# **Great Expectations and Big Challenges:** A FabLab as facilitator for personal fabrication of tools to self-manage diabetes

*Katrien Dreessen_ Jessica Schoffelen_ Danny Leen_ and Ollivier Piqueray_*

Social Spaces, CUO, LUCA School of Arts, KU Leuven and Hasselt University
*katrien.dreessen@khlim.be; jessica.schoffelen@khlim.be; danny.leen@khlim.be; ollivier.piqueray@khlim.be*

**Abstract**

*This article discusses the role of a FabLab as a research and making environment within the 'Bespoke Design' research project and its implications for the involved designers. 'Bespoke Design' deals with the participatory design of self-management tools for and with people with type 1 diabetes. The project furthermore explores the role of a FabLab in developing, sharing and documenting these tools. Although the context of a FabLab as an open and accessible workplace is beneficial for the idea of personal fabrication, we argue that it also poses important challenges.*
*The necessary skills and expertise for using the different machines in a FabLab form a major challenge related to accessibility and efficiency. After all, a lack of skills and expertise can discourage people to experiment or may lead to time and cost-consuming trial-and-error. Then, if these processes become too costly and time-inefficient, one can question the relevance of developing personalised tools.*
*However, we believe that including a FabLab in a participatory design approach can deepen the collaboration between the designer and participant, imposing new roles for the designer (i.e. a mediator between the participant and the machinery). Furthermore, designing in this context extends this mediator-role from conceptual design to the actual making of prototypes. Based on our experiences with 'Bespoke Design', we elaborate on the challenges when using a FabLab as research environment and the changing role of the designer within participatory design and making projects.*

**Keywords:** *FabLab, participatory design, personal fabrication.*

## Introduction

FabLabs are frequently introduced as leading us towards the next Industrial Revolution, proposing big expectations in the field of making products easily and locally, thus allowing new and accessible forms of personal fabrication (Gershenfeld, 2005; Mota, 2011).

Starting from these promises, we explore the role of a FabLab within the context of 'Bespoke Design' (*OPAK, www.designopmaat.be*): a participatory design research project involving the development of self-management tools for people with type 1 diabetes.

Bespoke Design can be framed within the tradition of Participatory Design (PD): a set of theories and practices related to the concept of involving end-users as full participants in the design process. PD stimulates designing with (instead of for) people, (potentially) leading to a feeling of shared ownership of the final product (Ehn & Badham, 2002; Robertson & Simonsen, 2013).

In this line of thought, Bespoke Design aims to involve users, from the first step of the process, wherein possible design problems are explored, to the making of final prototypes. This PD approach implies that we, together with people with type 1 diabetes, explore the everyday life with diabetes and ways to self-manage this condition.

Usually, PD approaches involve this exploration within the conceptual phases of a project. However, in Bespoke Design, we extended the participatory process to the making phase; resulting in a process of participatory making or making together (Seravalli, 2012 & 2013).

To fully explore and execute this making phase, the project is carried out in FabLab Genk (BE). While the context and philosophy of a FabLab allows for extending the possibilities for participation in a design project, we learned that this is not a simple process. There are still some challenges to overcome, which we discuss further on in this paper. Currently, many healthcare projects are already being carried out within different FabLabs (e.g. 3D printing of dental implants or other medical models, etc.). However, the main difference between those projects and Bespoke Design is the bottom-up approach of the project.

Bespoke Design specifically focuses on the everyday self-management of diabetes and not on a strict medical application or perspective. In this regard, the paper starts with a concise description of essential concepts in discussing diabetes (e.g. self-care and self-management), the need for tools that fit within the everyday life of people using them and the followed approach of PD.

Afterwards, we briefly discuss the concepts of personal fabrication and FabLabs before presenting Bespoke Design in more detail. Based on our experiences, we reflect on the idea of personal fabrication, the expectations and challenges of a FabLab for PD projects and how this affects the role of the designer. We conclude this paper by indicating some points for further research.

**Self-management Tools and Participatory Design**

Tools and technologies in the domain of healthcare are mostly designed and developed from a top-down perspective. In this approach, doctors usually define medical problems and solutions for the patients, maintaining the traditional separation between experts (i.e. doctors and designers) and laypeople (i.e. patients and users) (Storni, 2014).

