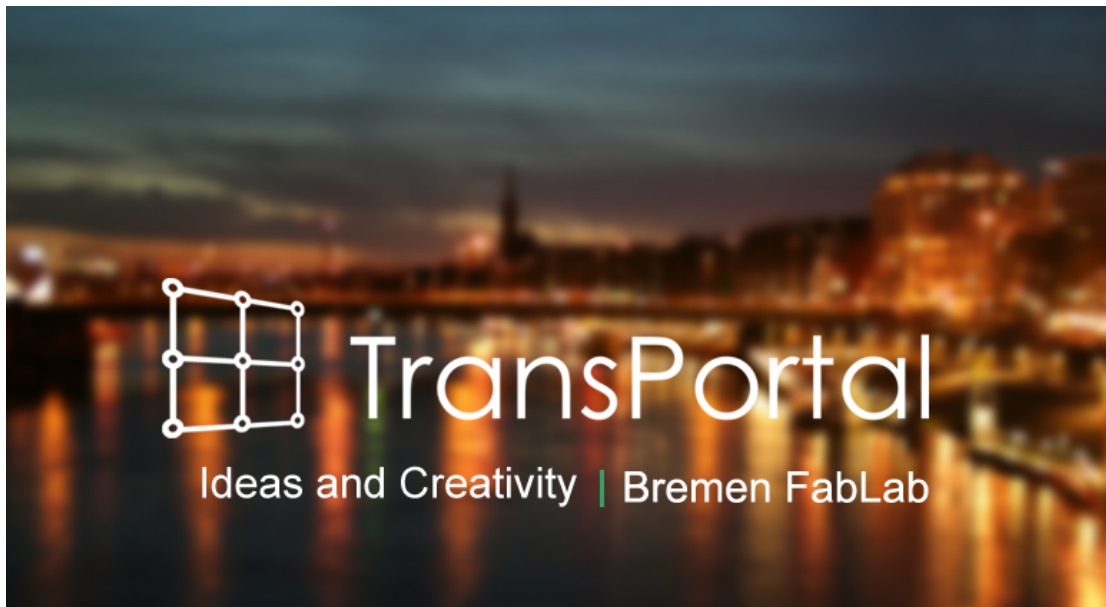# TRANSPORTAL MASTER PROJECT

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ABSTRACT

Ever since Gershenfeld passionately describe personal fabrication in his book "FAB: The coming Revolution on Your Deskstop", first published in 2005, the technology for such endeavor has been exponentially improved. From a campus-wide movement to a globally active and connected community, the advancement and initiatives for establishing a personal fabrication shows no sign of slowing down. However, just like Gernshenfeld himself noted, the challenge to fabrication community is not the technological aspect but the "social" and "organizational" aspects.

To contribute to the "social" and "organizational" aspects of fabrication laboratory (FabLab), TransPortal project takes the local context of FabLab in University of Bremen, studies it and offers suitable solutions to the issues found. From our initial study, we decide on tackling pressing issues of the lack of documentation system on the FabLab users' side and the absence of proper administrative platform for the FabLab staff members.

This report is a documentation of the process under which TransPortal project transpires. We will discuss how the requirements for our system are conceptualized and implemented. The philosophy, technology and methodology used in this project will be shown and justified.

The user study will invalidate the effectiveness and efficiency of TransPortal implementation. The satisfying result proves that TransPortal, as a system, has high usability and learnability while, as an initiative, opens door to more exploratory ideas to the betterment of personal fabrication community and experience.

1. INTRODUCTION

1.1 Background

Users of a FabLab have responsibilities. According to the Fab Charter - which is sort of a 'constitution' for the global FabLab Network and connects all the FabLabs around the world (for more detailed informations about FabLab see section 2.1) - the responsibilities of FabLab users are basically three things:

1. Safety: not hurting people or machines
2. Operations: assisting with cleaning, maintaining, and improving the lab
3. Knowledge: contributing to documentation and instruction

(Fab Charter, 2012)

That would be, of course, an ideal. As talks with Dr.-Ing. Dennis Krannich, one of the persons in charge of the still young FabLab at the University of Bremen, show the daily practice in the FabLab Bremen differs in some cases significantly from the ideal. (Personal communication, 2013) It was not uncommon that the staff of the FabLab at the University of Bremen observed and experienced different behaviors of the people who worked in the FabLab. People, for example, came into the lab and used the available tools; but once they were done, they left without documenting or sharing their works with either the FabLab Bremen or other sharing platforms like for example: YouMagine, Thingiverse, Instructables... etc. Furthermore they noticed several times that the FabLab users didn't clean up after they were done with their works. For Krannich the reason for this situation is not a spirit of mischief on the side of the FabLab users. Instead he assumes a lack in the organisation and communication on the side of the FabLab Bremen which he would like to improve. According to Krannich, there are two major problems resulting from this situation:

1. The FabLab Bremen and its staff have a lot of extra work to do and extra costs to pay in order to keep the FabLab safe and clean which in the long run could endanger the continuity of the FabLab Bremen financially.

2. The amount of people contributing to the collection of documentations and instructions is very little compared to the amount of people using the FabLab. This is problematic because the FabLab Bremen and the global FabLab network lives from sharing knowledge and active participation. (see section 2.1 for further informations about FabLab)

Against this backdrop, the main motivation for the project TransPortal - as part of

the international Master Program in the discipline of "Digital Media" at the University of Bremen - is to support the FabLab Bremen with the solving of the two problems mentioned above by elaborating a possible way to counter these problems through the use of digital media. In addition to that, it is a good opportunity to explore as well if other FabLabs around the world are dealing with the same or similar problems and might also benefit from the outcome of this project. Therefore it is envisaged that the results of this project will be made accessible to the global FabLab Network.

Especially because project TransPortal is a student project another motivation for the project team members is to learn and gain new knowledge from this project in many different matters. For example: dealing with state-of-the-art web- and digital fabrication technologies, with agile project management methods, with intercultural collaboration since it is an international study program, with scientific working processes… etc.

1.2 Research Question and Methodology

As stated in the previous section (see section 1.1) Dr. Krannich assumes a lack in the organisation and communication on the side of the FabLab Bremen. Organisation as well as communication are two fields in which digital media are used predominantly nowadays. Coming from the discipline of "Digital Media" it seems appropriate to the TransPortal project team to explore how digital media can improve the organisation and communication of the FabLab Bremen in order to prevent the two major problems mentioned in the previous section. (see section 1.1)

This results into the following two basic research questions:

1. What kind of a digital media setup is best placed to support the staff of the FabLab Bremen in their daily tasks of maintaining and organizing a FabLab while at the same time encouraging the FabLab users to fulfill their responsibilities regarding safety, operations and knowledge when they work in the FabLab? (see section 1.1)

2. How to design this digital media setup so that other FabLabs are able to adapt it into their workflow as well?

The methodical approach of the TransPortal project team to answer the research questions is deductive. Thus section one starts by giving an overview about the

background, the motivation, the research question and the conductors of the project TransPortal. The following chapter will elucidate the theoretical background knowledge that is important for the project TransPortal. This contains a description of the FabLab idea and the FabLab network as well as a description of the relevant Design Paradigms that underlie project TransPortal. The third chapter will be devoted to an As-is analysis in order to draw inferences from it about the intended system to be built. The As-is analysis will contain the exploration and description of first the current situation at the FabLab Bremen, secondly the situation at other FabLabs around the world through a questionnaire and thirdly related existing systems. The fourth chapter will then highlight the concept of the TransPortal system and it´s single components. The fifth chapter will be all about the implementation of the TransPortal system which then will be evaluated in chapter six. Last but not least the seventh chapter will be the conclusion of project TransPortal in which a summary of the results and an outlook for future work will be given.

1.3 The Project TransPortal

The conductors of this project are Xiaofen Peng from China, Raksmey Meas from Cambodia, Stefanos Trialonis from Greece and Simon Engelbertz from Germany. The four are all "Digital Media" students of the international Master program at the University of Bremen. The title of this project "TransPortal" is a word creation out of the two words "Trans-" and "Portal". "Trans-" can be translated with "across" or "beyond" (Oxford Dictionaries, 2014) which in a transferred sense signify for the project conductors the interweaving relationship of the real and the virtual world nowadays. The word "Portal" stands for a "doorway" or "gate". (Oxford Dictionaries, 2014) The combination of the two words should express the process of entering an environment in which the interweaving relationship of the real and the virtual world can be a very fruitful one through the careful use of digital fabrication tools, the sharing of knowledge and a community spirit.

The vision of the conductors of project TransPortal is to create a Web-based system which is able to connect with physical standalone devices built in the FabLab with the purpose of improving the daily organisation of FabLabs and the communication with their users. As the minimal goal of project TransPortal the conductors of the project aim to implement an open-source "sign on/off" standalone device and the basic infrastructure of an open-source web-based system which is able to connect with the "sign on/off" device. Furthermore the conductors of the project want to outline a concept for the open-source web-based system, which goes beyond the basic infrastructure and includes

sketches of further applications which might help persons in charge of FabLabs in carrying out their daily tasks and procedures while encouraging their users to fulfill their responsibilities according to the Fab Charter. (see section 1.1).

The process of project TransPortal was first organized and structured through the agile project management method "scrum[1]" and was later on replaced with "Kanban[2]" another agile project management method.

2. THEORETICAL BACKGROUND

In order to create and implement a Web-based system through which the FabLab Bremen as well as the global FabLab networks benefits, it is important to understand and highlight what FabLab is about and what the motivation of the FabLab network is. Hence this chapter starts with the description of FabLab, its idea and its network.

2.1 Fablab: Idea and Network

The idea of FabLab originates from a class called "How to make (almost) Anything" at the Massachusetts Institute of Technology (MIT) in 1998 in which the participants learned how to work with state-of-the-art digital fabrication tools like laser cutters, CNC mills, supersonic jets of water…etc.This class was initiated and given by Neil Gershenfeld, who is a professor at MIT and the director of the MIT Center for Bits and Atoms (CBA). (Gershenfeld 2005, pp.4-5) Gershenfelds primary motivation was to do research at the intersection of fabrication and computation in order to get Personal Fabrication off the ground which he sees as the next revolution after the digital revolution (Gershenfeld 2007, p.17). He envisions the progress of Personal Fabrication in analogy to personal computing and the emergence of open source software, which came a long way from mainframe computing to computing for personal needs. In this context he writes in his book "FAB":

"[…] possession of the means for industrial production has long been the dividing line between workers and owners. But if those means are easily acquired, and design freely shared, then hardware is likely to follow the evolution of software. Like its software counterpart, open-source hardware is starting with simple fabrication functions, while nipping at the the heels of complacent companies that don´t believe that personal fabrication "toys" can do the work of their "real" machines. That boundary will recede until today´s marketplace evolves into a

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[1] https://www.scrum.org/

[2] http://www.kanbanblog.com/explained/

continuum from creators to consumers, servicing markets ranging from one to one billion." (Gershenfeld, 2007, p. 15).

During his class "How to make (almost) Anything" Gershenfeld encountered a high "learning-teaching-dynamic" amongst the participants - who were not only MIT students but also independent artists, hobbyists, engineers... etc. from the area - which manifested in the freely and gladly exchanging of the participant's individual knowledge with each other in order to master the handling of the digital fabrication tools and to realize their projects. (Gershenfeld 2007, pp.6-7)

Encouraged by this serendipity Gershenfeld started to form the idea of FabLab which combined his visions of promoting the genesis of Personal Fabrication on the one hand and establishing a new peer-to-peer learning environment on the other hand. In order to explore if Gershenfelds idea of FabLab would also work outside of the MIT environment the CBA started FabLab in 2002 as their educational outreach component and supported the building of FabLabs in Costa Rica, in India, in Ghana, in Norway and in the US. From there on the idea of FabLab developed its own dynamics and gained many new supporters and sympathisers. During a presentation about FabLab at a TED Conference in 2006 Gershenfeld reflects positively on the development of FabLabs by saying the following:

"The message coming from the FabLabs is that the other five billion people on the planet aren't just technical sinks; they're sources. The real opportunity is to harness the inventive power of the world to locally design and produce solutions to local problems. I thought that's the projection 20 years hence into the future, but it's where we are today. It breaks every organizational boundary we can think of. The hardest thing at this point is the social engineering and the organizational engineering, but it's here today." (Gershenfeld 2006).

Today FabLab is considered to be a global "knowledge sharing network that spans 30 countries and 24 time zones". (FabFoundation 2013, what is a fablab) The FabLab network is a bottom-up organized network, that is, every fablab is fully in control of its processes and gets no regulations from a centralized entity. As a consequence of that there is a big variety of FabLabs with different motivations, target groups and forms of organization. The motivations for people to build up a FabLab range from hobby and DIY reasons to educational and research reasons to entrepreneurial and innovation reasons. The target groups also vary in a continuum from DIY people to students to designers to engineers to entrepreneurs... etc. Regarding the different forms of organization there are one-man mini FabLabs (e.g. the mini FabLab of Bart Bakker[3]), FabLab trucks (e.g. the FabLab truck of Jaap Vermaas[4]), independent FabLab clubs (e.g. FabLab

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3 http://www.minifablab.nl/

4 http://fablabtruck.nl/

Munich[5]), a FabLab within a museum (FabLab Chicago[6]), FabLabs within a University (e.g. FabLab Aachen[7]), FabLabs within a school (e.g. Fab@School Stanford[8]) and so on.

Nevertheless the FabLab network is advised and supported by an umbrella organisation which is called the Fab Foundation which was founded in February 2009 as an US non-profit 501(c) 3 organization that emerged from MIT's Center for Bits & Atoms Fab Lab Program. The mission of the Fab Foundation "is to provide access to the tools, the knowledge and the financial means to educate, innovate and invent using technology and digital fabrication to allow anyone to make (almost) anything, and thereby creating opportunities to improve lives and livelihoods around the world." (Fab Foundation 2013, about us)

The Fab Foundation gives a suggestion of a definition about what qualifies as a FabLab today. According to that there are mainly four qualities which make a FabLab:

1. Public access to the FabLab. So a FabLab must be open to the public for free or in-kind service/barter at least part of the time each week.

2. FabLabs support and subscribe to the FabLab charter, which functions as a sort of a 'constitution' for the FabLab Network (see appendix F for the full content of the Fab Charter)

3. FabLabs have to share a common set of tools and processes since the idea is that all the labs can share knowledge, designs, and collaborate across international borders. This set of tools is not static but so far it contains: a laser cutter for 2D/3D design and fabrication, a high precision milling machine for making circuits and molds for casting, a vinyl cutter for making flexible circuits and crafts, a fairly sophisticated electronics workbench for prototyping circuits and programming microcontrollers, if possible a large wood routing machine for furniture and housing applications and an inexpensive 3D printer, which is robust and is able to print with a fair resolution. A detailed list of recommended tools can be found on the website of MIT´s CBA[9].

4. FabLabs must participate in the larger, global FabLab network, that is, a single FabLab can't isolate itself. There are several ways for FabLabs to connect with each other. One way is to attend the annual FabLab meeting with varying venues or connect to it via public videoconferences. Another way is to collaborate and partner with other labs in the network on workshops, challenges or projects. To

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5 http://www.fablab-muenchen.de/

6 http://www.msichicago.org/whats-here/fab-lab

7 https://hci.rwth-aachen.de/fablab

8 https://tltl.stanford.edu/projects/fablabschool

9 http://fab.cba.mit.edu/about/fab/inv.html

participate in the Fab Academy is yet another way. The Fab Academy is a Digital Fabrication Program which "provides advanced digital fabrication instruction for students through a unique, hands-on curriculum and access to technological tools and resources." (Fab Academy, 2014)
(Fab Foundation 2013, FabLab criteria)

Peter Troxler, a FabLab activist and an independent researcher at the intersection of business administration, society and technology, even places the FabLab network - or the FabLab ecosystem as he calls it - in the context of the next industrial revolution referring to Jeremy Rifkin's book "The Third Industrial Revolution". (Troxler 2013, p.181) According to Rifkin:

"The Third Industrial Revolution will have as significant an impact in the twenty-first century as the First Industrial Revolution had in the nineteenth century and the Second Industrial Revolution in the twentieth century. And just as in the two former industrial revolutions, it will fundamentally change every aspect of the way we work and live. The conventional top-down organization of society that characterized much of the economic, social, and political life of the fossil fuel-based industrial revolutions is giving way to distributed and collaborative relationships in the emerging green industrial era. We are in the midst of a profound shift in the very way society is structured, away from hierarchical power and toward lateral power." (Rifkin 2011, pp. 36-37)

1st revolution	2nd revolution	3rd revolution
19th century	20th century	21th century
Printing press	Radio, TV	Internet
Coal and Steam	Oil and Electricity	Renewable Energies

Table 1: Industrial revolutions and their drivers: communication and energy sources. (Troxler 2013, p.183)

At the same time Troxler professes that the global FabLab network is struggling to define its form and purpose. He appeals to the global FabLab network by writing:

"[...] the FabLab community needs to stop being preoccupied with machines and sole practical making, and instead needs to wake up to the challenges of "the social engineering and the organizational engineering" and should start working on how to organize the ecosystem." (Troxler 2013, p.191)

Therefore he suggests shifting the focus on five key questions as a roadmap for the development of the global FabLab network. These five questions are:

1. How to build effective forms of collective action and self organization for FabLabs?
2. How to break free from traditional systems and creatively design new systems that tap into the capabilities of FabLabs?
3. How to protect the interests and creative freedom of makers while also ensuring wide access to new knowledge, processes and products?
4. How to appropriately and effectively create and capture value?
5. How to achieve equity and fairness?
(Troxler 2013, p.191)

For the Project TransPortal Troxler's appeal and suggestion is an affirmation of conducting this project since the intended Web-based system to be built aims to improve the processes within the social and the organizational realms of FabLabs with the help of digital media.

