they started out, since it was trivial to replace the parts students had modified. The open g-code interface allowed students to focus on their hacking ambitions instead of spending time on interfacing, licenses etc.

The project has provoked a significant amount of debate in the public. Engineers have criticised the hacking approach as substandard compared to state of the art, and cited regulatory concerns. It is our impression that the robot has served its purpose on multiple levels. It has allowed a new education praxis and has challenged traditional paradigms of control and access to technology. The robot became a critical object, a conversation starter on the subject of power and technology. From the very beginning the arm was specifically designed as an experimental conversation prototype rather than a final product with a guarantee of maintenance-free runtime. Instead the intention was to keep the conversation about robotics becoming more available and going outside of traditional STEM fields. We were well aware that the materials (plywood) are not sturdy to compete with the present state of the art on precision, stiffness and longevity. With this tradeoff in mind however, we were able to quickly produce five cheap hackable robots that we were not concerned about allowing students, the public and researchers to hack. Hence, the product was thought of as a catalyst for a process of reflection, conversation and controversy.

The project is also a good example of a productive relationship between experts and novices. It required a high level of skills to be able to design all the complex parts that constitute the robot arm, and lots of technical considerations have been put into designing the arm. These considerations were about striking the right balance between hackability, costs, sturdiness and possibility space, and avoiding over-engineering. Hence, the design was made to be able to attach more axis's for custom scenarios. Without experts developing based on those considerations there would not be a functioning robot arm. When the robot arm was already designed, it was a much simpler matter to customize it into specific use scenarios. Novice users could thus experiment on top of the possibility space that the experts had supplied - and the novice users did, productively, iteratively create five different functioning use cases - which the experts would not have had the time to do.

The arm enabled us to understand the possibility space and limitations of cheap hackable robotics. Because of the rapid prototyping technology used (primarily CNC milling of plywood), it was possible to create an ongoing flow of iterations, e.g. making different types of grabbers. When the first usable version was in place it only took a day to produce five more of them. All five robot setups served as conversation starters to create dialogue around robotics in the Fablab and the wider Maker community (being featured on blogs like <http://hackaday.com> ). What could they be used for and what was not possible (how far it could reach out, how much it could lift etc.) seemed to be a constant conversation topic.

## **Exhibit #2**

### **Fabmaker: Lowering the entry point**

<Insert fig 2>

*Exhibit #2*

*Students experimenting with constructing a drawing machine with the modular FabMaker.*

One thing is to have materials and machines to modify them at hand, another is to start a construction process on one's own. 'Fabmaker' is a project aiming to lower the entry point for novice users. Like Lego kits enabling children to construct and build physical 3D

models with few prerequisites, we wanted to emulate this simplicity in relation to digital making in the Fablab.

Fabmaker was developed by Mads Hoby and Nikolaj Møbius from FabLab RUC and is a tool that produces pieces that snap together without major modification. It is cheap, hackable, open-source and can be produced on standard FabLab machines - the pieces are made of laser cut 4mm HDF. Through a program (written in Processing) one can design infinite variations of elements. They are then converted to a vector file and can be laser cut as physical pieces. The designer of the pieces may have a predefined plan for how they should be combined, but interoperability enables the user to creatively invent new usage and combinations of the pieces and as they are so cheap and easily replaceable it is acceptable to modify, break, glue and drill in them if necessary.

The system is conceived as a meta-level approach to digital fabrication. Its intention is to allow a lower entry point for potential makers to start exploring different design solutions. Instead of only using mock-ups (post-it notes, illustrations, cardboard cutouts) they can start constructing working prototypes of their system by scavenging through boxes of different pieces and combining them to their liking. This gives users a chance to start the conversation in the physical realm without having to learn how to use the more complex machines in the FabLab. Participants need only use a glue gun to stick the pieces together. If they cannot find the exact piece they need, the cheap material allows them to break, cut and modify them. The system has been used on multiple occasions. For example, it has been used for workshops for a national program for talented secondary-school students, giving them the chance to construct and build their own robot platform that could roam around, avoid obstacles, pick up objects, draw. Hence, giving them the opportunity to start their experimentation with digital fabrication of artifacts and prototypes on a more advanced entry-level than the 'ordinary' Fablab beginner who would usually have to find a design online and follow a strict tutorial to replicate somebody's else's design.