The latter merely fulfils the role of a patient, experiencing some sort of health issue that can be diagnosed and for, which, ultimately, technology plays a role in his/her treatment, but without having any input in the design of that technology (Ballegaard, Hansen & Kyng, 2008).

Storni (2013, p. 54) considers this approach a 'medical perspective that is traditionally concerned with the universalities of a disease and not with the idiosyncrasies of those affected'. However, patients possess expert knowledge on living with a chronic disease (Nøhr, Bertelsen & Kanstrup, 2009). Therefore, an alternative approach should complement this strictly medical approach in two ways.

First, it should take into account the daily needs, thus aiming for developing healthcare tools and technologies that are integrated within and personalised to the everyday life of the people using them. Second, it should approach the design of these tools and technologies from a bottom-up perspective including the patient as an expert. Ballegaard et al. (2008) propose that, when designing health tools, one should keep in mind (1) continuity in space, (2) continuity in time and (3) the aesthetic dimension.

First, continuity in space implies that the use of the tools should not be limited to a certain location (e.g. tools that are only usable in a hospital setting). It should be possible to use them wherever one wants to. Second, continuity in time illustrates the necessity that the tools should incorporate – when possible – technologies and routines that are already part of everyday life. Finally, the aesthetics of the tools should fit with the preferences of those using them (Ballegaard et al., 2008).

Starting from these ideas, Bespoke Design deals with the participatory design of self-management tools for and with people with type 1 diabetes, who use these tools for controlling and managing their condition continuously (Bauer & Ringel, 1999; Funnel & Anderson, 2004; Wootton, 2000).

Managing diabetes on a daily basis requires both self-

Image 1

**Image 1.** A participant displaying his self-care and self-management tools.

care and self-management. Self-care relates to independent care (e.g. injecting insulin), while self-management concerns the necessary organizational framework to conduct self-care actions (e.g. making sure that you are carrying your tools with you) (Image 1).

Since diabetes is a complex condition that affects almost every aspect of daily life (i.e. nutrition, monitoring the use of medication, etc.), the general, medical oriented self-care solutions (e.g. lancet pen, glucometer, etc.) alone are not sufficient and are merely superficial answers to people's daily wishes and needs.

While these general self-care tools aim to serve as many persons as possible, Bespoke Design aims to develop bespoke self-management tools for one person that can later be redeveloped for others. Central to the project is that the design and redesign starts from the everyday experiences of the person with diabetes. Throughout the project, three different personalised self-management tools were developed for three participants.

**Personal Fabrication and FabLabs**

For developing these tools, Bespoke Design explores the context of a FabLab and the related idea of personal fabrication. A FabLab – Fabrication (or Fabulous) Laboratory – allows people to develop and perfect a prototype of almost any imaginable product and can be defined as 'a collection of commercially available machines and parts linked by software and processes we developed for making things' (Gershenfeld, 2005, p.12).

In this regard, personal fabrication is the idea that we can download or develop digital product descriptions and designs and supply these to the fabricator with the raw materials to process them. This is made possible because of recent advances in 'Open Source' electronics and personal fabrication possibilities, such as 3D printing (Ananthanarayan, Lapinski, Siek & Eisenberg, 2014; Mikhak et al., 2002; Gershenfeld, 2005; Mota, 2011).

The idea of personal fabrication implies that we no longer have to shop for and order products, but instead fabricate them ourselves, thus creating the opportunity for mass production (Gershenfeld, 2005). Although the idea of personal fabrication and FabLabs entails many expectations and opportunities, in Bespoke Design we encountered plenty of challenges that we describe later on.

One of the main characteristics of the FabLab concept is sharing. Within the international network of FabLabs, every FabLab shares knowledge about its projects and designs, enabling other FabLabs to (re)produce them in a way that fits their own context, environment and available resources (Zijlstra, 2010). This is facilitated by equipping each Fablab with a common set of tools. Moreover, FabLabs operate within the context of Open Design (Mandavilli, 2006; Mikhak et al., 2002).

The principles of Open Design are derived from a development methodology known in the software industry as 'Open Source'.[1] Open Design extends the philosophy of sharing, collaborating and making software public, and fosters collaborative efforts by providing a framework for freely sharing information (e.g. design documentation) (Vallance et al., 2001; Van Abel, Evers, Klaassen & Troxler, 2011). It is characterized by freely 'revealing information on a new design with the intention of collaborative development of a single design or a limited number of related designs for market exploitation' (Balka, Raasch & Herstatt, 2009, p.2).