2.2 Relevant Design Paradigms

To gain more insights for our project, we also looked into different design paradigms. Some paradigms are directly relevant to our project. They provide valuable understanding of components to build our system. In addition, some paradigms provide general design philosophy, albeit not directly relevant, that we integrate into our work. The following sections discuss each paradigm in more detail and how they fit in our system.

2.2.1 Open Design

Open Design can be described as a global movement and as a method or a way of operating in the realms of Design. The definition of Open Design is dynamic and it evolves with the progress of the movement. The term Open Design first appeared in the end of the 20th century within the spirit of the Open Source Initiative (OSI) which was founded in 1998 in California. (Open Source Initiative 2014) One of the pioneers who attempted to describe the idea of and the conditions for Open Design was the non-profit Open Design Foundation. Its definition of Open Design published online in 2000 contained nine bullet points which were:

1. Free Redistribution
2. Design Documentation
3. Derived Works
4. Integrity of the Designer's Design Documentation

5. No Discrimination Against Persons or Groups
6. No Discrimination Against Fields of Endeavor
7. Distribution of License
8. License Must Not Be Specific to a Product
9. License Must Not Contaminate Other Designs

(Open Design Foundation 2000)

The idea of Open Design gained more and more supporters and developed into a movement with a growing influence in the world of design. (Abel, Evers, Klaasen, 2011) Another important milestone in the development of Open Design is the Open Design Manifesto of Ronen Kadushin in 2010. Among other things he proclaims:

"A revolution in product development, production and distribution is imminent due to the Internet's disruptive nature and the easy access to CNC machines. Open Design is a proposal to make this happen. Its aim is to shift Industrial Design to become relevant in a globally networked information society." (Ronen Kadushin, 2010)

Furthermore, he describes Open Design as a method with the two following preconditions:

"1. An Open Design is CAD information published online under a Creative Commons license to be downloaded, produced, copied and modified.

2. An Open Design product is produced directly from file by CNC machines and without special tooling.

These preconditions infer that all technically conforming open designs and their derivatives are continuously available for production, in any number, with no tooling investment, anywhere and by anyone. " (Ronen Kadushin 2010)

The latest big influence in Open Design is the Book "Open Design Now - Why Design cannot remain exclusive" published in 2011. Through a collection of articles from various Design experts this book discusses the present state of Open Design and looks ahead to the future of design.

Open design is very much inherent in the global FabLab network which is indirectly formulated by the Fab Charter:
"Designs and processes developed in fab labs can be protected and sold however an inventor chooses, but should remain available for individuals to use and learn from." (Fab Charter, 2012)

2.2.2 User-centered Design

What is User Centered Design
User Centered Design (UCD) is a design philosophy that the end users of a product, users' needs, wants, and experience should be put in the center of the design process. In User Centered Design, it requires the designer to analyze and have a better understanding of the needs, wants, and limitations of end users and then makes design choices that incorporate this understanding(Pratt & Nunes, 2012).

The term "User Centered Design" originated in Donald Norman's research laboratory at the University of California San Diego (UCSD) in the 1980s (Norman & Draper, 1986). In their point of view, UCD should emphasize on the importance of having a good understanding of the users and "the needs of the user should dominate the design of the interface, and the needs of the interface should dominate the design of the rest of the system." (Norman 1986).

Why We Need User Centered Design
When designing a product, it is often very difficult for designer to intuitively understand how users will understand, perceive and use their designs. UCD requires designers not only analyze and foresee how users engage with a product, but they also test their design in the real world with actual users through the whole product design process (Andy, 2012).

User-Centered Design and Traditional Waterfall Methodology

Waterfall development process
"A waterfall development process consists of a series of consecutive stages of work until the completion of the project, which ends with the delivery of the application according to the requirements defined at the beginning of the project." (Carraro, 2011, para.5)

Generally, the process has three main stages like this:

Figure 1: Three main stages of waterfall methodology

The performance of products will be measured in the real market when they are launched.

A study by IAG Consulting[10] shows that projects applying waterfall methodology fail half of the times to reach goals and require more time and budget to achieve them. The main reasons are:

1. The definitions of requirements are made before starting a project and not revised later.
2. The performance measurement happens at the end stage which has already consumed almost all budge hours for design and development.

(Carraro, 2011)

User Centered Design Process

User centered Design process proposes an iterative process for interface development. The iteration consists of three stages: analysis, elaboration and testing (Carraro, 2011). Figure below shows the iterative process of UCD.
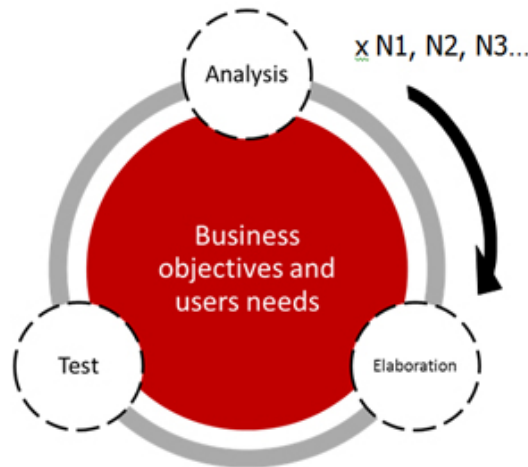
Figure 2: Three stages of UCD process

Compared with waterfall development process, UCD process has as many instances of analysis as iterations and tries to achieve the business objective and users needs. With successful iterations in analysis and testing stage, it provides constant feedback where each assumption is developed, tested and refined. In this way, UCD process largely reduces the risk that Waterfall methodology has, fulfilling the users' needs and goals.

How to "do" User Centered Design

In UCD, there are numbers of design methods used in the design process. Below four of these frequently used methods are listed (see Table) (Preece, et. al, 2002).

Method	Purpose	Stage of the Design Cycle
Background Interviews	Collecting data related to	At the beginning of the

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[10] http://esj.com/articles/2009/09/29/wasted-it-development-spending.aspx

and questionnaires	the needs and expectations of users; evaluation of design alternatives, prototypes and the final artifact	design project
Focus groups	Include a wide range of stakeholders to discuss issues and requirements	Early in the design cycle
On-site observation	Collecting information concerning the environment in which the artifact will be used	Early in the design cycle
Personas	Used to describe typical users and understand the people who the design is for	Early in the design cycle

Table 2: User Centered Design Methods

These methods will be applied in different stages of a design cycle according to its purpose. For example, personas are used to describe target users and define what the needs and goal they have, so it should be start to apply early in the design cycle based on research data. In our master project, we adopt personas as our design tool. In section 4.2.3, more discussion of Personas related to our project will be presented.

Advantages and Disadvantages of User Centered Design

UCD helps designers achieve user's expectations about a new product in which they involve users to the design process. This leads to a sense of ownership for the final products that often result in higher user satisfaction and smoother integration of the product into the environment (Preece, et. al, 1994; Preece, et. al, 2002).

However, UCD has it limitations while it has much more advantages compared with traditional design process. Table below summarizes the advantages and disadvantages of user-centered design (Abras, et.al , 2004).

Advantages	Disadvantages
Products are more efficient, effective, and safe	It is more costly.
Assists in managing users 'expectations and levels of satisfaction with the product.	It takes more time.
Users develop a sense of ownership for the product	May require the involvement of additional design team members (i. e. ethnographers, usability experts) and wide range of stakeholders
Products require less redesign and integrate into the environment more quickly	May be difficult to translate some types of data into design
The collaborative process generated more creative design solutions to problems	The product may be too specific for more general use, thus not readily transferable to other clients; thus more costly

Table 3: Advantages And Disadvantages Of User-Centered Design

2.2.3 User-Experience Design

Certain names have involved in shaping and defining the term "User-Experience Design" (UXD). In this chapter, we attempt to draw a crisp theoretical profile for UXD by presenting the opinions of Donald A. Norman, John Dewey, Peter Wright and John McCarthy, and a few more, on experience, user-experience (UX), and - by extension - UXD. Apart from theory, practical implications and implementations, which derive from the onchanging nature of the UX/UXD theory, indicate that an effective approach, in terms of designing a perfect UX, goes hand in hand with the current technological paradigm. Therefore, we ought to additionally refer to today's technology, specifically in the context of the web.

First and foremost, lets talk about experience. According to John Dewey (1980) "Experience occurs continuously, because the interaction of live creature and environing conditions is involved in the very process of living." (p.35). John goes on, differentiating between experiencing and having an experience; the course of an experience does not always have the intended ending; fragments of experience that won't merge into an experience. Jodi Forlizzi and Katja Battarbee (2004) compliment John Dewey's differentiation by introducing three categories of experience: *experience, an experience, co-experience*. According to them, the plain word "experience" refers to the uninterrupted stream of consciousness and energy that compose our existence. *An experience* is a stream which has merged into a story, a notion, or an entity. Alternatively, *an experience* is a subject with specific traits, definable points of beginning, middle and ending, which can be named and discussed. Lastly, *co-experience* refers to the collective consciousness:

experiences which are born and shared between people.

John McCarthy and Peter Wright (2004) come to enhance our perception of experience by stating that "experience is ever present. [...] There is no God's eye view or privileged position of neutrality or authority." (p. 50). It is subjective by nature. Experience in different contexts can also have very different meanings. That's why McCarthy and Wright divide the idea of experience in four major "threads" on a theoretical level in their user experience framework: the sensual, the emotional, the compositional, and the spatio-temporal threads. The sensual thread might seem obvious: senses. We perceive everything with our senses, therefore the sensual thread is what keeps and connects the user with the experience. The emotional thread is the user's feedback when he is in confrontation with the various stimuli, which make up his experience. Concerning the compositional thread, it is the story: parts that make up the experience. Lastly, the spatio-temporal one refers to the space and time variables of the experience.

The idea of threads compliments John's and Peter's efforts, which try to capture the multidimensional nature of the different aspects of human experience, which are continuously "running" in parallel and generally perceived as one. Additionally, they define six individual sense-making processes: anticipation, connection, interpretation, reflection, appropriation, and recount. At this point, we won't provide an explanation to each of the above processes, since they are pretty self-explanatory. We will refer to a few of them later on this chapter, where we are also going to shortly clarify their functionality.

In essence, experience doesn't stop. It goes hand in hand with our conscious existence. It can be personalized or it can be part of a collective mind. The act of describing and talking about it constitutes a different experience. The way we explain experience, the methods and paradigms we use, when we integrate it in our studies, help us understand the way humans think and act in real time. This is particularly important in human-computer interaction (HCI).

Now let's talk about UX. Simply put, UX is "the person's perceptions and responses resulting from the user and/or anticipated use of a product, system or service". As of 2014, this is the updated definition by ISO 9241-210:2010(en). The "product, system or service" part of the definition puts technology into play. Technology is a parameter which changes according to the variable of time. As long as the state of technology (applied on a product, system or service) on a given point in time satisfies all the needs it was made to satisfy, then this is where UX rises to an obvious position of immense importance. This is when technology becomes nearly invisible to the user and the experience matters the most. In John McCarthy's and Peter Wright's (2004) book "Technology as an Experience" this phenomenon is very accurately described: "Today we don't just use technology, we live with it. Much more deeply than ever before we are aware that interacting

with technology involves us emotionally, intellectually and sensually. So people who design, use, and evaluate interactive systems need to be able to understand and analyze people's felt experience with technology." (preface).

In the process of designing for a UX, we go through the 5 planes of UX, as defined by Jesse James Garrett (2000), which are: strategy, scope, structure, skeleton, and surface. These steps gradually move from abstract to concrete. Below we provide a short explanation for each of the planes. Additionally, where applicable, we relate to our own work and methodology.
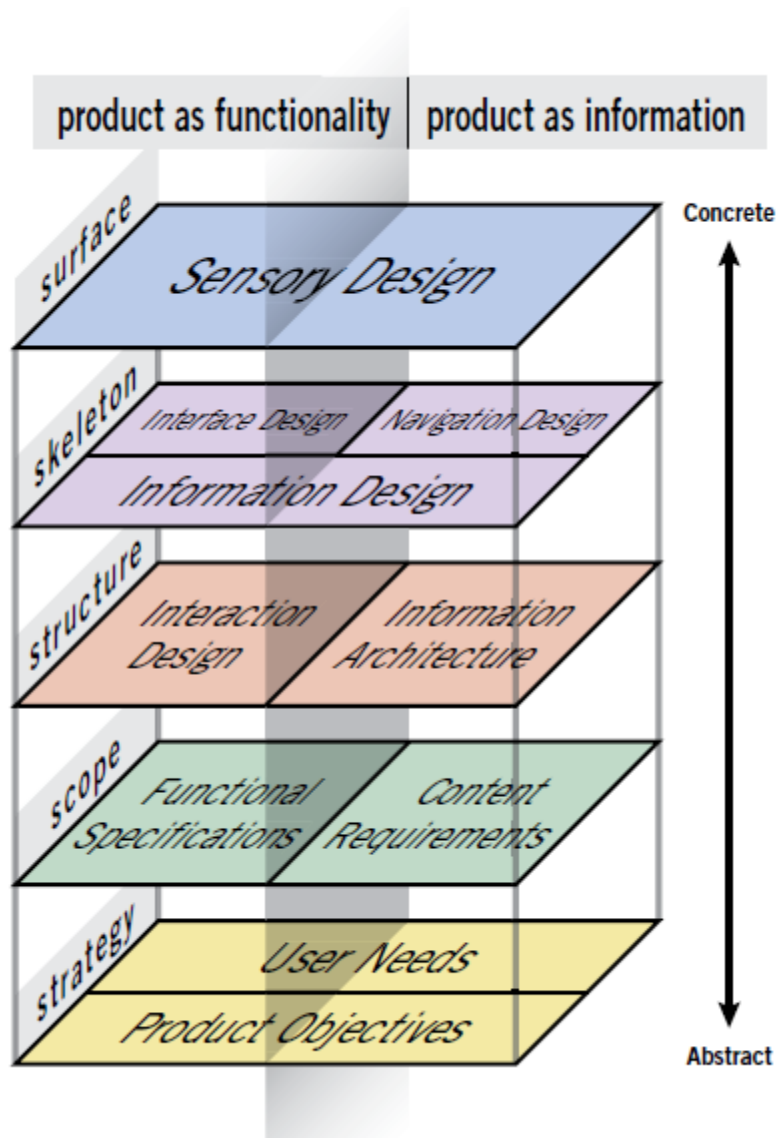
Figure 3: The Elements of User Experience

Strategy:
The planning of the strategy constitutes the beginning of the entire process. By

planning, we mean answer basic questions, such as: "What purpose will the website fulfill?". Additionally, we set our goals, define what the users want, and specify the "bigger picture". The strategy we followed is transparent in the introductory section (chapter 1).

Scope:
Scope is the migration of the strategy to the requirements. This involves the development of tasks and user's stories (personas); what tasks should users be able to accomplish on the site to help them reach their goal? Further insight into our strategy is provided in chapter 4.2.3, where we talk about the target audience and we define our personas.

Structure:
The beginning of the development of taxonomy. The structure usually comes in the form of user flow diagrams, which depict the set of actions a user will take through the website. In the case of TransPortal, this was a series of blackboard charts, similar to Figure 8, presented on chapter 4.2.1.

Skeleton:
This is the blueprints of the product. In our case it is the wireframe of the website. This describes the position of the elements around the page. Where the buttons go, ..., etc. Concerning the sketches (prototypes), we created Hi-Fi ("clickable" sketches done in Axure[11]) and Lo-Fi (paper sketches) deliverables, which can be seen on chapter 4.2.3.

Surface:
This is the visual interface layer that puts all the components together. Simply put, this is the content of the website: colors, typeface, logo, personality, buttons, images, ..., etc. Snapshots of our early surfaces are presented in chapters 4.2.5 and 4.2.6.

Moving on, towards the justification of our design and methodology, we draw definite relations between theory and practical approach, in terms of designing and building a web page and a registration terminal. We define a specific process. Generally, processes in UXD may differ. This is due to the fact that not all products are of the same nature. The manifestation of the 5 planes of UX mentioned earlier, come into a more compact and tweaked diagram, which applies to us:

Figure 4: TransPortal UXD process

As the diagram above depicts, our first move was to research: conduct a survey

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[11] www.axure.com

(chapter 3.2), look for and consequently look into potentially related works (chapter 3.4). Our approach on strategy remains as we described shortly above, on the corresponding "strategy" plane, and in this case we merge it with the plane of "scope". Next, "implementation" brings the planes of "structure" and "skeleton" together with development (coding of website) and the building of the sign on/off device. The final steps of our process ("beta release" and "further optimization") refer to the early beta release of our website and sign on/off device, the sessions of usability testing (see chapter 6), and the finalization (slight improvements) of the website and sign on/off device after the users' feedback.

At the end of the day, by following a specific UXD process and methodology, our goal is to reach a deeper understanding of the user, satisfy his needs, and enable him to submerge into a total sensory and conscious involvement with our product. This later leads to a better product. We design more than just a website and a sign on/off device-contraption; balancing functionality and aesthetics up to a desirable analogy.

2.2.4 Generative Design

What sets generative design, as a concept, apart from other design paradigm is the fact that generative design focus on the process of making artworks, more than the artworks itself. As, Soddu, (1992) noted "Generative Design is a morphogenetic process using algorithms structured as not-linear systems for endless unique and un-repeatable results performed by an idea-code, as in Nature"[12]. The idea is to create a rule-based process with parameters that can be tweaked so that the results are unique and but the process are fastened.