Contrary to the industrial arm, the students in this project have been able to engage much more directly in the design process of the different pieces. Designing the pieces themselves became a generative (programming) learning process in itself. To design the pieces, they had to understand basic object oriented programming concepts like classes, functions and placement of objects in a graphical 2-dimensional coordinate system.

By enabling the students to design the pieces as part of their process we managed to create an integrated learning and design process in which the teaching itself improved the framework available for the next course. From this perspective the students and experts were treated as equal in a mutually inspirational process where everyone are co-designers. To generate this dialogue, we told the students that the pieces needed to be usable for high-school students and would be published online for the public to use. This gave everyone a common incentive and framing to discuss the possibilities.

Through this collaborative process, students, teachers and experts jointly gained knowledge about how to design parametric, generic components with an open possibility space. Current and future students were enabled to quickly gain their first personal custom designed success of rapid prototyping. This reward greatly differed from just “assembling a kit” based on somebody else's design. The quality of designing your own custom components became apparent as a core quality.

### **Exhibit #3:**

#### **The Plastic Shredder: Do it yourself plastic recycling machinery**

<Insert fig 3>

##### *Exhibit #3*

*Jason Knight from FabLab RUC demonstrating the plastic shredder at “the Goldmine”, a creative, grassroot-based upcycling facility positioned at a recycling station in Copenhagen*

While the design and construction in the two previous examples were initiated, performed and facilitated by the technology gurus at FabLab RUC, the third exhibit we want to discuss exemplifies the synergetic potentials of inviting external stakeholders into the lab to use its facilities.

The production and dissemination of plastic waste is increasingly acknowledged as a major ecological threat. Research projects, political initiatives, such as the French ban on plastic bags, and research projects on possibilities for regulation and control as well as attempts to clean landscapes and oceans of plastic refuse flourish. One example joined by several researchers and students is the Plastic Change initiative, an initiative trying to reduce the amount of plastic in the oceans ( <http://www.plasticchange.org> ). One of the projects in FabLab RUC exhibits a different approach to addressing this issue.

FabLab RUC has developed an internship program specifically designed for bringing such projects from the outside world into the FabLab. Hence, the program is not primarily oriented towards a regional or even national context, but includes stakeholders from a variety of countries. One of our interns in this program, Jason Knight (Brunel, UK), came to the lab with an idea for reusing plastic waste in new ways and the knowledge of how to convert shredded plastic into moldable forms. Unfortunately, he did not have a viable method of shredding used plastic into pieces small enough to be used. It turns out that significant force is required to shred plastic. It was not a simple task. He used the lab to create a rather complex and high powered machine that, with metal teeth, would shred the plastic into small enough pieces. The process took multiple iterations over 9 months before a reliable and strong enough construction was built; a machine enabling Jason to mass shred plastic refuse and start to mold different products out of the reused plastic, as was his original idea.

In contrast to the other two projects discussed here the plastic shredder was primarily a product, invented, designed and constructed by one person: Jason Knight. The shredder became a tool for his own process of allowing him to build the machinery necessary to recycle plastic (shredder + heating oven + press forms), and in the process experiment with designs and materials drawing on the different knowledge present in the Lab through other users and the gurus the gurus. In particular, the initial lack of knowledge on how to make such a machine generated a rather inventive process in the FabLab in which the intern constantly had to figure out design solutions with the machinery available. Some gears were laser cut from steel because they needed to be strong and small while other gears were made oversized in wood because they had to have a large gearing ratio. The process in itself is valuable on multiple levels, but the final design became more than just a concept/conversation piece/prototype. It became a functioning tool that had a valuable role in a greater recycling process. The shredder enabled the next step to be prototyped. Specifically, to start melting the plastics and make molds.