Relating to the idea that a product is never finished and can be reworked endlessly, the Open Design approach corresponds seamlessly with the empowerment of people with diabetes and designing bespoke self-management tools in participatory ways. Within Bespoke Design, we incorporate the philosophy of FabLabs and Open Design to document the design and making process of the self-management tools in order to stimulate others to rework them for new contexts (Schoffelen et al., 2013). In the following sections we focus on the design and development process of self-management tools for one particular participant and the challenges we encountered when using the FabLab as a research environment.

**Developing Bespoke Prototypes in a FabLab: Expectations and challenges**

To explore the everyday life with diabetes, the participants with type 1 diabetes mapped their experience of using self-care and self-management tools daily, together with the designers. This way, the participants provided the design team with insights in relation to the day-to-day issues encountered when dealing with diabetes.

Participatory observations (Image 2) and an interview with an endocrinologist provided further understanding; touching issues like motivation for self-care, restocking food, using tools in public, forgetting tools, etc. After this exploratory phase, designers and participants collaboratively built scenarios to tackle specific issues that were found (Schoffelen et al., 2013).

These scenarios were translated into videos and used as input for a FabLab workshop (involving other designers), resulting in the creation of three (conceptual) prototypes for three participants. In this paper, we focus on a particular development process of a series of prototypes designed for a male triathlete with type 1 diabetes. This case illustrates our reflections on the expectations and challenges of a FabLab in a PD context and the changing role of the designer.

The participant in question (the pseudonym Bill was used to maintain anonymity) wanted to wear his self-care tools (glucometer, lancet pen and insulin pump) close to his body when working or during sport. Furthermore, he indicated that the pump's thread for the catheter was too long and impractical (Image 3).

Through different PD workshops (involving Bill and the product designer engaged in Bespoke Design) and by using the 3D printers of FabLab Genk (the Objet 30 and the MakerBot Replicator 2), two 3D printed prototypes were developed and then redeveloped.

The first prototype took on the form of a system to roll up the thread for the catheter. The other prototype entailed a clip system to attach Bill's self-care tools to his body. The technique of 3D printing was chosen since it supports a rapid prototyping process in which a prototype can quickly go through different iterations of making, testing, re-making, re-testing and so on (ie. a process of trial and error).

Moreover, 3D printing allows one to easily create detailed designs (in terms of resolution and finishing), which is very useful in this particular case where different types of holders for self-care tools were developed. The product designer who made the prototypes (together with Bill) had no prior knowledge of 3D printing techniques but could rely on the knowledge and experience available in the FabLab.

As shown in the table below, we will disprove, nuance or confirm common expectations and opportunities of FabLabs and the idea of personal fabrication by discussing our experiences of using the FabLab environment for this PD project. These expectations relate mostly to three main issues: accessibility of the machines, transferability among FabLabs and the cost of personal fabrication in terms of time and money.

A first series of issues are related to the accessibility of the FabLab machinery. FabLabs are often considered as innovative workplaces where one can easily make (almost) any object (Gershenfeld, 2005; Mota, 2011).

Image 2

Image 3

*1. Richard Stallman, often attributed with the concept of Open Source software (OSS), stated that developers and users should be provided with: (1) the freedom to run the software, for any purpose, (2) the freedom to modify the software, (3) the freedom to redistribute copies of the original software and (4) the freedom to distribute modified versions of the software (Stallman, 1999; Vallance, Kiani & Nayfeh, 2001).*

**Image 2.**
A participant using self-care tools (i.e. injecting insulin).

**Image 3.**
Bill showing the long pump's thread for the catheter.

| Expectations | Challenges |
| --- | --- |
| *FabLabs are open and accessible labs where one can create everything.* | *FabLabs are open and accessible labs that are equipped with a limited amount of available machines.* |
| *3D printing enables us to make everything.* | *Different technologies, materials and characteristics determine and limit possible outcomes.* |
| *FabLabs facilitate the international and open exchange of designs and projects.* | *This exchange is limited by the absence of an international format and the fact that every lab is differently equipped.* |
| *Prototypes are finished products.* | *Prototypes are mostly first iterations of working prototypes and far from ready for large scale production.* |
| *FabLabs enable making personalised solutions.* | *Personalised solutions are economically not feasible due to the time-demanding process for designers and participants.* |
| *Making prototypes in a FabLab is a rapid and low-cost process.* | *The different iterations require a lot of time and thus result in a high cost per product in the end.* |
| *FabLabs are open workplaces that easily enable Participatory Design.* | *Designing and making prototypes in a participatory manner demands an important engagement from the participant and designer, with a different role for the designer involved.* |