In this project, although it is not directly connected, we can still take the concept of generative design, the focus of process creation, and apply it to our design of the whole TransPortal platform. We aim to build a system that will enable a streamline and intuitive "creation process" while leaving "options" as parameters for users to tweak to their likings. This will ensure a manageable centralized process which produces unique user experience based on their own preferences.

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[12] http://www.generativedesign.com/

Figure 5: Simplified generative design process[13]

3. AS-IS ANALYSIS

Our first step to improving the FabLab is to understand its current state. To do this, we attempted to do an As-is analysis of the existing FabLab system because such analysis "is a prerequisite to understand how processes are executed in the current system. Unlike most object oriented design models, where technical aspects are considered for development, an As-is model serves analysts as an important model for understanding and improvement of business processes." (Lodhi, Kassem, Köppen & Saake, 2010, p. 2). However, as it is noted that As-is analysis can become time consuming and complex (Jisc infoNet, 2013), we limited our scope to only analyzing the current state of the FabLab in the University of Bremen, commonly called "FabLab Bremen", and several other FabLabs we have contacts with.

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[13] http://www.generative-gestaltung.de/

3.1 FabLab Bremen

The following Informations primarily originate from the FabLab Bremen e.V. website[14] and from personal communication with the supervising lecturers Sabrina Wilske, Dr. Bernd Robben and Dr.-Ing. Dennis Krannich during a Master-Project preparation class at the University of Bremen which was called "FabLab - Introduction to Tangible Computing and Digital Fabrication" and took place from April to August 2013. The three of them are employed at the working group „dimeb" at the University of Bremen and are in charge of the FabLab Bremen as well.

The FabLab Bremen started off in 2010 as an initiative leaded by the toolmaker, artist and networker Karsten Joost. (Joost 2013, pp.27-31) It took around three years until the funding for the tools, the location and the staff was succeeded. So in the beginning of 2013 the FabLab Bremen opened up its doors at the University of Bremen for the first time. The official foundation though happened in September 2013 when the FabLab Bremen became a "Verein", a german organizational form for associations with non-profit purposes. The founders and those in charge are the research group Digital Media in Education "dimeb" (University of Bremen) lead by Prof. Dr. Heidi Schelhowe and the "Sportgarten e.V." which is a non-profit association for children and teenagers in the realms of sports in Bremen. Further staffs of the FabLab are three student assistants who primarily take care of the maintenance of the FabLab and the support of workshops with a monthly time exposure of averagely 100 hours in total. The foci of the FabLab Bremen are mainly four things:

1. The engagement with Digital Media and production technologies
2. The qualification of junior employees
3. The promotion of media literacy
4. The arousing of interest for technical and creative occupations as well as for new technologies

(FabLab Bremen e.V., 2014)

Therefore, the main target group of the FabLab Bremen is a mixture of pupils, students, teachers and scientists. Through the "OpenLabDay" which takes place on every first and third monday in a month the FabLab is also accessible for the public. Furthermore, the FabLab sees itself to be a cultural and interdisciplinary environment with mediating and connecting functions in the fields of technology, design, art and society. Hence it is aiming at collaborations with educational and research institutions, enterprises from the creative industries as well as institutions from the cultural sphere in the form of workshops and projects. The communication of general informations about the FabLab as well as the

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[14] http://www.fablab-bremen.org

promotion of events (e.g. workshops, open lab day, ... etc.) mainly happens through the website of the FabLab and through Emails and verbal messages. (FabLab Bremen e.V. 2014) Communication and cooperation with other FabLabs happen irregular. If it occurs it´s done mostly via workshops, conventions, meetings and Emails. The persons in charge of the FabLab haven't implemented a particular platform for its users to document and publicize their work. So far the few users who were sharing their works used general online sharing platforms like for example "Thingiverse"... etc. The system for scheduling appointments with users and making reservations of equipment/tools usually works after the principle "First come, first served" or the users make a reservation for the tools via email or verbal communication with the FabLab staff. Students who want to borrow equipment from the FabLab, for example a microcontroller, can do that by asking the staff of the FabLab and filling out a rental paper form. Important usage data of the FabLab equipment (e.g. Laser Cutter values, ... etc) is solely collected and stored internally on a computer inside the FabLab so that the users can access it. Yet the data is not made available online for the public and the global FabLab network. (Dr. Krannich, personal communication, 2013)

Looking at the background information about the FabLab Bremen it is conspicuous that there is no central place where information regarding the FabLab and its users are gathered so that all those in charge of the FabLab can see what is going on. That is problematic in an environment where various people work at different times since it carries the risk that important information like for example which user borrowed which tool for how long...etc. might not reach every person in charge of the FabLab even though he or she must know about it. That in the end might cause a lot of confusion and in worst case might lead to a loss of equipment or something like that. Another problem that becomes obvious is that there is neither a local platform in the FabLab Bremen where the users could share their works with other users nor is there a usage data collection of gained FabLab specific knowledge which is shared with the global FabLab network. This on the other hand is not in the sense of the FabLab network since sharing knowledge locally as well as globally is one of the most important parts of the FabLab idea.
In the context of these two aspects the conductors of project TransPortal see a high capability of the intended Web-based system to provide a remedy.

3.2 Survey from different FabLabs

In addition to the analysis of the current situation of FabLab Bremen, we also managed to devise a survey to get a general situation of other FabLabs so that we could have better idea of the how various systems were being implemented.

3.2.1 Methods

The Questionnaire

To reach out and gather information from different FabLabs, we employed an online survey using the free Google docs form[15]. The questions in the form were in English and the time window for responses was approximately two months. The questionnaire was sent by email to an aggregated list of FabLab contacts. The questions were divided into five different sections (see appendix A for the complete questionnaire):

1. General/personal information
2. Basic FabLab information
3. Specific questions regarding organization
4. Evaluation of FabLab's organizational tools and aspects
5. Open-ended question regarding needs and wishes

The Respondents

The contacts for this survey were aggregated from two main FabLab-related websites. One is Fab Foundation[16] a US non-profit organization originated from MIT's Center for Bits & Atoms Fab Lab Program. Another site is FabLab wiki page [17] which stores a collection of contacts to different FabLab around the world. The survey targeted the FabLab managers or those in authority as we focused our work on facilitating the FabLab workflow. Around 100 online forms were sent and by the end of response window, a total of 38 responses were collected.

3.2.2 Results

As mentioned in point 3.2.1, participants of the survey had a response window of approximately two months. After this period, the team collected 38 responses and closed off the survey. Although the survey contained 31 questions divided into 5 different sections, we would like to only discuss main survey results. Other information was treated as background information only.

It is interesting to see that more than 41% of the FabLab in the survey are independent body which means they do not have an inherit system for managing

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[15] https://docs.google.com

[16] http://www.fabfoundation.org/fab-labs/

[17] http://wiki.FabLab.is/wiki/Portal:Labs

lab as those FabLabs (25%) that are affiliated to a school or university.

Form of Organization

Legend:
- Part of a school
- Part of a university
- Independent Fablab (e.g. club)
- Other

8.3%
16.7%
41.7%
33.3%
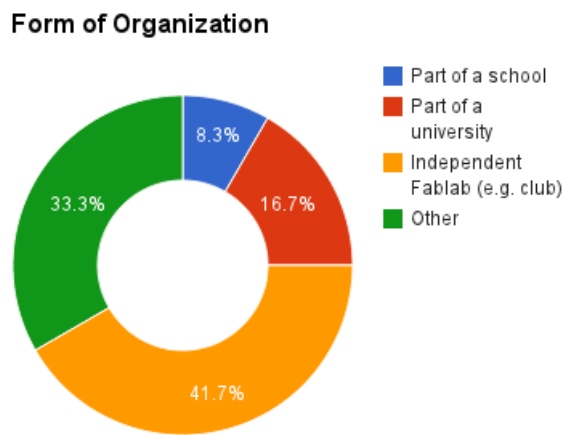
Figure 6: Form of FabLab organization

The survey asked respondents to select the main targets of their (multiple choices possible). The result shows that students, DIY people and designers were nearly equally targeted, followed by engineers and entrepreneurs.

Main target audience

Entrepreneurs	DIY people	Designers	Engineers	Students	Other
15	26	24	16	27	4
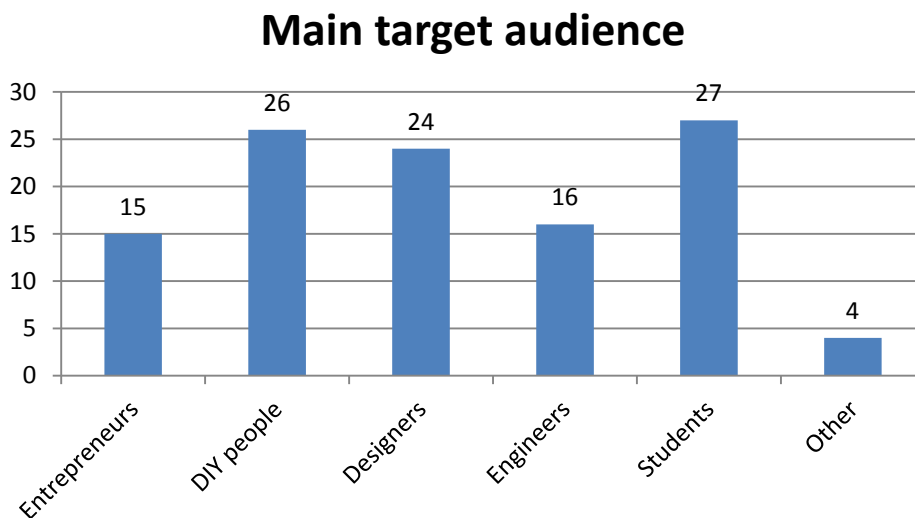
Figure 7: Main target audience
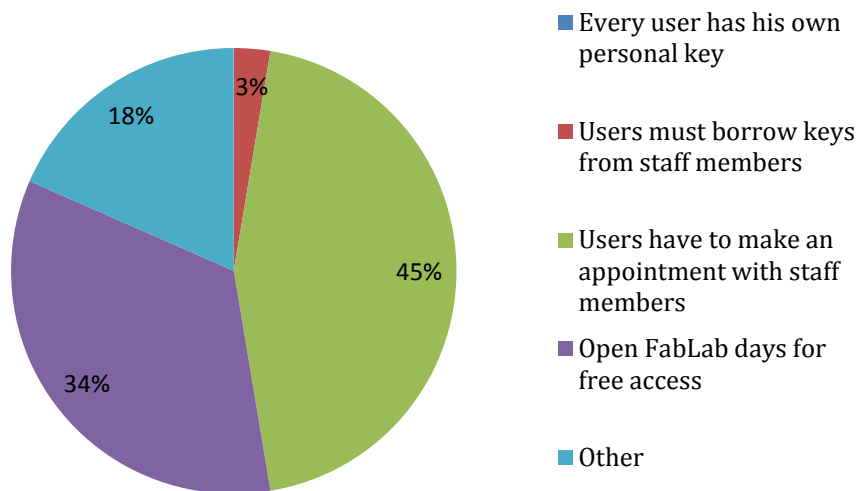
Access to FabLab

Systems that few people use

Part of the survey asked respondents to whether or not their FabLab had a system for documenting and sharing users' work. 74% of the FabLabs have a platform for users' to upload and publicize their projects; however, the next question, which asked the respondents to specify their platform, showed that many different systems were used by the FabLab (see appendix C). Even more interesting, more than 80% of the respondents said the default system was used by only a few users or none at all.
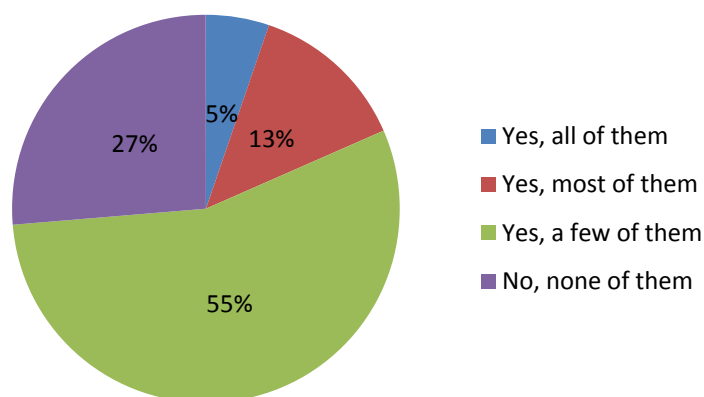
Important Features

The survey also asked respondents to rate the importance of several features including a website, scheduling system, registration system, inventory system, documentation and usage data recording. The following table shows the importance of each system to the respondent.

Importance of systems

	1 (Most important)	2	3	4	5 (Not important)
Web site	61%	26%	5%	3%	5%
Registration	24%	16%	24%	16%	21%
Scheduling	21%	29%	34%	5%	11%
Inventory	13%	24%	47%	11%	5%
Documentation	37%	24%	18%	16%	5%
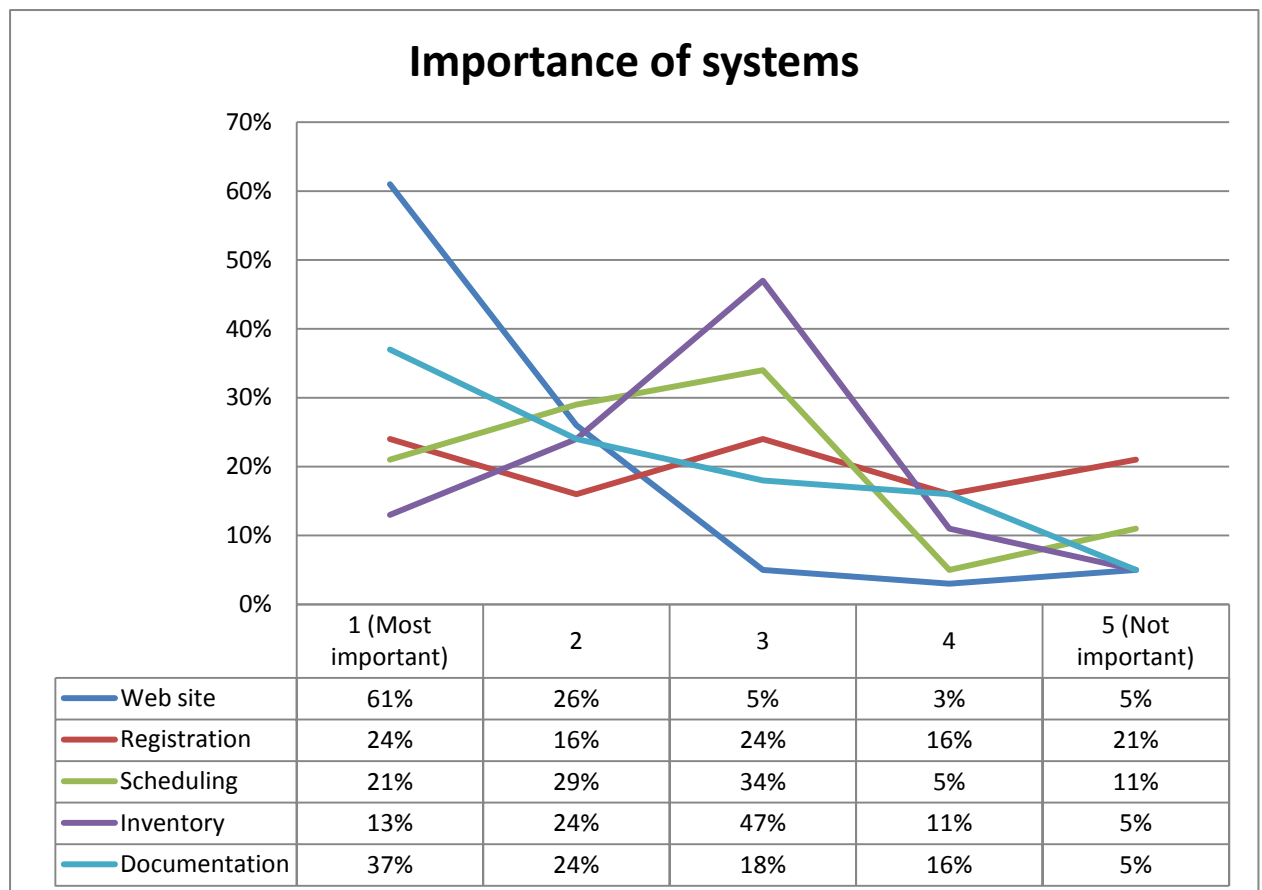
Figure 10: Rating on importance of systems

As the table shows, a web site receives the highest importance rating[18] (87%) from respondents followed by documentation system (61%), scheduling system (50%), registration system (40%) and inventory system (37%).

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[18] Importance rating = % of "most important" + % of "important"

3.3 System Requirements

As mentioned in the end of section 3.1, the current situation in Bremen FabLab needs remedial solution; and the TransPortal team believes that a web-based platform would fit best. The result of the survey from different FabLab confirms this justification as nearly 90% of the respondents placed high importance on a website and more than 60% said they needed documentation system. Combining our understanding of the current Bremen FabLab and comparing it to the result of our survey, we formulate several key requirements for the system that we will work on:

- **_R1: Provides documentation capabilities for FabLab users_**
  It is very clear from previous discussion in section 3.1 as well as the result from section 3.2.2, the fundamental capability of a proper Fablab system must enable users to create their works and keep the record of such process in a systematic and streamline manner. Simple as it sounds, there is already evidence that users don't just use what is given to them (Fig. 4). Therefore, our system must strive to provide this fundamental functionality that is accepted by the intended users.