The project also exemplifies the potentials of allowing an intern the time and freedom to take care of his own design and learning process. The gurus in the Lab did not point towards a problem - they did not tell him how to approach it and which strategy for a solution to pick. He had freedom to work through trial and error over an extended period of time. Throughout the period he ran into, and overcame, many obstacles. This, primarily, as



a consequence of the surprisingly high amount of force needed to shred plastic bags. Using a Fablab for industrial processes with industrial forces is ambitious. Jason's working process has been exemplary. Every time he ran into an obstacle he would engage in conversations with some of the experts about possible solutions. Since he was walking on an unwalked path (shredders are widely available as expensive, specialist, industrial product, but few try to make their own) the experts could not give him definite answers, instead they had to give him multiple possible solutions for him to try out.

However, the value of the 'plastic shredder' is not only to shred plastic, but also to create debate, expanding the possibility space for exploration - dovetailing into a political discussion and moving the Maker movement towards cradle to cradle thinking, instead of just using materials and then throwing them out. Hence, the shredder also contributed more broadly to thoughts and conversations on 'waste', as it highlighted the potential of thinking recycling as more than just sorting your trash in the right piles for pick up. By using the plastic shredder, plastic waste can become a resource enabling ordinary people to create and shape their own artifacts from this material. The plastic shredder has been demonstrated on multiple occasions, hence becoming a conversation piece to trigger such debates and experiments. One of these demonstrations involved installing it for a day at a recycling station, as part of a municipality project - 'the goldmine' - aimed at shining a spotlight on the role of upcycling and recycling in cities, consequently turning the station into a production facility where the trash of the municipality could be reused on the spot. Processing plastic as a raw material provoked different kind of responses from the public from fascination of the colorful and 'cool' objects that could be made (e. g. a skateboards) to repulsion over treating a potential harmful waste product as a resource for everyday consumption. Both types of responses in different ways show how the project worked as a prop for critical reflection and debate on the role of plastic in contemporary society (Haldrup 2017).

### **The bizarre bazaar: itineraries for the road ahead**

Currently there is a great deal of interest in academia in drawing on design methods as a tool in education. To a large extent these interests have been built on how to incorporate brainstorming, sketching and prototyping as part of a solution-oriented approach to

research and teaching, drawing in particular on plan driven models of the design process. The recent marriage between 'Making' as an approach to design and academia however, to some extent, challenges this thinking; challenges the idea that post-it notes and open-ended structured theoretical design processes are enough - actually working with the material could be an important contribution to learning processes, especially in relation to problem oriented strategies.

In this paper we have pointed to the central feature of the FabLab in a university context as offering a space for material experimentation and engagements that exceeds the emphasis on text and visual representation that normally forms the pivot of academic and design research. A hybrid hub, enabling entanglements and manipulations with hybrid associations of technologies, materials, bodies and minds. Furthermore, the three selected exhibits discussed in this article, all demonstrate that the relationship between sketching, prototyping and design to some extent becoming entangled, as practitioners are able to jump directly to an integrated, generative, iterative process, 'making' functional material designs.

As seen in the discussion of e.g. the robot arm (exhibit # 1), the fabrication of the robot arm functions rather as a conversation piece - a tool for continuing the sketching process and furthering idea generation. Much the same is seen in relation to the plastic shredder in exhibit # 3, where the functioning prototype enabled idea generation for whole new sets of prototypes based on other users and participant's ideas.