Table 1

**Table 1.** Expectations and challenges concerning personal fabrication and FabLabs as research environments.

In reality, FabLabs cope with a limited amount of available machines and materials that can be used, thus restricting the potential objects that can be made. Besides, one also needs to use them and experiment with them intensely to gain thorough insights in to its working and properties (Weichel, Lau, Kim, Villar & Gellersen, 2014).

The product designer for Bespoke Design had no previous experience with (designing for) 3D printing, let alone with the specific 3D printers available in FabLab Genk. However, his background in product design proved to be essential for quickly picking up the necessary skills required for designing 3D objects (e.g. using Rhino software). Many software design tools are in fact designed with expert users in mind, impeding someone who is just making the first steps into creating 3D objects, as was the case with Bill in Bespoke Design (Mellis, 2014).

Recent developments in software design tools, however, try to lower the threshold to 3D modeling by restricting the range of possible objects (e.g. chairs or furniture), although this was not applicable to the design of self-management tools in Bespoke Design (Mueller, Mohr, Guenther, Frohnhofen & Baudisch, 2014).

Another issue we experienced is the fact that the technology of some software tools is not yet fully functional and/or insufficiently meets user expectations and needs. For example, when using 123D Catch to create 3D scans of Bill's tools (glucometer, lancet pen and insulin pump), the outcome resulted merely in a 3D impression of the tools instead of an accurate, functional 3D model. As the goal of Bespoke Design was intensively involving Bill in the making process of the different prototypes (i.e. making them collaboratively), this proved to be quite cumbersome as he had no knowledge or prior experiences on using software design tools for 3D objects.

In general, 3D printing is considered a disruptive technology with endless opportunities (Calderon, Griffin & Zagal, 2014; Lipson & Kurman, 2013; Ratto & Ree, 2012). However, each 3D printer has its own properties (size and height of the printable object, layer thickness, etc.), uses a specific technology (FDM technology, polyjet technology, etc.) and type of material (photopolymers, thermoplastics, etc.) that influences the size, sustainability, strength and finishing (in terms of layer thickness and resolution) of the printed object (Hofmann, 2014; Ludwig, Stickel, Boden & Pipek, 2014).

Within Bespoke Design two types of 3D printers were used, i.e. the Objet 30 and the MakerBot Replicator 2. The Object 30 printer is a polyjet printer, while the MakerBot Replicator 2 uses the Fused Deposition Modeling (FDM) technology. This means that printing the same prototype on both printers led to different results in terms of both strength and finishing.

For instance, a prototype for the above-mentioned clip system (Image 4) was first printed on the MakerBot. However, when Bill used this prototype in his daily routines, it proved to be insufficiently strong, resulting in a broken clip system. Moreover, for several prototypes we found that the wall-thickness is a crucial factor for the printed models' fragility. Wall-thickness is largely dependent on the material used (and the imposed minimum thickness), but also on the design of the prototype, making it nearly impossible to predict the necessary thickness for different printers.

Second, the large variety of available types of 3D printers and technologies complicate sharing experiences or designs among FabLabs or beyond.

FabLabs are closely related to a more general culture of openness, sharing and collaborating (see: Fab Charter – *http://fab.cba.mit.edu/about/charter/*). However, reality shows that little information is shared within the international network of FabLabs, since opening up the creation process and sharing it online through the use of so called 'Fab Moments' proves to be a considerable challenge for most FabLab users (due to lack of time or

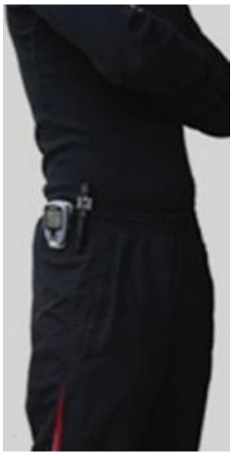

Image 4

Image 5

**Image 4.** Bill wearing a prototype of the clip system.

**Image 5.** The system to roll up the thread.

motivation) (Schoffelen & Huybrechts, 2013).