- **_R2: Provides sharing capabilities of the documentations within the site network and the Internet_**
  In addition to documentation, our system will enable users to share their work. As one of the Fablab goals is the encourage creativity and participation, the ability to share users' works is an imperative feature. Posch et al. noted, "a big motivation to get active for children and people in general is seeing things they particularly like or by the prospect of becoming a leading example themselves." (2010, p. 254)

- **_R3: Provides administrative supports for managers of FabLab_**
  People behind FabLab are just as important as the audience of the FabLab. Therefore, the system should support the work of FabLab staffs, be it a manager or administrator. Our system, by taking into account the discussion in section 3.1 about the absence of central administrative platform, will enable the basic, yet mandatory, functionalities of the FabLab internal processes including registration, scheduling and inventory systems. The importance of such systems is also confirmed by our survey with other FabLab (Fig. 5).

- **_R4: Provides a modular system with flexibility and upgradability_**
  Although our system is localized for the Bremen FabLab, we also intend to make our system modular meaning it can be customized to fit the needs of other labs with similar working environment. Also, given the rate at which technology evolves, our system must be upgradable to make sure it doesn't become obsolete. This means we will have to use an open-sourced framework with promising updatability.

3.4 Related Works

We synthesized from section 3., As-Is analysis, a set of system requirements as discussed in section 3.3 above. In this section, we look at works that previously tried to implement similar features. The goal is to understand how we can achieve the stated requirements based on already existing knowledge. Given the extensiveness of analysis done previously in the works discussed below, it would be hugely redundant to redo evaluation on very feature-specific system. Instead, we will only provide an overview of those related works and discuss what can be learned from them together with how we can integrate it in our project.

3.4.1 SHARE

SHARE seeks to create an environment that enables engineers to work together by using the internet (Toye et al., 1993). Toye discussed challenges faced by engineers, particularly in "gathering and organizing information, communicating with clients, suppliers and colleagues, negotiating tradeoffs, and using each others' services." (p. 1).

SHARE provides very good overview specifications to deal with such issues, which are strongly similar to those faced by FabLab mangers and users. The project proposes "an open, heterogeneous, network-oriented environment" which enables users to "participate on a distributed team using their own tools and data bases" (Toye et al., 1993, p. 2).
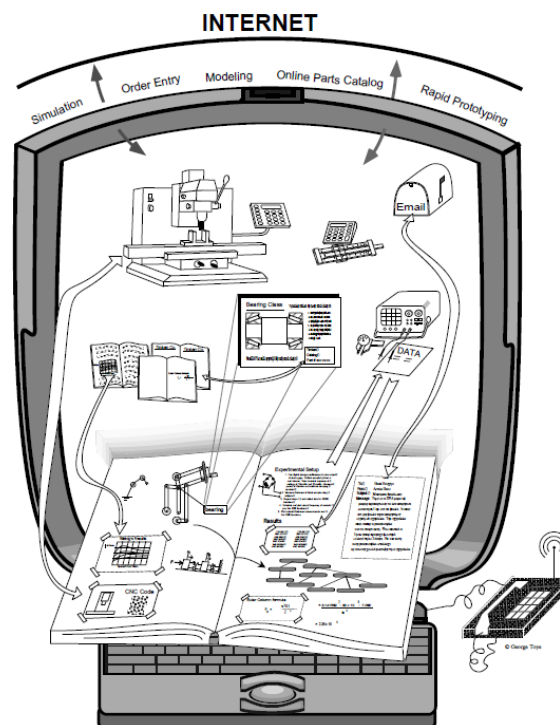
Figure 11: SHARE concept

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3.4.2 Fabiji

In author's own word, "Fabiji is a project documentation system specialized for Fablab users who design and create products, and the documentation software is written for iPad"(Zhao, 2012, p.7). Zhao managed to create a prototype software with two main features: assisting users in creating basic project documentation and encourage exploration of others' project.   Our project can benefit from Zhao's discussion on mobile systems available for documentation and scheduling. Furthermore, in his work summary, Zhao provided good observation on the fact that Fablab needs to create a more centralized and consistent users' experience. Simply put, a good system for FabLab users will provide all the services, (i.e. documentation, scheduling, inventory...etc) in one place (Zhao, 2012).
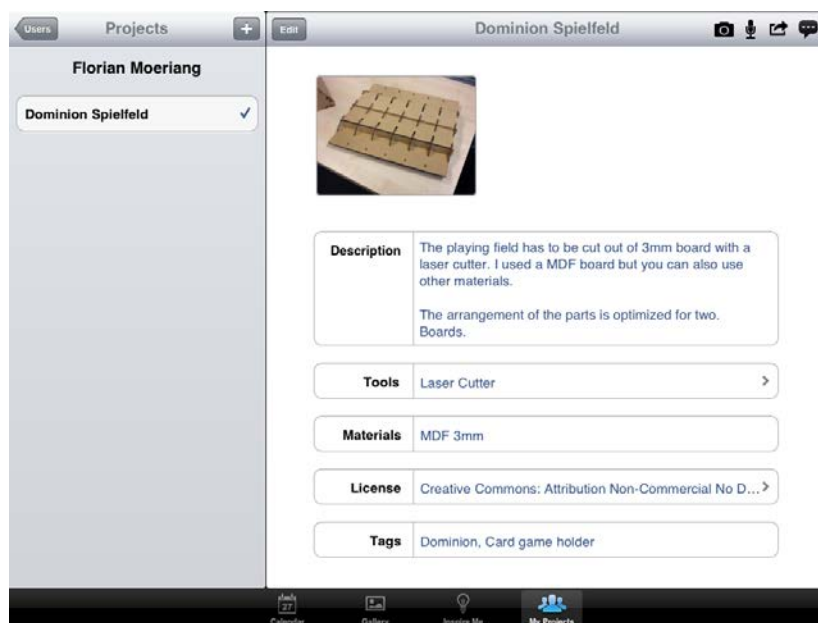
Figure 12: Screenshot of Fabiji iPad app

However, tying a platform to one ecosystem, in this case, iOS system, present the limitation on accessibility from users. The need for the users to own an iPad to document their own projects is problematic simply because we cannot expect every FabLab user to own an iPad. This reassures our justification to build a web-based platform integrated into a central website for such system.

3.4.3 FabCenter

FabCenter by Tim Hemig (2013) is the closest project to the TransPortal project. It deals with similar issues of documentation and sharing within FabLab as well as scheduling system for users. Furthermore, the project also creates prototype of an administrative system that can be used to manage FabLab internal process such as managing inventory.

Hemig (2013) has done a very extensive and conclusive analysis of several major online documentation and sharing tools as well as various online scheduling systems. In his analysis, Hermig apparently concluded that Thingiverse[19] has the highest "best practices" and recommended similar implementation.
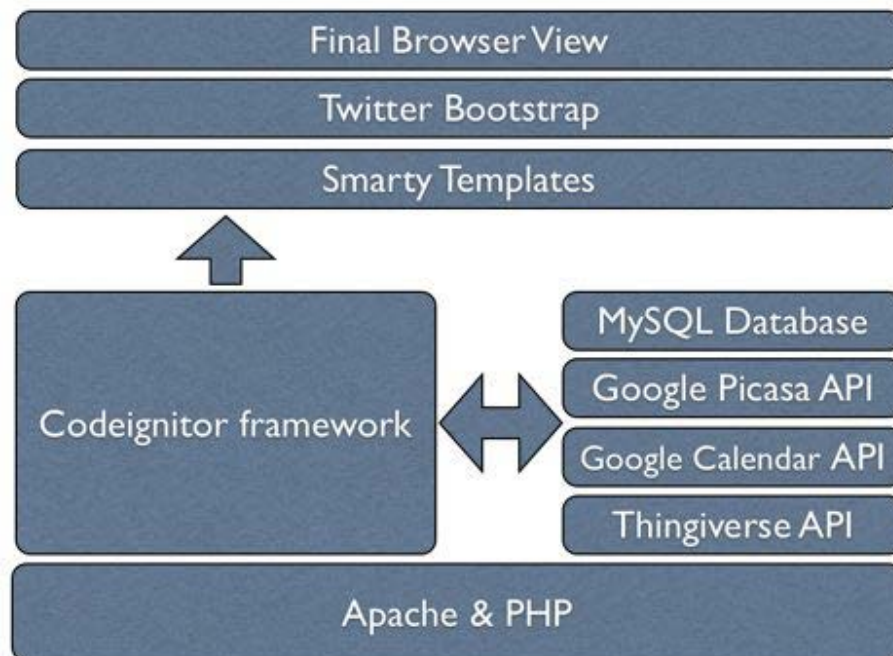
As Fig. 13 shows, FabCenter integrates many different APIs to achieve its features. While this practice quickens the development process, it also presents some inheriting issues. As Hermig noted, "another approach would be to overcome the technical difficulties we encountered in that matter. This requires the API of the involve services to evolve, too" (2013, p. 77). So, from this, we learn that API dependency can be an issue. That is why we try to limit the use of API wherever possible.

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[19] http://www.thingiverse.com

4. CONCEPT

Before the concept of the TransPortal system will be elucidated it is helpful at this point of the documentation to recall the research questions (see section 1.2), the minimal goal (see section 1.3) of project TransPortal as well as the key requirements (see section 3.3) of the TransPortal system since these were the main driving influences for the concept.

The research questions are:

1. What kind of a digital media setup is best placed to support the staff of the FabLab Bremen in their daily tasks of maintaining and organizing a FabLab while at the same time encouraging the FabLab users to fulfill their responsibilities regarding safety, operations and knowledge when they work in the FabLab? (see section 1.1)

2. How to design this digital media setup so that other FabLabs are able to adapt it into their workflow as well?
(see section 1.2)

The minimal goal is:

The implementation of an open-source "sign on/off" device and the basic infrastructure of an open-source web-based system which is able to connect with the "sign on/off" device.
In addition to that the TransPortal project team wants outline a concept for the open-source web-based system, which goes beyond the basic infrastructure and includes sketches of further applications which might help persons in charge of FabLabs in carrying out their daily tasks and procedures while encouraging their users to fulfill their responsibilities according to the Fab Charter. (see section 1.3)

The key requirements are:

• R1: To provide documentation capabilities for FabLab users
• R2: To provide sharing capabilities of the documentations within the site network
and the Internet
• R3: To provide administrative supports for managers of FabLab
• R4: To provide a modular system with flexibility and upgradability
(see section 3.3)

In the following - with the research questions, the minimal goal, the key requirements as well as the other insights of the previous sections in mind - the concept of the TransPortal system will be presented.

4.1 General structure of the TransPortal system

Figure 14 describes the general structure of the TransPortal system and its integration into a local FabLab as well as the FabLab Network.
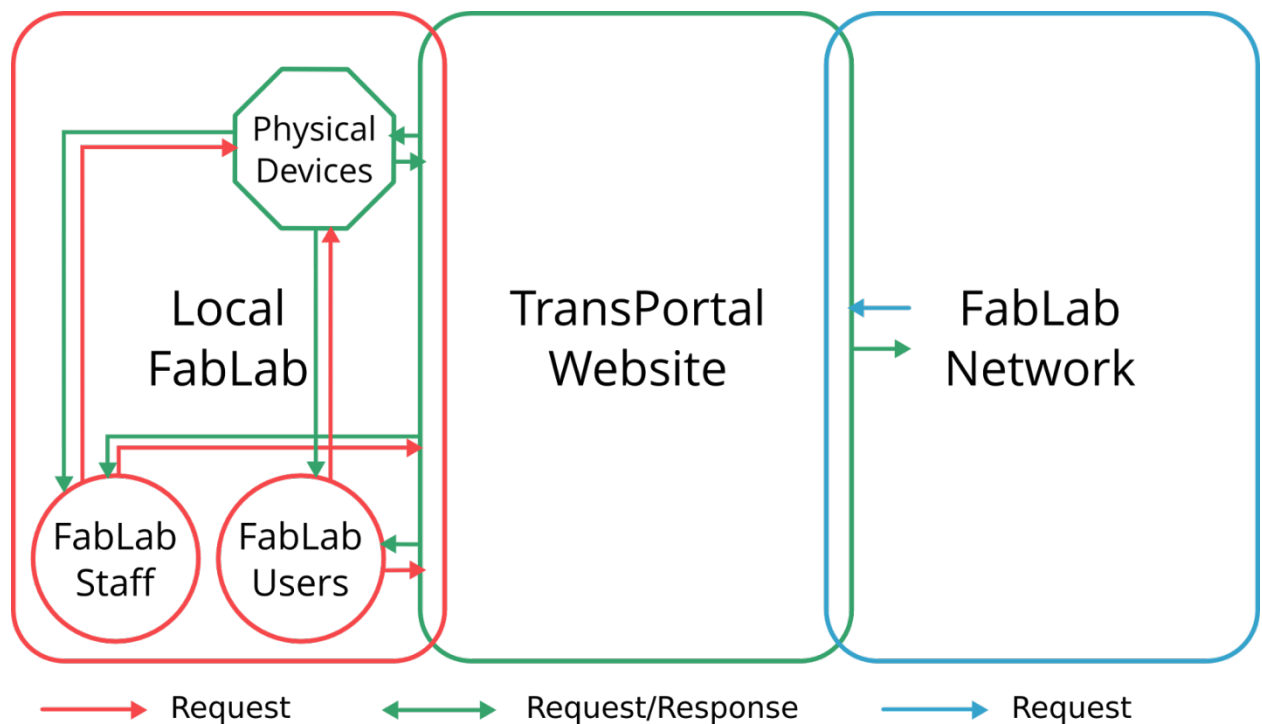
The TransPortal system consists of a website and a physical device which is able to communicate with the website through a wireless internet connection. The website is stored on a local server of the University of Bremen and is accessible through a web browser. Simply put, it works according to the request-response principle in the context of client/server-communication.[20] The local FabLab Staff as well as the local FabLab Users have their own user accounts within the website through which they can request and manage their data. Only the FabLab staff has admin rights though. The content created and shared by the local FabLab Staff and the local FabLab Users can be accessed by the global FabLab network as well as by everyone else with access to the internet simply by

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[20]

http://code.tutsplus.com/tutorials/http-the-protocol-every-web-developer-must-know-part-1--net-31177

browsing the website. Yet the user accounts are only provided for the local FabLab Staff and the local FabLab Users in order to prevent or at least minimize malicious use of user accounts. In this context the introduction of an "Open FabLab Network ID" is conceivable but that goes beyond the constraints of this project and therefore it won't be elaborated further. The physical device is named "sign on/off device" by the TransPortal project team. It is supposed to function as a standalone device which registers the FabLab users entering and leaving the FabLab by scanning customized member IDs of the FabLab users. The sign on/off deviceis the first in a range of possible physical standalone devices which are built in the FabLab Bremen with the purpose of improving the daily organisation of FabLabs and the communication with their users. An idea for future projects might be for example a physical standalone device which grants the user´s access to the different FabLab tools according to whether he or she had an introduction into the handling of the specific tool.

In the following two sections the concepts of both the website and the sign on/off device will be elucidated in more detail independently of each other.

4.2 Website

4.2.1 Idea and Requirements

As discussed earlier in the previous chapters, our work on the website is an extension of the existing Fablab website. We set out first to determine the main audiences that this site will serve. And after our survey and literature reviews, we have come up with three main targets:

1) Registered Bremen Fablab users,
2) Bremen Fablab administrator
3) Interested web surfers.

With these targets in mind we discussed what functionalities each target will have.
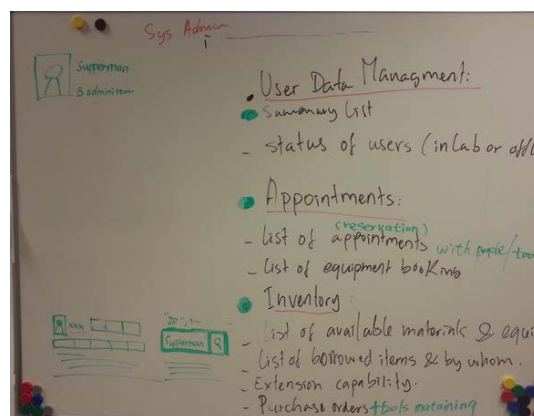
Figure 15: Early feature concept for System Administrator

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The main features available to all three targets are available as following:

1. Registered Fablab users (registered users):
   - Create and upload documents of their projects and choose to publicize or privatize the files.
   - Create appointments with lab staff.
   - Book lab equipments.
   - Borrow lab equipments.
   - View their inventory list including borrowed items and appointments.
   - View their usage data and export it to pdf file format.
   - View and comments on public project of other users.
   - Reply to comments on their projects.

2. Fablab Administrator:
   - Create and manage users of Fablab.
   - Create and manage inventory list of Fablab.
   - Manage appointments by lab users.
   - Create and manage calendar events.
   - Send and receive emails.
   - View and access data on lab usage.

3. Interested web surfers (not registered users):
   - View public project of registered users without any registration.
   - Interact with users' posts (e.g. Favorite, comment .etc)
   - Download public project files.

4.2.2 Design Method: User Centered Design

Design Method: User Centered Design
User Centered Design (UCD) is a design philosophy that the end users of a product, users' needs, wants, and experience should be put in the center of the design process. In User Centered Design, it requires the designer to analyze and have a better understanding of the needs, wants, and limitations of end users and then makes design choices that incorporate this understanding(Pratt & Nunes, 2012).