We here claim that the 'Making' approach actually enables the relation between the product and process to be reversed. By focusing on material fabrication, future processes of idea generation and sketching are furthered. In contrast to 'normal' design exercises in education, the cases from the FabLab also blur - intentionally - the distinction between novice users and highly skilled experts. Two of three of the examples discussed in this paper are primarily driven by and initiated by the experts in the Lab, but by using functioning prototypes or - as in the case of exhibit #2 - parametric 'building blocks' for making prototypes as starting points for design processes rather than outcomes. Meanwhile exhibit #3 demonstrates how a stakeholder from the 'outside' world, increase and develops knowledge at the same rate as, and parallel with, the experts in the lab. These approaches both enable students and experts to be treated as equals in mutually inspirational processes where everyone are co-designers.

In doing this the buildup and transfer of personal experiential knowledge becomes a key concern. In exhibit #2 students were enabled to quickly gain their first personal custom designed success of rapid prototyping. This reward greatly differed from just “assembling a kit” designed by someone else. Through a collaborative process, students and teachers gained knowledge about how to design parametric, generic components with an open possibility space; hence students experiential and personal knowledge was integrated in further explorations with designing ‘kits’. Similarly, in relation to exhibit #1, the rapid prototyping technology used enabled an ongoing flow of iterations, where five different prototypes were built in only one day, following the first usable version serving as conversation starters to create dialogue around robotics in the FabLab and the wider Maker community. What could they be used for and what was not possible seemed to be a constant conversation topic.

In summing up we contend that ‘making’ as a tool in academic research and education enables

1. The relation between product (outcome) and process to be reversed (or at least blurred).
2. The distance between experts and novices in the lab to be bridged by participating in collaborative fabrication processes.
3. Experiential knowledge to be shared by providing novices with possibilities of exploring ‘high tech’ possibility spaces by drawing on a multitude of iterations and experiments.

In all three instances it is the density and proximity of a diverse range of people, technologies and materials that the bizarre bazaar of the FabLab provides that account for the specific character of this particular form of knowledge creation. Whereas the weakness of the FabLab is the ability to conduct controlled user-tests with specified target groups the strength is that effects can be evaluated and modified almost instantaneously within the hybrid hub of the lab.

FabLabbing in a university context is to some extent antagonistic, as the collaborative approach of ‘Making’ is oppositional to the hierarchical and meritocratic structure of academia. In this sense FabLab RUC reflects a marriage between grassroots

movements, academia and high-tech environments. Bridging these differences in practice by providing a collaborative fabrication lab inside the university enable (and indeed demands) new forms of collaboration and learning. The three points mentioned above are, as we see them, the key features that Fablabs enable in a university context. A key point for making these potentials succeed is however to create a space in which they can unfold; a space in which cross pollination, collaboration, participation, friendly competition and integration of a conglomerate of knowledges on different levels can thrive. This is what we aim to capture by adding 'the bizarre' to 'the bazaar'.

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## Webpages

<https://ruc.dk/fablab>  
<https://www.fablabs.io/>  
<http://www.plasticchange.org>  
<http://hackaday.com>

## Digital Ressources

FabLab RUC

<https://ruc.dk/fablab>

The Industrial Robot Arm

<https://www.youtube.com/watch?v=sHgINSOTm9I>  
<https://www.youtube.com/watch?v=HrgawXSiDdk>  
<https://www.youtube.com/watch?v=SzhCcEObfXI>

FabMaker:

<https://www.youtube.com/watch?v=EjSuYpqx2c0>  
[https://www.youtube.com/watch?v=gE\\_3tAhb8ww](https://www.youtube.com/watch?v=gE_3tAhb8ww)  
<https://www.youtube.com/watch?v=oe-qR6EMIvM>

The Plastic Shredder

<https://www.youtube.com/watch?v=iu5Sz3p-ihw>

## Figure captions

*Exhibit #1*

*Kid exploring the industrial robot, showcased at a science fair in Copenhagen*

*Exhibit #2*

*Students experimenting with constructing a drawing machine with the modular FabMaker.*