As we stated above, one of the underlying ideas of stimulating exchange among FabLabs is equipping them with a common set of tools. However, as we experienced in Bespoke Design, sharing the designs of the prototypes with other FabLabs does not always end in comparable results since different types of 3D printers (in terms of technology, properties and material) are used; thus limiting the opportunities for easily sharing and reworking the designs.

Furthermore, the relative novelty of the technique, the different technologies, materials and applications as well as the use of different terminologies and the general lack of expert knowledge in FabLabs hamper the use of 3D printing technology in terms of personal fabrication. There is no general open repository that collects information on the different types of printers, the materials used, the strength of the materials, etc., making it impossible for novice users to have a clear view on the end result of the prototype before printing (Ludwig et al., 2014; Mayson, 2013).

Third, the idea that 3D printing is a quick and inexpensive process needs to be nuanced. For personal fabrication, it is cost-efficient that one can make a prototype without having to produce a whole series or use expensive moulds. As we experienced in Bespoke Design, 3D printing of personalised self-management tools is time-consuming. Not only the printing times are considerably high (Mueller et al., 2014) but making these tools requires different iterations, which can strongly increase the overall costs.

For example, the clip system for Bill was remade seven times before an adequately functional and testable prototype was obtained. We mainly used the Object 30, which features a fairly high average printing cost in contrast to the cheaper and more fragile prototypes printed by the Makerbot. As a result of switching from the Makerbot to the Object 30, the total cost of printing the different prototypes (i.e. of the clip system and the system to roll up the thread (Image 5)) was higher than initially estimated.

Nonetheless, the trajectory in Bespoke Design was limited to the design and making of personalised prototypes of self-management tools. In this sense, the environment of a FabLab was a useful setting since it provided us with access to and knowledge of (in the form of assistance from the FabLab manager) the machines to iterate through different prototypes. However, transforming these prototypes into working products (produced on a larger scale) requires additional steps.

Furthermore, the specific participatory setting of Bespoke Design further increased the investment of the designer and participant (in this case, Bill) needed to develop a set of personalised self-management tools. Although, a FabLab, as an open research environment, facilitates collaborating in an informal setting, it requires an enormous engagement of the participant to continuously invest time and energy in the design and making process of a limited amount of prototypes. While this is the case for every PD project, the participation of Bill in the making process prolongs the period of time that the participant is engaged in the project.

Reflecting on the process of making self-management tools together with Bill, we found that creating individualised solutions adapted to the needs of one particular person is a long-term process that is time-consuming for both the designer and participant, which is not always feasible in an economical sense.

The final series of prototypes for Bill are being used for several months now and have proven to be sufficiently usable and firm for daily use. However the aesthetics of the prototypes, in terms of look and feel, should be further improved in order to attract and be manufactured for a larger group of potential users.

Therefore, as we experienced in the project, 3D printing is not the straightforward, easy and low-cost process that common rationale dictates. It is in fact - like most prototyping processes – a continuous case of trial and error, (re)designing and (re)testing, still requiring a lot of input from the designer.

As experienced in Bespoke Design, the willingness and motivation of Bill to intensively participate was unfortunately not enough to overcome his lack of knowledge and skills on 3D printing for him to actively participate in the making process, exposing implications and new rules for the designer.

**Implications and New Roles for the Designer**

The goal of this paper was to explore the idea of personal fabrication and the role of a FabLab as a research environment for PD projects. Our experiences in Bespoke Design, and more specifically with developing a series of tools for Bill, indicate that a FabLab can enable a close relation between designer, participant and machines, placing the role of the designer as a mediator for participation in a different context.

While this role is well known in the conceptual design phase (see Participatory Design), the role of the designer as mediator in making prototypes – which a FabLab allows – is relatively new. This change from participatory design to participatory making (or making together) demands different or additional roles for the designer (Stapers, Sleeswijk Visser, & Kistemaker, 2011; Seravalli, 2012 & 2013). As was the case in Bespoke Design, the designer fulfilled the role of a mediator between the FabLab environment and the participant. This means that the concept and philosophy of a FabLab needed to be explained to the participant before involving him strongly in the making process of the prototypes. Furthermore, in retrospect, we can distinguish some additional tasks for the designer in the prototyping process, as defined by Seravalli (2013).