In Norman's point of view, "the purpose of the system is to serve the user, [...] .The needs of the users should dominate the design of the interface, and the needs of the interface should dominate the design of the rest of the system." (Norman, 1986, p.61). During design process, UCD method requires designers

always to keep what users' goals in mind and foresee how users would use the products. Also, a series of user tests will be carried out to gain feedbacks and see what usability problems may cause difficulties to users. In this way, it improves the design to fulfill users' needs, instead of forcing users to change their behavior to use the products.

Personas

According to Alan Cooper's goal directed design process, in User Centered Design, personas are fictitious and specific concrete characters which are created to represent the goals and behavior of a hypothesized group of users (Cooper, 1999). It is a useful tool to define target users based on a series of credible data for further product design.

During User Centered Design process, personas will be created based on the research data and involved with main stakeholder user group in the process. Generally, personas' profile description includes goals, life experience, behaviors attitudes, skills and motivations. With these fictional personal details, it makes realistic characters. During the development of the product, usually more than one person will be created. These personas present the target users but one of them should be the main focus for design based on their priority of person features. Therefore, during the design process, there would be persona 1, persona 2, persona 3 or more to help define the product (Cooper, 1999).

Based on the user research data analysis which had been done and discussed in previous sections, three main personas for TransPortal website are created, which are Sheldon, Howard and Amy. They present three major target users of TransPortal website: registered user, system admin and visitor (non-registered).

Profiles of the three Personas: Sheldon, Howard and Amy

Sheldon: TransPortal Registered User

- Name: Sheldon

- Age: 26 years old

-Occupation: Student at University Bremen

- Hobbies: DIY, reading, playing games, drawing

Figure 16: Sheldon photo

Experience with web surfing and FabLab:

Sheldon is currently taking a course called "FabLab: How to make almost anything" project that needs to use FabLab tools. Sometimes when he comes to the university FabLab and wants to use 3D printer, but find out that machine was used by somebody else. Therefore, he needs to wait quite long time for his turn.

He hopes the FabLab can provide a FabLab tool schedule so that he can make reservations of 3D printer with FabLab manager. He also has the need to document his project work and also want to know how other people work on their FabLab projects and wishes to share and connect with similar-minded people.

Howard: System Administrator

- Name: Howard

- Age: 31 years old

- Occupation: Student with part time job as FabLab assistant

- Hobbies: Singing, football, gym, DIY projects

Experience with web surfing and FabLab:

Howard used to work as assistance in a library in which he had to deal with certain book-recording system. Now he is working in Bremen FabLab and finds it difficult to manage the lab because the number of FabLab users and new inventory tools now is growing. He needs a better system to keep track of the equipments and user information.

Amy: website visitor

- Name: Amy
- Age: 22 years old
- Occupation: first year student at Bremen University
- Hobbies: Swimming, shopping, cooking, DIY projects

Experience with web surfing:
Amy is a well-connected individual with frequent accesses to website and social media networks like Facebook and Twitter. She likes to browse through some design-related websites in her free time to get inspirations. She has friends who work with Fab Lab, she is curious and what to know what the lab is all about. She may find some inspirations from other people's projects for her work.
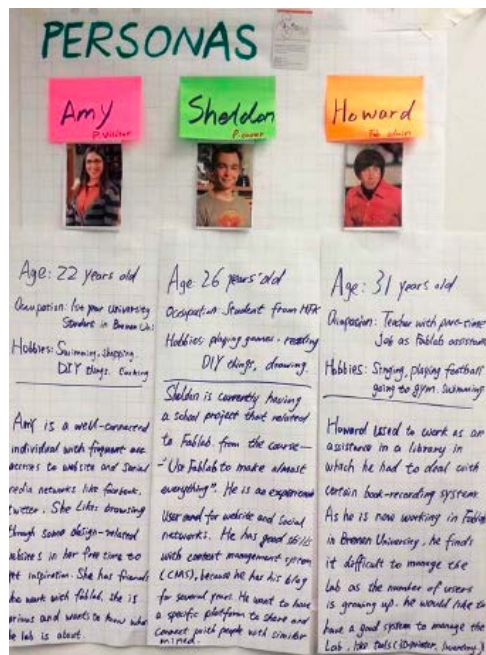
Figure 19: Persons Board in Project Room

By creating personas for the TransPortal FabLab website, it helps us emphasizes communicating the design and its rationale among designers and users. As Cooper said: "It's easy to explain and justify design decisions when they're based on personas' goals…" (Cooper, 1999). In Fig. 19, it shows the Personas board in our project room which help us understand the target users and foresee its way of interacting with our website.

Iterative Design of the User Interface

Redesigning user interfaces based on the user testing can help improve the usability. Iterative design is a design methodology based on a cyclic process consisting of creating paper or computer prototypes, testing the prototypes, and then making changes based on the test results (Nielsen, 1993). It allows designers to realize usability problems during the design process before products are widely used. "Even the best usability experts cannot design perfect user interfaces in a single attempt, so a usability engineering lifecycle should be built around the concept of iteration" (Nielsen, 1993, para.2). The design will change in every iterative with improvements in specific interface elements which caused user difficulties in previous design versions.

In Jakob Nielsen's essay Iterative User Interface Design (Nielsen, 1993), according to his case studies result, iterating through at least three version of the interface is recommended, since some usability problems may decrease in some versions if a redesign has focused on improving other parameters. Fig. 20 shows the relation between design iterations and interface usability.

35
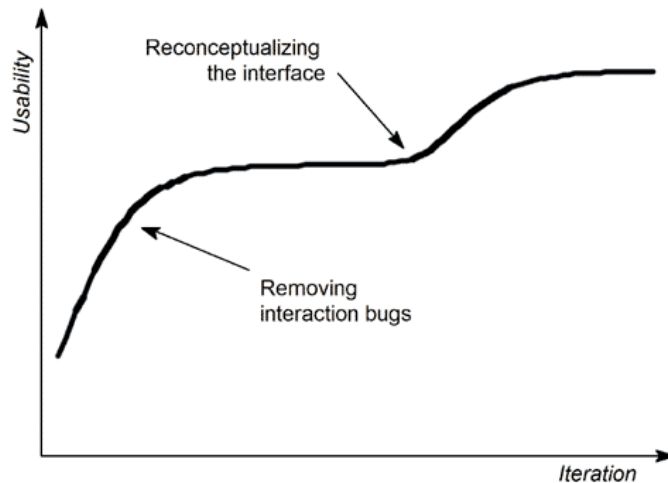
Figure 20: Interface quality as a function of the number of design iterations: Measured usability will normally go up for every additional iteration, until the design potentially reaches a point where it plateaus (Nielsen, 1993).

The design process of TransPortal website for Bremen FabLab is designed according to iterative design methodology.

Based on the user research data, a series of paper sketches were drawn at the early beginning (see Fig. 21).
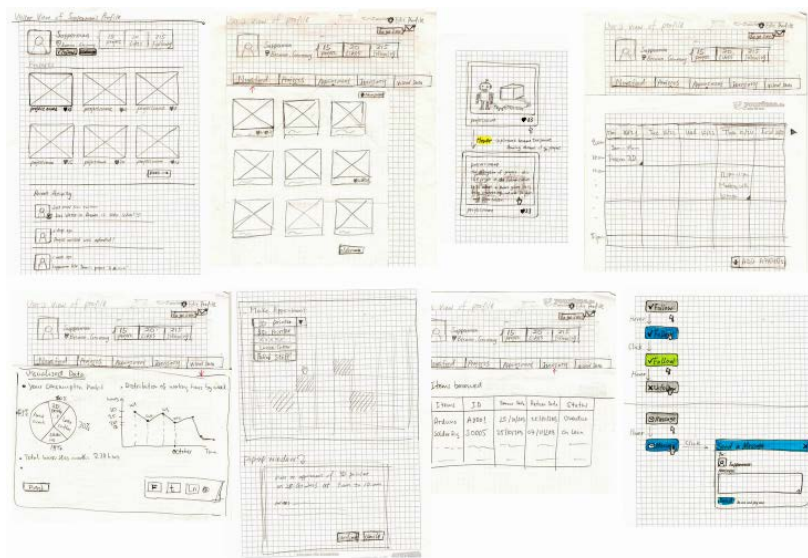
Figure 21: Paper Sketches of TransPortal Website

After the first paper prototype was evaluated and discussed by group, brief feedback and usability issues were collected and improved in the next version of prototype. Below shows the main feedbacks:
1. Newsfeed on user dashboard page should be classified with keywords.

2. User's appointments and tool reservation should be shown in "Coming Events".
3. When users successfully upload a project, feedback should be shown.
4. "Ok" (left) and "Cancel"(right) button positions should maintain as the same in different pages.
5. In Inventory page, borrowed items information should be summarized and shown to user, especially the "overdue" ones should be highlighted.

In order to get more specific feedback from users, we use Axure[21], an interactive website prototype creating software, to design different website pages with improvements based on the group feedback and prepare them for a usability test interview based on the previous paper sketch prototype version.

Here in Fig. 22 shows the interactive website prototype we designed by using Axure:
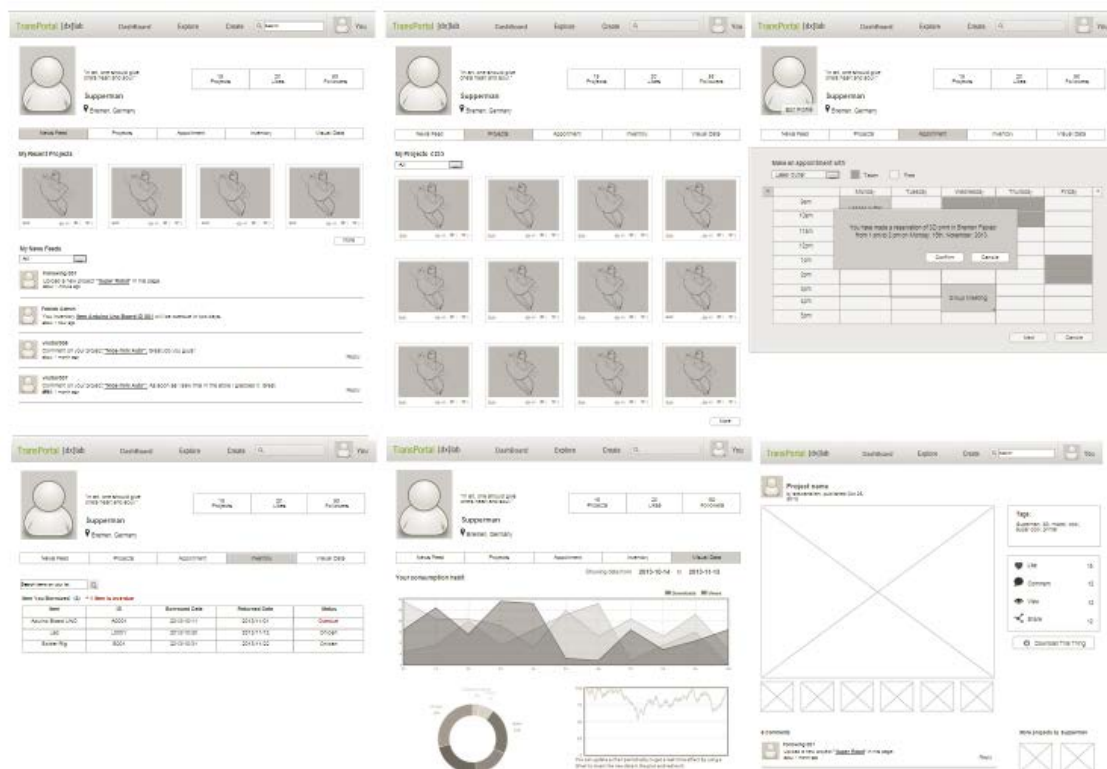
Figure 22: Interactive prototype

Usability Test on 13rd, November

Five Participants' (User A, User B, User C, User D and User E) feedbacks on different features are summarized below:

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21 http://www.axure.com/

Homepage:
1. For the top right login menu, the interaction should be "hover" and then shows drop down menu.

Project page:
1. It should show the project status: in progress, recently, most like and etc.
2. Clarifying "Like" in the view of profile owner and visitors, e.g.: The number of "likes", when cursor hover on it, it should show the list of users who like the project. The button (heart-shape button) should be clickable for user to like the project.

Newsfeed page:
1. Dividing newsfeed according to priority.
2. Newsfeed should be distinguished by some tags, e.g.: a comment icon on the right bottom shows it is the comment news.

Appointment page:

1. " 👁 " uses the eye symbol instead of triangle to show in the appointment table to indicate the more information of view detailed information. (Interaction should be "hover" and then show detailed information; click and then edit appointment).

2. Highlight the current day on calendar.

3. Extend time period of appointment in calendar(e.g: google calendar) (interaction: drag to select more)

4. Different colors for different types of appointments, make it distinguish from others. (Review of Google Calendar)

Inventory page:
1. Important message should be show in a better way, for example, pop up windows when user login to their page.

Project overview page:
1. "Edit" button would be better shows in project page, not in the thumbnail of projects.
2. Add "add project" in the project overview page.

Figure 23: User Test of TransPortal FabLab Website

With the feedback we got from user test and analysis result, we redesign the website. Fig. 24 shows the 3rd version of TransPortal Website design.
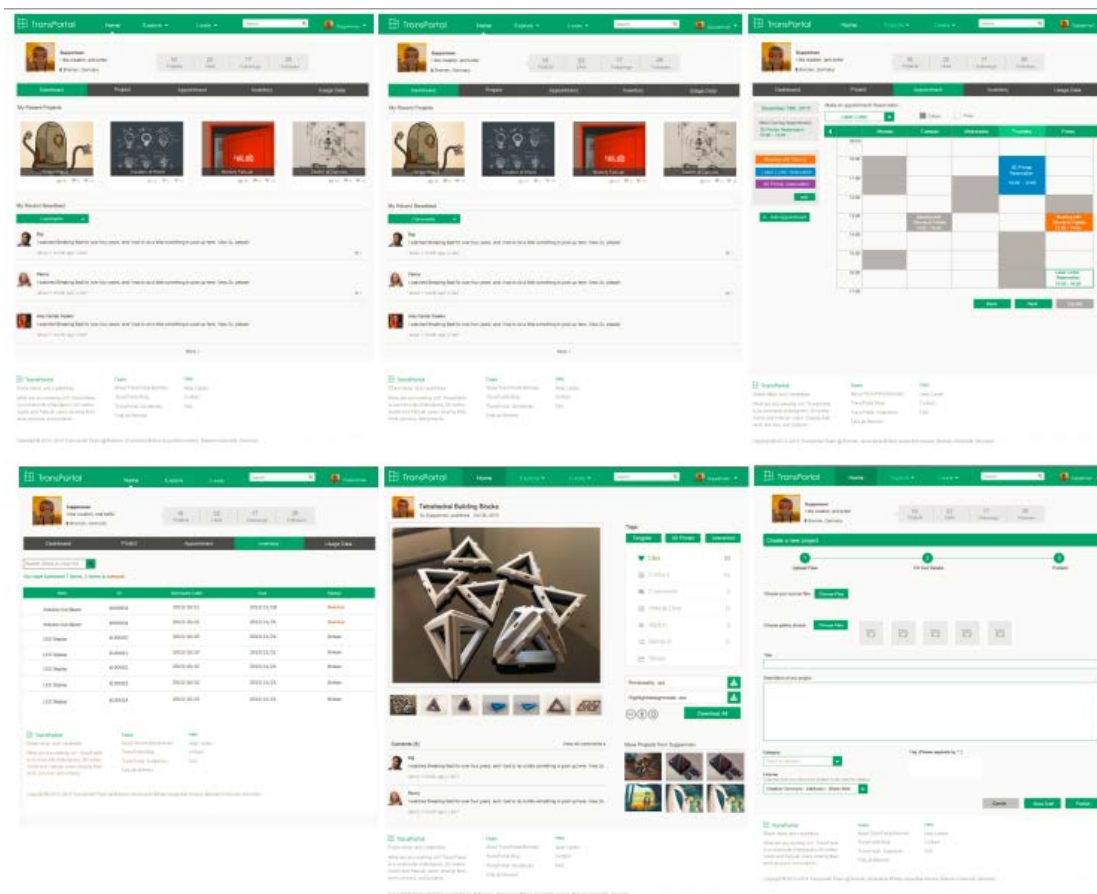
Figure 24 : Overview of Design of TransPortal Website

As Nielsen recommended, iterating through at least three versions of interface is recommended. This 3rd version of TransPortal website is "usable" enough for further functional development.

4.2.3 TransPortal FabLab Website Logo

Most Bremen people are very proud of their local football team - Werder Bremen. The enthusiastic from Werder Bremen and city visitors in local Werder Bremen souvenir shops are very impressed by one colour, which is the main symbol colour from the football team - green, a colour full of vitality. The passion need to be passed on to people. It is used as the main theme colour of local Bremen Fab Lab website. Fig.25 shows the logos of Werder Bremen and TransPortal Website. Both of them use green and white color.

Figure 25: Werder Bremen Logo(left) Logo of TransPortal FabLab Website(right)

What we want to convey via logo

"Ideas worth spreading", is the slogan of TED which a nonprofit devoted in areas of Technology, Entertainment and Design. The Bremen Fab Lab also has the same insight into it.

FabLabs give people new perspectives on creating and realizing their ideas in mind. The great invention of 3D printer, laser cutter and other tools which are not easily available in the past and mostly only serve the purpose for industry mass productions, now become part of the facilities of FabLabs. The design of FabLab tools have simple user interface to operate and the shape design as cube. As you can see in Fig. 26, the cube firstly looks like FabLab room and the cube shape machine in FabLabs, like 3D Printer, laser cutter and etc. Moreover, the logo structure is performed from the molecule perspective constructing by atoms, the "Tangible Bits"[22]. The dots (atoms) on vertex represent: different FabLabs from different places around the world and people who have creative mind and passions are connected to each other via sharing ideas and creativity. The frontal plane of the cube is taken as a simplified style with original perspective (Fig. 26).