*Exhibit #3*

*Jason Knight from FabLab RUC demonstrating the plastic shredder at “the Goldmine”, a creative, grassroot-based upcycling facility positioned at a recycling station in Copenhagen*

## **Figures**

*Figure 1*



*Figure 2*



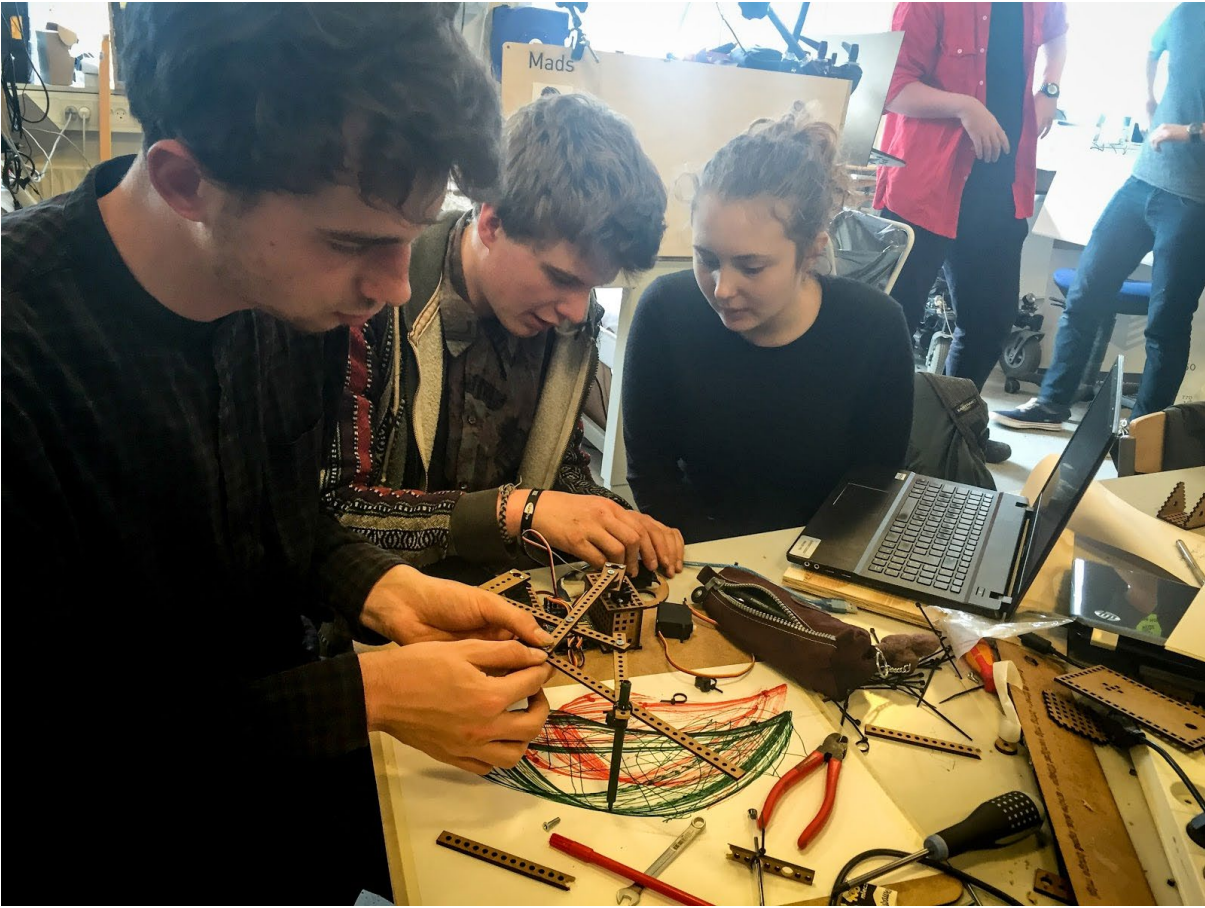


Figure 3