First, an important element in the entire making together process is introducing the practices of prototyping to the participant. The design team, and specifically the product designer who designed the prototypes in a one-on-one relation with Bill, experienced the uncertainty that designers are often confronted with when designing in participatory ways.

PD projects are in essence always uncertain since they rely heavily on the input from other participants and therefore have an unclear or unpredictable outcome (Dreessen, Huybrechts, Laureyssens, Schepers, Baciu, 2011; Huybrechts, Schepers & Dreessen, 2014). Subsequently, the design, but also the participation, is placed in an uncertain situation (Huybrechts et al., 2014). Iteratively developing prototypes further increases this uncertainty and requires the designer to explain this iterative process to the participant who is unfamiliar with these practices. Or as stated by Seravalli (2013, p. 12):

> *Transferring a prototyping approach to non-designers can be quite difficult since it means to accept that failures are positive occasions from which one can learn: if failure is related to a project where a lot of resources are invested and expectations come into play, it is difficult to consider it as something that should be welcomed.*

Although this way of working was sometimes difficult to grasp for Bill, he stated in a final evaluation the value of gained insight in this process. Closely related to the latter, is the task of the designer to ensure a continuation of the prototyping or making the process engaging enough for the participants involved. This continuous process of trial and error requires important efforts from the designer to maintain a steady participant involvement by keeping them motivated to participate actively throughout the project.

A final task for the designer in this process of making together relates to the ownership of and giving up control over the project. PD, at its core, is about sharing ownership and releasing control by the designer over the design process (Schepers, Huybrechts & Dreessen, 2011).

As mentioned before, taking participation further into the making process increases the importance of releasing control by the designer even more and changes the relation between the designer and participant. On the one hand, this can imply a more passive role for the designer: a mediator between the participant and the machines, a problem-solving guide aiding participants when necessary. However, as we experienced, this was not the case due to the lack of knowledge on 3D printing by the participant. On the other hand, the relation between the designer and participant can become more concrete since it involves the making of tangible prototypes.

For instance, we found that during the project participants think aloud very concretely and also explore possibilities while holding or collaboratively making the tangible prototypes (e.g. asking for specific functionalities to be included in a prototype), deepening the collaboration between designer and participant.

## Conclusion

Although the context of a FabLab as an open environment and the idea of personal fabrication can be very beneficial for the idea of personal fabrication, some important challenges remain. As described in this paper, the main issues we experienced in Bespoke Design can be subdivided in to three categories.

A first major obstacle relates to the accessibility of the FabLab machinery and having the necessary skills to operate them. As our experiences with Bill showed, this proved to be a major obstruction preventing him from actually making the prototypes together with the designer. Furthermore, the lack of standardization and documentation, the lack of experience in 3D printing and the use of various 3D printers, complicated the making process for everyone involved.

As stated in the second category, this lack of standardization (using the same type of machines) among FabLabs, the absence of a repository on the use of 3D printers and the lack of sharing through the system of Fab Moments, hinders easily sharing information. Furthermore, it also obstructs designers and novice users to get a clear view on the cost, material properties, look and strength of the design, resulting in an uncertain outcome with most print jobs.

The final issues relate to the common idea that 3D printing is an easy and quick process for prototyping. Due to the relatively high printing cost, the printing time and the different iterations needed to obtain a functional and testable prototype, one can question the use of this technique for developing personalised tools.

However, we believe that choosing a process of participatory making (thus including a FabLab in a PD approach) provides the designer with new roles and tasks in these kinds of design projects (i.e. a mediator between the participant and the machinery), and creates a more profound relationship between the participant and the designer.

Furthermore, designing in this context expands this mediator-role from conceptual design (exploring problems and possibilities through co-design methods) to the actual making of tangible prototypes.

We believe that developing a discourse concerning this new mediating role of designers in participatory making, similar to the discourse of methods and tools in participatory design, can be very valuable. This paper can be seen as a small contribution to this discourse, although additional research is required.