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[22] http://tangible.media.mit.edu/project/tangible-bits/

The power of ideas and sharing connects us, inspires us to be a good and curious thinker and what is more important would be that we can make it by using FabLab tools and technology. A city of vitality and creativity encouragement will bring more new thoughts of collision. And that would be the point we want people have in mind when they see the logo.

4.2.4 Design Principle: Flat User Interface Design

Flat User Interface Design is a minimalist aesthetic principle currently used in various Graphical User Interfaces. It emphasizes that user interface should be "flat" with the style of clean layouts, open space, solid color, and crisp edges (Luke, 2013).
In its essence, flat design has two objectives:

> 1. Embracing the limits of the screen and working within those parameters rather than trying to disguise them.
>
> 2. Using this newfound simplicity as a starting point for streamlining designs, and making websites faster and more functional.
>
> (Luke, 2013, para. 5)

Flat design can be easily understood by users with its minimalistic user interface instead of detailed illustrations. It simplifies the old complex skeuomorphism design style UI design so that users can focus on the information and finish their work tasks effectively. Currently Microsoft windows 8 Metro UI and Apple's mobile operating system IOS 7 are adopting this flat design, showing the promising future of this creditable flat user interface design style.

TransPortal Bremen FabLab website follows the Flat User Interface Design principle with the main theme color of vitality green. The website emphasizes more on the usability, that is, users can easily share their ideas and creative work

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via this platform. Therefore, clean, open space and clear layout flat user interface was designed for users' sake. Figure 27 shows the overview part of TransPortal FabLab website UI elements.
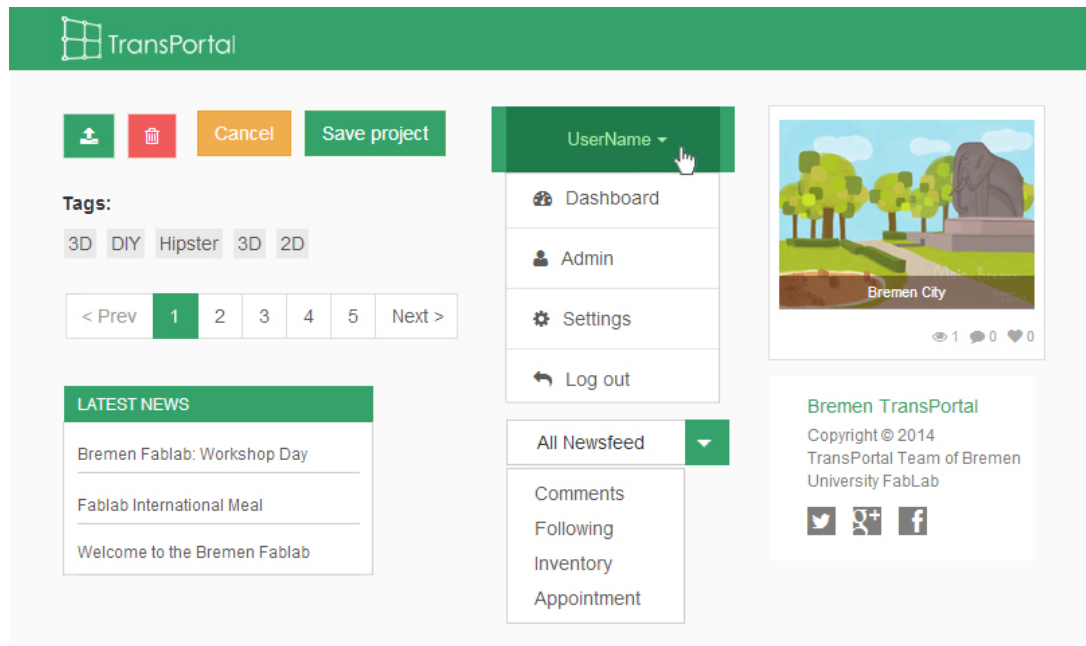
Figure 27: Overview of Flat User Interface Elements of TransPortal Bremen FabLab Website
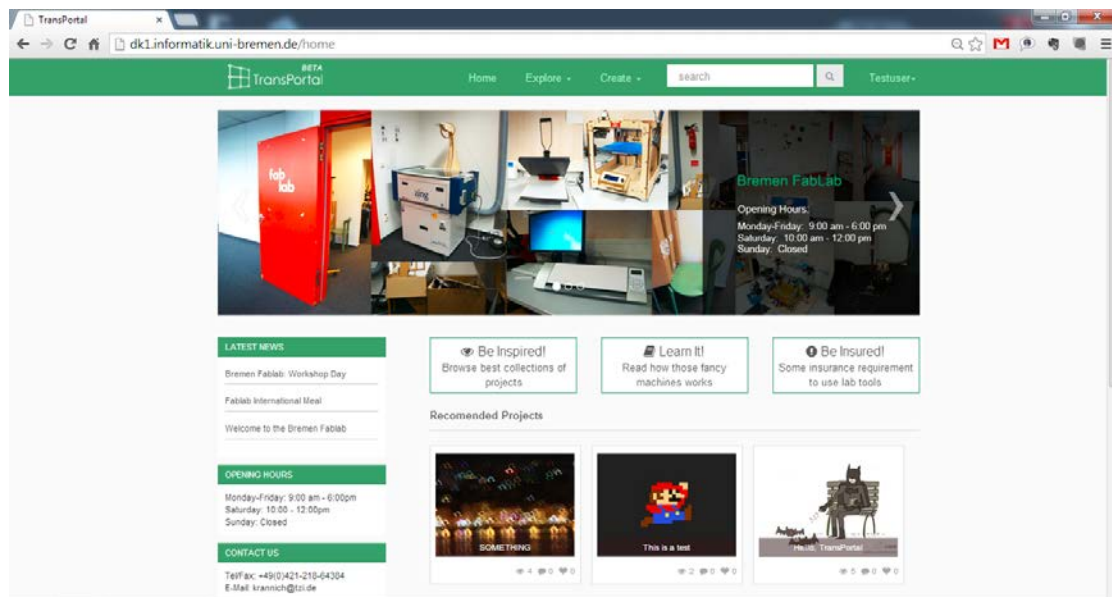
Figure 28:Snapshot of TransPortal FabLab Website Home Page

Figure 28 shows the home page of TransPortal FabLab website. The Clear information structure and layout of the user interface makes user easily use the website.

4.3   The sign on/off device

4.3.1 Idea

The basic intended idea of the sign on/off device is to be a haptic counterpart of today´s common log in/out processes when using web applications like for example facebook, twitter, google plus, youtube, flickr...etc. Instead of clicking a virtual Button to enter or to exit a personal account or profile within a certain web application the FabLab user will be encouraged to push a haptic "Enter-Button" or "Esc-Button" located on the sign on/off device according to whether he or she wants to enter or exit the FabLab. The sign on/off device will work in combination with a FabLab member ID which will contain the username of a FabLab user in the form of an QR code. The member ID is supposed to be designed and customized by the FabLab user with the help of the digital fabrication tools in the FabLab, e.g.: laser cutter, vinyl plotter, 3D-printer...etc. In doing so the new FabLab users will get to know the handling of the the digital fabrication tools. Hence the designing and customizing of the FabLab member ID could be used by the FabLab staff as an introductory workshop for the handling of the the digital fabrication tools. The entering or exiting process of the sign on/off device is not planned to be a replacement for logging in or out into the particular user account within the TransPortal website. Due to safety reasons that will still be executed on the TransPortal website by entering the username and the password. Yet the the sign on/off device will be connected to the TransPortal website so that the entering and exiting times can be stored on the local server which is hosting the TransPortal website. According to whether the user agrees with it or not the data of the entering and exiting times can be used in further applications within the TransPortal website such as displaying the status of a FabLab user on the homepage of the TransPortal website so that other users can see who is present at the FabLab in the moment, just to mention one possibility.

The main purpose of the sign on/off device though will be to slow down the FabLab users before they enter or exit the FabLab. In doing so the FabLab user gets a short moment to realize that he or she is entering or exiting a communal workshop where - unlike in a service company -   each user has responsibilities according to the Fab Charter (see section 1.1 and 2.1) Therein the TransPortal project team sees an indirect way to communicate with the FabLab users and to increase their awareness of supporting the FabLab staff in maintaining the FabLab and in sharing their works and knowledge with the local FabLab and therewith the entire FabLab network. Another potential that comes with the sign on/off device is the strengthening of the identification with the local FabLab on the side of the FabLab users. Through the possession of a FabLab member ID - especially self-designed IDs - the FabLab users might feel more connected to the local FabLab. That on the other hand might also increase the will of the FabLab

users to support the FabLab staff in maintaining the FabLab and in sharing their works and knowledge with the local FabLab and therewith the entire FabLab network. To stress these purposes, the TransPortal project team named the device "the sign on/off device" while "to sign on" also means to commit oneself to an undertaking and "to sign off" is to conclude an activity.   (Oxford Dictionaries, 2014)

Figure 29 shows the first draft of the functionality of the sign on/off device.
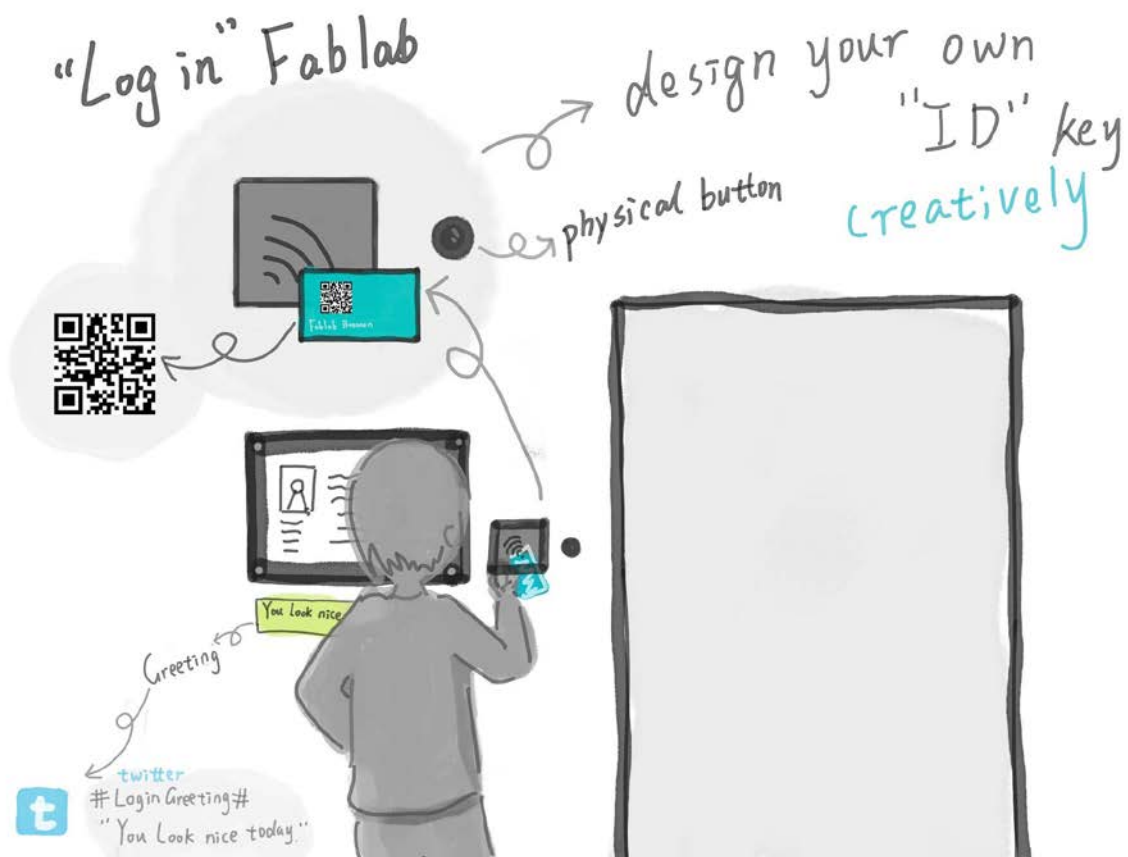
Figure 29: first draft of the functionality of the the sign on/off device

4.3.2 Requirements

Figure 30 shows the eight basic requirements for the sign on/off device

1. Camera to scan the QR codes

The sign on/off device needs a camera unit in order to capture the QR codes from the member IDs. It should also be able to communicate with the microcontroller.

2. Power supply

It needs to be ensured that all the electronic components of the sign on/off device are supplied with enough power.

3. Microcontroller

The sign on/off device demands a microcontroller which is capable of processing all the data and provides all the interfaces needed to connect the camera unit, the ESC-/ENTER-Button and the adapter for the wireless internet connection.

4. Wireless internet connection

In order for the sign on/off device to be able to request the TransPortal website it needs to contain a stable adapter for the wireless internet connection. The internet connection should be preferable wireless to avoid as many cables as

possible since cables might diminish the flexibility and the compactness of the sign on/off device.

5. ESC & ENTER button

The sign on/off device requires two buttons, one ESC-Button and one ENTER-Button. By pushing the ENTER-Button the FabLab users "sign on" to the FabLab and by pushing the ESC-Button the FabLab users "sign off" the FabLab.

6. Case & wall mounting

The sign on/off device needs a case which is on the one hand as compact and light as possible and on the other hand provides enough room to house all its single components. Since the sign on/off device is supposed to hang on the wall close to the FabLab Bremen entrance it should also contain a mechanism which makes it possible to hang it up the wall.

7. Feedback system

The sign on/off device demands some kind of a feedback system to signalize the entering or leaving FabLab users that the "sign on" or the "sign off" process was successful.

8. Low- Budget/Tech

The components of the sign on/off device should be affordable and easy to use to make sure that as many people as possible are able to build their own sign on/off device. Yet the components should be reliable and of good quality to grant that the sign on/off device is working properly.

4.3.3 Design

The design concept for the sign on/off device derives from its basic intended idea of being a haptic counterpart of log in/out processes within common web applications as well as from its main purpose of slowing down the FabLab users before they enter or exit the FabLab (see section 4.3.1). Therefore the TransPortal project team decided, on the one hand, to keep the interaction design of the sign on/off device to a minimum to ensure no distraction, and on the other, to give the case of the sign on/off device an uncommon design so that it arouses the attention of the FabLab user as an eyecatcher. In this context figure 31 shows an example of a common design for a registration kiosk as a comparable device to the sign on/off device. Furthermore the TransPortal project team aimed to represent the idea of personal fabrication - one of the basic ideas of FabLab (see section 2.1) - through the mixed use of digital fabrication tools, classic tools and DIY materials. Another aspect of the design

concept was to provide the sign on/off device with a cultural identity through incorporating a cultural cliché of a typical German device into the design.

Figure 31: common design for a registration kiosk; source[23]

With that said the first design idea of the sign on/off device was to build a cuckoo clock with an "IN" and an "OUT" button and replacing the cuckoo with a motor-driven webcam to scan QR codes. Figure 32 shows the first sketch of this design idea.
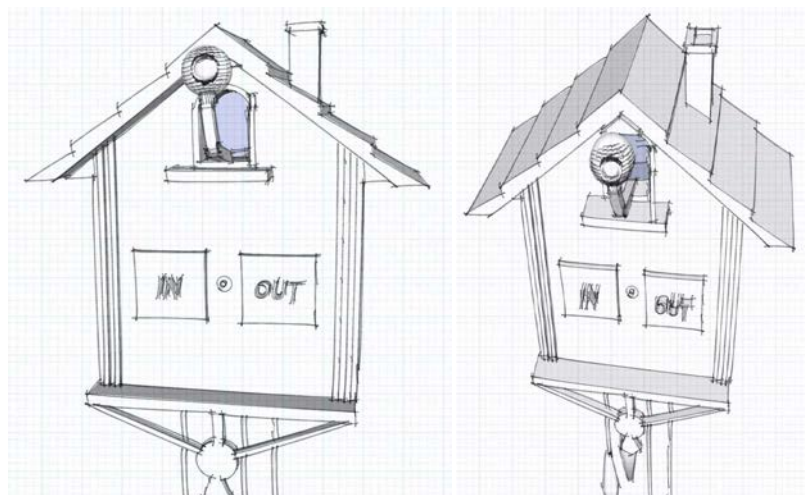
Figure 32: first sketch of the sign on/off device designed in Google SketchUp[24]

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[23] http://www.pixeltiming.com/software_/advancedKiosk

On second thought the idea of building a whole cuckoo clock as the case for the sign on/off device appeared too clichéd to the TransPortal project team. Therefore the first design idea was modified a bit. Instead of building a whole cuckoo clock the TransPortal project team decided to create a case in the form of an octagon referring to a "Stop" traffic sign. This on the other hand is supposed to support the main purpose of slowing down the FabLab users before they enter or exit the FabLab more distinctly (see section 4.3.1). Figure 33 shows a diagram of the second and final Design idea. Additionally the "IN" and an "OUT" button were changed to an "ENTER" and an "ESC" button in order to stress the correlation between the "sign on/off" process of the TransPortal device and the log in/out processes within web applications.

Figure 33: Diagram of the second and final Design idea; sources[25] [26]

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[24] http://www.sketchup.com/de/products/sketchup-pro

[25] Source for the cuckoo clock photo: http://www.fitsmybudget.com/

[26] Source for the webcam photo: http://www.7dayshop.com/

5. IMPLEMENTATION

5.1 Website

5.1.1 Technologies

a. Overview

We develop the web page using Laravel 4[27], which is a PHP 5.3 framework. In addition to that, we are using Bootstrap 3[28], which provides us with out of the box designs and helps us develop the front-end part rapidly. Along with Bootstrap 3 come CSS3 bundles, however we are also writing our own CSS3 code to match our design. For the storage and manipulation of data we use mySQL[29]. It is noteworthy at this point to mention the software we are making use of to write our code: Sublime Text Editor 2[30].

b. Laravel

Undoubtedly, Laravel is a versatile and dynamic framework. Laravel's architecture (part of it being the MVC or Model View Controller) can handle everything from web serving to database management right down to HTML generation. Taking into consideration the fact that our team was not familiar with web development, and only had basic knowledge of web-oriented programming languages (html, php, javascript, …, etc.), the framework provided a set and well-defined working environment. That was crucial for the project, since we had to get accustomed to the framework and learn the aforementioned programming languages, while implementing and realizing what we learn at the same time.

The main characteristics of Laravel, which also constitute parts of the reason we chose to learn and work with it are: Eloquent ORM, Blade Engine, Controller. Below we briefly attempt to explain and describe the roles of each.

Eloquent ORM:
Laravel has an Object Relational Mapper (ORM) called Eloquent. What is an ORM however? Simply put, we have two separate worlds: the object-world and the data-world. In the data-world, our data are expressed in terms of tables, which have rows and columns. On the other hand, in the object-world, the data are

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27 http://laravel.com/

28 http://getbootstrap.com

29 www.mysql.com

30 www.sublimetext.com

represented by objects. The above notion, in conjunction with the fact that PHP is an object-oriented programming language, provide a reasonable justification for any developer to use Eloquent ORM: It makes more sense to convert the data into objects, since we are describing the entities in our code as objects.

Blade Engine:

Blade is actually a templating engine that comes along with Laravel. More analytically, the naming convention, which is used to declare a "blade view" (alternatively a blade template) is rather simple: achieved by adding ".blade.php" as an extension to the name of the file. Furthermore, the syntax is more elegant than plain PHP. The example below demonstrates the difference in syntax, assuming we assign the string-value "Hello World!" to the variable $hello:

Blade syntax:

{{ $hello }}

PHP syntax:

<?php echo "Hello World!" ?>

The above samples of code produce the same result. However, the elegant and "low-profile" character of blade, makes coding considerably more comfortable - especially when dealing with hundreds of lines of code. Additionally, Blade prevents us from repeating unnecessary code. This is because it allows us to use "layouts", which can - in our case for example - carry the common look or "master" view across the different pages of our website.

Controller:

As the name suggests, a Controller is the brain of the framework. They are classes which manage the communication between models and views, and carry out tasks, such as: receiving input from the user, ..., etc.

Below we embed a set of figures and tables which describe the framework in more detail:
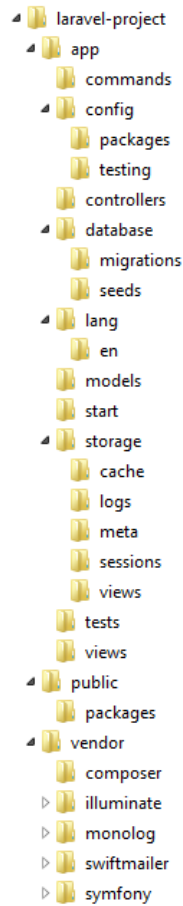
Top-level folders	Purpose
/app/	Contains the controllers, models, views and assets for your application. This is where the majority of the code for your application will live. You will be spending most of your time in this folder!
/public/	The only folder seen to the world as-is. This is the directory that you have to point your web server to. It contains the bootstrap file index.php which jump-starts the Laravel framework core. The public directory can also be used to hold any publicly accessible static assets such as CSS, Javascript files, images and other files.
/vendor/	A place for all third-party code. In a typical Laravel application, this includes the Laravel source code and its dependencies, and plugins containing additional prepackaged functionality.

Table 4: A rundown on the function of each of the files and folders[31]

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[31] http://laravelbook.com/laravel-architecture/

For the implementation of our website we require specific functionalities. These come from sets of scripts and bundles which are available to us through Laravel.

Name	Description
Validator	The Validation class is a convenient facility for validating data and retrieving validation error messages.
Sentry 2	User authorization and authentication package. It provides features such as groups, permissions, custom hashing algorithms and additional security features.
Migrations & Seeding (Artisan)	A sort of version control for our database.

Table 5: Components and bunldes of Laravel 4 and their tasks[32]

c. Bootstrap

As we mentioned in the introduction of this section, Bootstrap 3 is a handy tool when it comes to front-end development. In conjunction with Laravel 4, we are using Bootstrap's bundles.

More specifically, Bootstrap 3 is an html, css, javascript framework, which we are using mostly for the creation of buttons, table layouts, navigation bars and options. On the table below we list the bundles from Bootstrap 3 which we are making use of:

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[32]   http://laravelbook.com/laravel-architecture/

Name	Description
Paginator	Provides for pagination links for our website.
Button groups (e.g. Success)	Includes buttons with predetermined style and color.
Navbar	These are responsive meta components that serve as navigation headers for our website.
Glyphicons	Includes a pool of 200 pre-made icons.
Dropdown Menu	Toggleable, contextual menu for displaying lists of links.
Alerts	Includes alerts which provide contextual feedback messages for typical user actions.

Table 6: Basic components of Bootstrap 3 and their tasks[33]

The handling of e-mails (i.e. user's account confirmation link sent to his e-mail address) is done using Google's SMTP (Simple Mail Transfer Protocol).

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[33] http://getbootstrap.com/components/

d. Database Structure

```
groups
    Field          Type               Extra
P   id             int(10) UNSIGNED   Auto Increment
    name           varchar(255)
    permissions    text               Allow Null
    created_at     timestamp
    updated_at     timestamp

    Index                Fields    Extra
    groups_name_unique   name      Unique
```

```
items
    Field          Type           Extra
P   id             bigint(20)     Auto Increment
    name           varchar(255)
    quantity       bigint(20)
    status         tinyint(4)
    category       tinyint(4)
    image          text
    updated_at     datetime
    created_at     datetime
```

```
itemsusers
    Field          Type           Extra
P   id             bigint(20)     Auto Increment
    item_id        int(11)
    user_id        int(11)
    due_at         date
    quantity       int(11)
    borrowed_at    date
    updated_at     datetime
    created_at     datetime
```

```
migrations
    Field          Type           Extra
    migration      varchar(255)
    batch          int(11)
```

```
projects
    Field          Type           Extra
P   id             bigint(20)     Auto Increment
    user_id        bigint(20)
    title          varchar(255)
    content        longtext
    files          text
    docs           text
    docnames       text
    created_at     datetime
    updated_at     datetime
    favorite       bigint(20)
    views          bigint(20)
    comment_count  bigint(20)
```

1

Figure 35: Database structure- part 1

```
throttle
    Field               Type                Extra
P   id                  int(10) UNSIGNED    Auto Increment
    user_id             int(10) UNSIGNED
    ip_address          varchar(255)        Allow Null
    attempts            int(11)
    suspended           tinyint(4)
    banned              tinyint(4)
    last_attempt_at     timestamp           Allow Null
    suspended_at        timestamp           Allow Null
    banned_at           timestamp           Allow Null


tutorials
    Field           Type            Extra
P   id              bigint(20)      Auto Increment
    user_id         bigint(20)
    title           varchar(255)
    description     text
    content         longtext
    created_at      datetime
    updated_at      datetime


users
    Field                   Type                Extra
P   id                      int(10) UNSIGNED    Auto Increment
    Role                    tinyint(1)
    username                varchar(255)
    email                   varchar(255)
    password                varchar(255)
    permissions             text                Allow Null
    activated               tinyint(4)
    activation_code         varchar(255)        Allow Null
    activated_at            varchar(255)        Allow Null
    last_login              varchar(255)        Allow Null
    incognito               tinyint(1)
    inlab                   tinyint(4)
    enteredlab_at           datetime
    leftlab_at              datetime
    persist_code            varchar(255)        Allow Null
    reset_password_code     varchar(255)        Allow Null
    title                   varchar(20)         Allow Null
    first_name              varchar(255)        Allow Null
    last_name               varchar(255)        Allow Null
    company                 varchar(255)
    street                  varchar(255)        Allow Null
    zipcode                 varchar(50)         Allow Null
    city                    varchar(255)        Allow Null
    QRkey                   varchar(255)
    created_at              timestamp
    profile_pic             text
    updated_at              timestamp
    description             longtext

    Index                   Fields      Extra
    users_email_unique      email       Unique


users_groups
    Field       Type                Extra
P   id          int(10) UNSIGNED    Auto Increment
    user_id     int(10) UNSIGNED
    group_id    int(10) UNSIGNED
```

2

Figure 36: Database structure- part 2

Both snapshots above depict the current state of TransPortal's database structure. Below we provide a brief analysis of that structure, in terms of design

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and entity relationship. We start by providing a short explanation regarding each of the entities (tables) and most of their attributes. It is noteworthy that each table has a unique identifier for each instance of the entity, defined as "id", which contains an auto-incrementing value.

Groups:

Groups is an entity which holds two important attributes: *name* and *permissions*. This table serves a unique purpose of defining the type of membership a user has, which - thus far - can either be *admin* or *standard*.

Items:

This table is practically the inventory. The attributes defined here are: *name, quantity, status, category, image, updated_at, created_at.* The *name* is simply a string value which defines the name of the item. The *quantity* contains a numerical value, which describes the (remaining) amount of articles of the corresponding item. *Status* takes a binary value: "0" when no quantity is available for lending, and "1" when at least an article is available. Furthermore, *category* alternates between two numerical values: if the item is lendable outside the laboratory, then the value is "2", otherwise it is "1". Also, items can be accompanied by an image file. The path to the image's location on our server is stored in the *image* attribute. Lastly, *created_at* and *updated_at* contain date format values (format: YYYY-MM-DD HH:MM:SS), which stand for precisely what their name gives away: the time an instance of the entity (items) was created, and the later attribute tells us when the instance was updated.

Itemsusers:

Jokingly, the name of this table might indicate a lack of imagination, however this makes up for a pretty self-explanatory entity: lending-records. The *user_id* and *item_id* attributes defined here, correspond to the unique identifiers ("ids") from the *users* and *items* tables accordingly. In addition, we have *quantity* as an attribute to describe the amount of borrowed articles. Of course, we also define the date an item was borrowed (*borrowed_at*) and the date it is due (*due_at*).

Migrations:

According to Laravel's documentation[34], "Migrations are a type of version control for your database." (#Introduction). This is useful, when more than one developers are working on the same database. In our case, the database was the

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[34] http://laravel.com/docs/migrations

responsibility of mainly one member of the team. Therefore, the present table was not utilized. It remains there, however, since it came with Laravel's installation.

Projects:

Users can create projects. For the *project* entity we need, first and foremost, the user's id (*user_id*); the user who created the project. A project has a *title, content* (text)*,* and *files*. In this case, *files* contain the path to the images of the project. Images and the "rest of the files" (such as documents in the form of .pdf) are stored in separate folders on the server. Other files' paths (which files are not images), are stored in the *docs* attribute. *Docnames* contains the default name of those files within the *docs*. This might seem confusing, however we use this patent in order to display the name of the files on the page of the project. Since we encrypt the default name on the path in *docs* as a counter-measure to URL hacking. Furthermore, *favorite*, *views*, and *comment_count* contain numbers with which we can estimate the publicity of a project, similarly to facebook's "likes". Lastly we have our timestamps: *created_at* and *updated_at*.

Throttle:

Here we record the login attempts from the users (*user_id*) along with their *ip_addresses*. Admittedly, we do not utilize this table. However, it may provide somewhat useful information to the back-end administrator.

Tutorials:

In a similar fashion to *projects*, tutorials are created by users (*user_id*) with a *title*, *description* and *content*. Of course, we have the usual timestamps of *created_at* and *updated_at*

Users:

Users is the most important entity. It is characterized by many attributes, some of which can be pretty obvious: *username*, *email*, and *password.* These values make up for the heart of the user's account. Furthermore, the user submits a few mandatory and a few optional personal data: *title*, *first_name*, *last_name*, *company*, *street*, *zipcode* and *city*. Then comes the activation, in which case the user receives an email with an automatically generated *activation_code*. After his activation is successful, the *activated* attribute is "1" and the activation date is recorded (*activated_at*). In addition, we have *role,* which represents the type of membership of the user: "1" means that he is an admin, "2" makes him a standard member. The *permissions* attribute indicates if a user is authorized to use the 3D printer ({"3d_printer":1}), the laser cutter ({"lasercutter":1}), both

({"3d_printer":1; "lasercutter":1}) or none ({"3d_printer":0; "lasercutter":0}). Concerning his presence in the lab, this is indicated by *inlab*: if the value is "1" then he is present, otherwise he is not in the lab. The timestamps of the user's arrival and departure at/from the lab are recorded in *enteredlab_at* and *leftlab_at* accordingly. Additionally, the user can go "incognito", where - in terms of database - the attribute *incognito* with a value of "1" will make the user's "in lab" status invisible. Lastly, we store the user's QR key in the corresponding column (*QRkey*), the path of the image, which he has uploaded and used as profile picture, in *profile_pic,* and a short *description* (text) of his choice.

Users_groups:

In this table we store *user_id* and *group_id.* This is used to define the type of membership (as we described on part "Groups" above) a user has.

All in all, the current database structure has a considerable margin of further optimization: some redundancy is apparent within the tables, and probably some names can be changed to be more descriptive.

5.1.2   Specific features/functions

In this section we analyze the features and functions of TransPortal's web page.

a. User groups:

We have three different groups of users: Unregistered user/visitor (Amy), Registered user/profile owner (Sheldon) and Administrator (Howard). Naturally, each group has different rights when it comes to interacting with other users and their posts/messages.

b. Permissions:

Permissions constitute a way of controlling the usage of specific equipment in the laboratory (e.g. restricting people from using the laser cutter, unless they take the appropriate tutorial). Although permissions are just a value in a database at the moment, the ultimate goal is integrating a system to the machine (e.g. laser cutter), which will be connected to our database. Thus, the system, after scanning user's credentials, will determine if he can use it or not.

c. Admin Panel:

The section of the page, which can only be accessed by users who are authorized as "admins", contains five sections: dashboard, inventory, users, calendar, analytics. Dashboard contains an overview of the status of the inventory and users in the form of a progress bar. Additionally, there is a section which displays the users who are in the lab. Another section which is actually a placeholder,

concerns the history logs (recorded actions taken by admins). The inventory and users are actually pages where the admin is able to manage the items (also coordinate item-lending) and the user database. We expand on inventory, users, calendar, and analytics more in the tools section (f) which follows soon after.

d. Project/Tutorial Creation:

Registered users have the ability to create a project and publish it, along with the files (images or documents) of their choice. Additionally, they can create tutorials.

e. Project/Tutorial Browsing:

Any user is able to navigate to the project/tutorial exploration page on the website. From there he is able to browse through all available projects and tutorials. These are available to download if he wishes to do so.

f. Tools:

We define as tools the web applications "Calendar", "Inventory", and "Analytics" which are available to the profile owners and administrators of the website. Also, a definite tool is the page where the users can be managed, and is only available to administrators.

The Calendar is a web application, which is accessible through the "Appointment" option from the navigation bar. It works similarly to Google Calendar® in the sense of user experience and interaction: The user is able to scale the calendar from a single day to a month. Additional features include: Labels to drag and drop. Of course, there are some restrains concerning the rights of the user, the type of day (working day, Sunday, or holiday) and the actions of other users combined. Concerning the admin side, this has not been implemented yet.

The Inventory is a handy web application addressed to the profile owners and administrators of the website. Through the Inventory the user is able to see the availability of items and rent them if he wishes to do so. Most importantly he is able to track the items he has borrowed. For an administrator, the Inventory provides further functionality by allowing him to edit the items in terms of name, status and quantity. Additionally, he can manage the items which are lent to users and keep track of them.

Concerning the "Analytics" part, the idea is to connect specific charts on the page (e.g. visitors around the world, page views, …, etc.) with actual data from the Google Analytics Application [r]. TransPortal's website already has an account with Google there, and one can access the data by visiting the official site. Unfortunately, the integration with our website has yet to be achieved. Therefore this section is not yet available.

The "users" section is a page with a table, which draws data from the corresponding users table on the database. There, the user can see the most important data of each user and choose an action through these basic options: view, edit, delete, and block. The view option allows the administrator to view all the details of the user's account (except their password of course). By selecting edit, he is able to update those details. Furthermore, delete is an option which will literally delete the user from the database (account deletion). Block - although not functional yet - will deprive users from certain basic rights, such as posting comments, etc.