**Acknowledgement**
Bespoke Design is a collaboration between Social Spaces|CUO and FabLab Genk and is funded by OPAK of LUCA School of Arts (KU Leuven). More information (in Dutch) can be found on the project blog: *www.designopmaat.be*

## References

**Ananthanarayan, S., Lapinski, N., Siek, K., & Eisenberg, M.**, 2014. 'Towards the Crafting of Personal Health Technologies', in *Proceedings of the 2014 conference on Designing interactive systems*, pp. 587-596. ACM.

**Ballegaard, S. A., Hansen, T. R., & Kyng, M.**, 2008. 'Healthcare in Everyday Life: Designing healthcare services for daily life', in *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, pp. 1807-1816, ACM.

**Balka, K., Raasch, C., & Herstaat, C.**, 2009. *Open Source Beyond Software: An empirical investigation of the open design phenomenon*, R&D Management Conference, 2009.

**Bauer, J. C., & Ringel, M.**, 1999. *Telemedicine and the Reinvention of Healthcare*, McGraw-Hill Professional Publishing.

**Calderon, A., Griffin, J., & Zagal, J. C.**, 2014. 'BeamMaker: An open hardware high-resolution digital fabricator for the masses', *Rapid Prototyping Journal*, 20(3), pp. 245-255.

**Dreessen, K., Huybrechts, L., Laureyssens, T., Schepers, S., & Baciu, S.**, 2011. *MAP-it. A Participatory Mapping Toolkit*, Leuven: Acco.

**Ehn, P., & Badham, R.**, 2002. 'Participatory Design and the Collective Designer', in T. Binder, J. Gregory & I., Wagner (eds.), Proceedings of *Participatory Design Conference*, pp. 1-10. Malmö, Sweden.

**Funnel, M. M., & Anderson, Robert M.**, 2004. 'Empowerment and Self-management of Diabetes', *Clinical Diabetes*, 22, pp. 123-127.

**Gershenfeld, N.**, 2005. *FAB. The Coming Revolution on Your Desktop. From Personal Computers to Personal Fabrication*, New York: Basic Book.

**Huybrechts, L., Schepers, S., & Dreessen, K.**, 2014. 'Participation and Risky Trade-offs', in L. Huybrechts (ed.), *Participation is Risky: Approaches to joint creative processes*, pp. 7-89, Amsterdam: Valiz.

**Hofmann, M.**, 2014. '3D Printing Gets a Boost and Opportunities with Polymer Materials', *ACS Macro Letters*, 3(4), pp. 382-386.

**Lipson, H., & Kurman, M.**, 2013. *Fabricated: The new world of 3D printing*, Indianapolis: John Wiley & Sons.

**Ludwig, T., Stickel, O., Boden, A., & Pipek, V.**, 2014. 'Towards Sociable Technologies: An empirical study on designing appropriation infrastructures for 3D printing', in proceedings of the conference on *Designing Interactive Systems 2014*, pp. 835-844. ACM.

**Mandavilli, A.**, 2006. 'Appropriate Technology: Make anything, anywhere', *Nature*, 442, pp. 862-864.

**Mayson, S.**, 2013. 'People-Centred Desktop Design and Manufacture: A review of web enabled open source tools for localised community focused inclusive design', *Include Asia 2013: Global Challenges and Local Solutions in Inclusive Design*, 1.

**Mellis, D. A.**, 2014. 'Do-It-Yourself Fabrication of Electronic Devices', *Pervasive Computing*, IEEE, 13(3), pp. 22-29.

**Mikhak, B., Lyon, C., Gorton, T., Gershenfeld, N., McEnnis, C., & Taylor, J.**, 2002. 'Fab Lab: An alternate model of ICT for development', paper presented at the *International Conference on Development by Design*, Bangalore, India.

**Mota, C.**, 2011. 'The Rise of Personal Fabrication', in proceedings of *The 8th ACM conference on Creativity and cognition*, pp. 279-288. ACM.

**Mueller, S., Mohr, T., Guenther, K., Frohnhofen, J., & Baudisch, P.**, 2014. 'faBrickation: Fast 3D printing of functional objects by integrating construction kit building blocks', in proceedings of *The 32nd annual ACM conference on Human factors in computing systems*, pp. 3827-3834. ACM.

**Nøhr, C., Bertelsen, P., & Kanstrup, A.M.**, 2009. 'Breaking Barriers to Self-management of Chronic Diseases', in: McDaniel, J. G. (ed.). *Advances in information technology and communication in health* (Vol. 143), Ios Press.

**Ratto, M., & Ree, R.**, 2012. 'Materializing Information: 3D printing and social change', *First Monday*, 17(7).

**Robertson, T. & Simonsen, J.**, 2013. 'Participatory Design: An introduction', in J. Simonsen & T. Robertson. (eds.), *Routledge International Handbook of Participatory Design*, pp. 1-17, New York: Routledge.

**Stallman, R.**, 1999. 'The GNU Operating System and the Free Software Movement', *Open Sources: Voices from the open source revolution*, 1, 280.

**Schepers, S., Huybrechts, L., & Dreessen, K.**, 2011. 'MAP-it: On friction, risk and releasing control', *Swedish Design Research Journal*, 2(11), pp. 32-38.

**Schoffelen, J., & Huybrechts, L.**, 2013. 'Sharing is Caring: Sharing and documenting complex participatory projects to enable generative participation', *Interaction Design and Architecture* (s), 18(1), pp. 9-22.

**Schoffelen, J., Huybrechts, L., & Dreessen, K.**, 2013. 'Please Resuscitate! How to share a project concerning self-management in diabetes to enable participants to elaborate on it after project completion?', paper presented at *Design4Health Conference*, Sheffield (UK).

**Seravalli, A.**, 2012. 'Infrastructuring for Opening Production, Ffrom Participatory Design to Participatory Making?', in proceedings of *The 12th Participatory Design Conference: Exploratory Papers, Workshop Descriptions, Industry Cases -Volume 2*, pp. 53-56, ACM.

**Seravalli, A.**, 2013. 'Prototyping for Opening Production: From designing for to designing in the making together', in proceedings of *The 10th European Academy of Design Conference*, Gothenburg, Sweden: University of Gothenburg.

**Stappers, P. J., Sleeswijk Visser, F., & Kistemaker, S.**, 2011. 'Creation & Co: User Participation in Design', in B. van Abel, R. Klaassen, L. Evers, P. Troxler (eds.) *Open Design Now: Why Design Cannot Remain Exclusive*, pp. 140-148, Amsterdam: BIS Publishers.

**Storni, C.**, 2013. 'Design for Future Uses: Pluralism, fetishism and ignorance', *Nordes*, 1(5).

**Storni, C.**, 2014. 'Design Challenges for Ubiquitous and Personal Computing in Chronic Disease Care and Patient Empowerment: A case study rethinking diabetes self-monitoring', *Personal and Ubiquitous Computing*, 18(5), pp.

1277-1290.

**Vallance, R., Kiani, S., & Nayfeh, S.**, 2001. 'Open Design of Manufacturing Equipment', *CIRP 1st Int. Conference on Agile, Reconfigurable Manufacturing*.

**Van Abel B., Evers L., Klaassen R. & Troxler P.**, 2011. (eds.), *Open Design Now. Why design cannot remain exclusive*, Amsterdam: BIS Publishers:.

**Weichel, C., Lau, M., Kim, D., Villar, N., & Gellersen, H. W.**, 2014. 'MixFab: A mixed-reality environment for personal fabrication', in proceedings of *The 32nd annual ACM conference on Human factors in computing systems*, pp. 3855-3864, ACM.

**Wootton, R.**, 2000. 'The Development of Telemedicine', in: M. Rigby, R., Roberts & M., Thick (eds.), *Taking health telematics into the 21st century*, pp. 17-26. Abington: Radcliffe Medical Press.

**Zijlstra, T.**, 2010. Foreword, *FabYearBook 2010*. *http://www.instructables.com/id/FabYearBook-2010/* [accessed, 10th September, 2014]

**Katrien Dreessen** *is a researcher at Social Spaces I CUO, coordinator of FabLab Genk and is conducting a PhD on how FabLabs can outreach their philosophy and activities to new groups other than the traditional makers.*

**Jessica Schoffelen** *is a researcher at Social SpacesICUO and conducting a PhD concerning design for participation and opening up design and art projects through documentation.*

**Ollivier Piqueray** *is a researcher at Social SpacesICUO and involved in several projects for Social SpacesICUO research group, among which is Bespoke Design.*

**Danny Leen** *is a researcher at Social SpacesICUO and manager of FabLab Genk. Currently, he is preparing a PhD on parametric design of self-management tools for chronic diseases.*