5.2 Sign on/off device

5.2.1 Hardware

According to the requirements of the sign on/off device (see section 4.3.2) the TransPortal project team decided for the following Hardware components:
- Raspberry Pi Model B[35]
- Micro-USB power adapter 5V/DC 1200mA for Raspberry Pi[36]
- Adafruit 16-Channel 12-bit PWM/Servo Driver - I2C interface - PCA9685[37]
- Power adapter VOLTCRAFT FTPS 5-18W 5 V/DC 3500 mA for Servo Driver[38]
- Logitech C270 USB HD Webcam[39]
- EDIMAX EW-7811UN Wireless USB Adapter, 150 Mbit/s, IEEE802.11b/g/n[40]
- Analog servo motor[41]
- 2 micro buttons[42]
- 6 RGB LEDs with common cathode, 5mm Water Clear 10000mcd[43]

Figure 37 shows how the Hardware components were installed in the case of the sign in/off device. Figure 38 on the other hand illustrates how the Hardware

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[35] http://www.raspberrypi.org/

[36] http://www.exp-tech.de/Zubehoer/Netzteil/Micro-USB-Netzteil-5V-DC-1200mA-fuer-Raspberry-Pi.html

[37] http://www.adafruit.com/products/815

[38] http://www.conrad.de/ce/de/product/514241/Tischnetzteil-Festspannung-VOLTCRAFT-FTPS-5-18W-5-VDC-3500-mA

[39] http://www.logitech.com/en-gb/product/hd-webcam-c270

[40] http://edimax-de.eu/de/produce_detail.php?pd_id=297&pl1_id=1&pl2_id=44

[41] http://www.pollin.de/shop/dt/MDI5OTcxOTk-/Fundgrube/Modellbau/Servomotor_analog.html

[42] http://www.pollin.de/shop/dt/NDY5OTc1OTk-/Bauelemente_Bauteile/Mechanische_Bauelemente/Schalter_Taster/Mikro_Eingabetaster.html

[43] http://www.impolux.de/extern/datasheet/led/LED%200870%20RGB%205mm%20klar%2010000mcd.pdf

components are connected. Beneath figure 38 the purposes of each component is described in seven points.
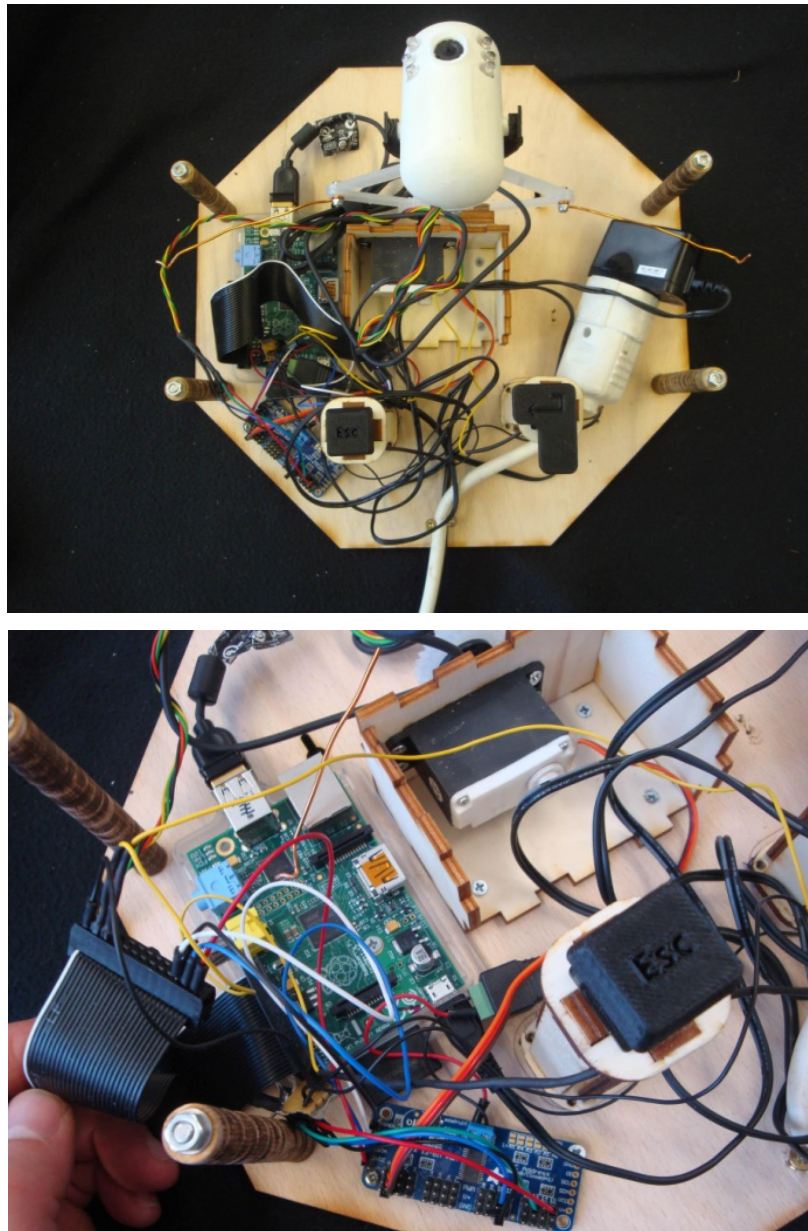
Figure 37: Installation of the Hardware components
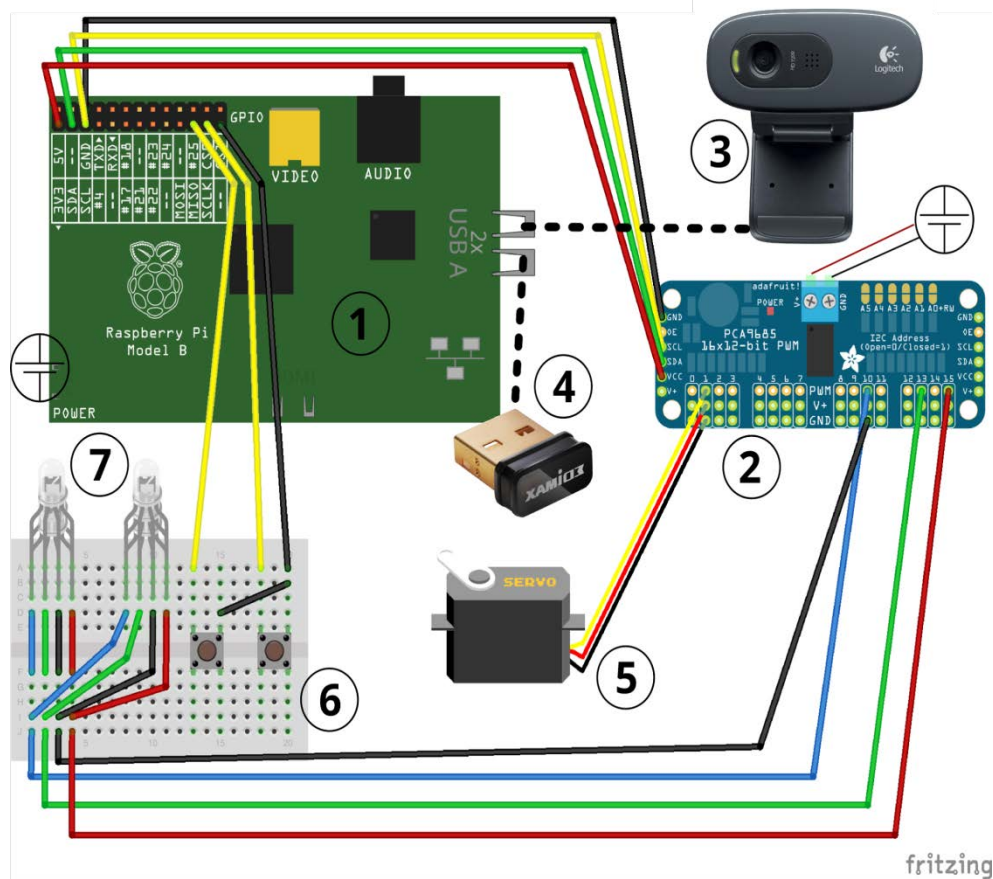
Figure 38: wiring plan of the Hardware components; sources[44] [45]

1. The Raspberry Pi Model B - "The Brain"

The TransPortal project team decided to use the Raspberry Pi Model B as the microcontroller respectively Single Board Computer for the sign on/off device since it is powerful enough to process all the incoming and outgoing data and it provides two USB interfaces to which the USB webcam and the USB wireless adapter can be connected. Furthermore it contains a "General purpose input/output" (GPIO)[46] interface through which the PWM/Servo Driver can be controlled and therewith the servo motor and the LEDs. Two other benefits of the Raspberry Pi Model B are that it is affordable and it is not as power consuming as for example an ordinary desktop personal computer would be since it is only powered by a 5V/DC 1200mA Micro-USB power adapter. (see beginning of section 5.2.1)

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[44] "Fritzing" is the software with which the wiring plan was created, source: http://fritzing.org/home/

[45] The photos of the webcam and the wireless USB adapter are taken from: http://www.amazon.de

[46] http://elinux.org/RPi_Low-level_peripherals

2. The Adafruit 16-Channel 12-bit PWM/Servo Driver - "The servo motor/LED controller"

The Adafruit 16-Channel 12-bit PWM/Servo Driver is a I2C interface[47] and therefore it can be connected to the GPIO interface of the Raspberry Pi Model B. Its purpose is to take care of the control of the servo motor and the RGB LEDs through pulse-width modulation(PWM).[48] It is powered through the 3.3V pin of the Raspberry Pi and it is also connected to a second external power adapter in order to provide a stable 5V power supply for the servo motor. The wiring of the two is as follows:

1. the VCC pin of the PWM/Servo Driver needs to be connected to the 3.3V pin of the GPIO interface of the Raspberry Pi Model B,

2. the SDA pin of the PWM/Servo Driver needs to be connected to the SDA pin of the GPIO interface of the Raspberry Pi Model B,

3. the SCL pin of the PWM/Servo Driver needs to be connected to the SCL pin of the GPIO interface of the Raspberry Pi Model B,

4. the Ground (GND) pin of the PWM/Servo Driver needs to be connected to the GND pin of the GPIO interface of the Raspberry Pi Model B. (see figure 38)

3. Logitech C270 USB HD Webcam - "QR code scanning unit"

The webcam is connected to one of the two USB interfaces of the Raspberry Pi Model B and takes care of the capturing of the QR codes from the FabLab member IDs. (see section 4.3.2) For the sign on/off device the webcam board was carefully taken out of its case and put into a customized case.[49](see section 5.2.3)

4. The EDIMAX EW-7811UN Wireless USB Adapter - "Wireless Internet connector"

The EDIMAX EW-7811UN Wireless USB Adapter is connected to the second USB interface of the Raspberry Pi Model B. It ensures a stable wireless connection to the internet so that URL requests to the TransPortal Website can be made. Furthermore it makes it possible to communicate with the Raspberry Pi Model B from a desktop personal computer within the same network via a SSH connection.[50]

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[47] http://www.nxp.com/documents/other/UM10204_v5.pdf

[48] http://fab.cba.mit.edu/classes/MIT/961.04/topics/pwm.pdf

[49] Tutorial about how to built the camera board out of its case:

http://hci.rwth-aachen.de/fabscancamera

[50] http://elinux.org/RPi_Remote_Access

5. Analog servo motor - "Driving force for the cuckoo"

The analog servo motor is connected to channel 1 of the PWM/Servo Driver. Its purpose is to realize the moving in/out mechanism for the webcam as replacement of the cuckoo in a classic cuckoo clock. The wiring is as follows:

- the GND wire of the servo motor is connected to the GND pin of the PWM/Servo Driver´s channel 1
- the 5V wire of the servo motor is connected to the V+ pin of the PWM/Servo Driver´s channel 1
- the signal wire of the servo motor is connected to the PWM pin of the PWM/Servo Driver´s channel 1.

(see figure 38)

6. Two micro buttons - "The ENTER- and ESC-Buttons"

The two micro buttons initiate the "ENTER" respectively the "ESC" process. The signal pin of the "ENTER" button is connected to the SPI MISO pin (GPIO 09)[51] of the GPIO interface and the signal pin of the "ESC" button is connected to the SPI SCLK pin (GPIO 11)[52] of the GPIO interface. The GND pin of each button is connected to a free GND pin of the GPIO interface. (see figure 38)

7. Six RGB LEDs - "The feedback system"

The six RGB LEDs represent the feedback system of the sign on/off device. They light up in blue, red or green according to the corresponding status of the "sign on/off" process. A more detailed description about the "color code" will be given in section 5.2.2. The LEDs are integrated into the case of the Webcam. (see section 5.2.3) There are two rows of three LEDs which are connected in series. The two rows though are connected in parallel so that only four wires need to be connected to the PWM/Servo Driver. (see figure 38) The wiring is as follows:

- the GND wire of the RGB LEDs is connected to the GND pin of the PWM/Servo Driver´s channel 10
- the red wire of the RGB LEDs is connected to the PWM pin of the PWM/Servo Driver´s channel 15
- the green wire of the RGB LEDs is connected to the PWM pin of the PWM/Servo Driver´s channel 13
- the blue wire of the RGB LEDs is connected to the PWM pin of the PWM/Servo Driver´s channel 10

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[51] WiringPi Library notation: https://projects.drogon.net/raspberry-pi/wiringpi/pins/

[52] WiringPi Library notation: https://projects.drogon.net/raspberry-pi/wiringpi/pins/

5.2.2 Software

For the software of the sign on/off device the TransPortal project team used the programming language "python"[53] within "Raspian"[54], the selected operating system for the Raspberry Pi Model B. Figure 39 shows the general procedure of the program through a flow chart.
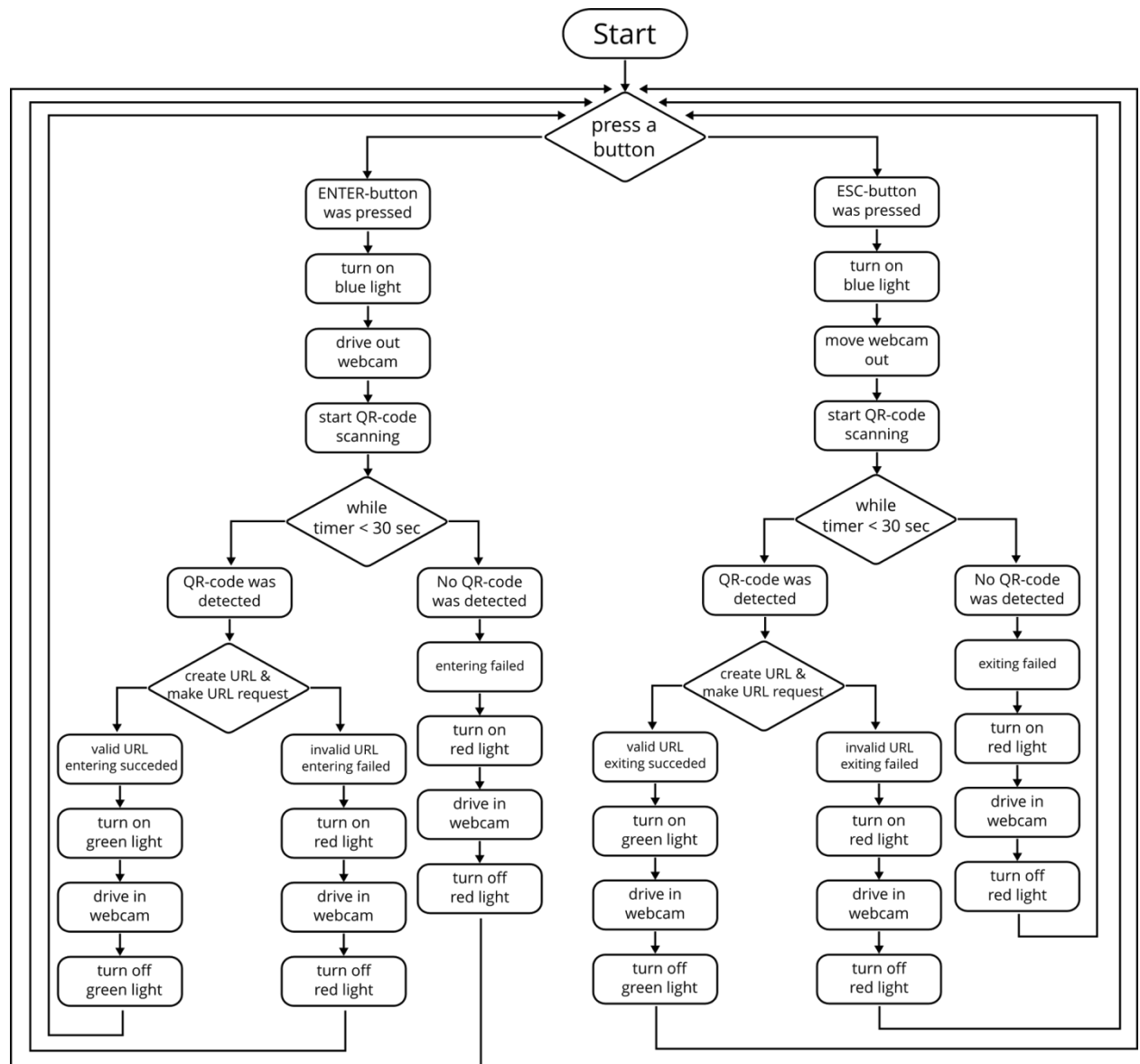
Figure 39: flow chart of the sign on/off program

In the following the python code of the "main" program as well as of the "QR codescanning" function will be described in more detail. The correlating python

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[53] https://www.python.org/

[54] http://www.raspbian.org/

code for the communication with the TransPortal website will be explained in section 5.3. The whole python code of the sign on/off device though can be found in the appendix E.

main5.py:

```python
1 #!/usr/bin/env python
2 #-*- coding: UTF-8 -*-
3 """
4 Main Program
5   @ Simon Engelbertz
6 """
7 import RPi.GPIO as GPIO
8 import time, gpiocall, qrcode, urlcallenter, urlcallesc, servos2
9 ENTER_Button = 9
10 ESC_Button = 11
11 GPIO.setmode(GPIO.BCM)
12 GPIO.setwarnings(False)
13 GPIO.setup(ENTER_Button, GPIO.IN, pull_up_down = GPIO.PUD_UP)
14 GPIO.setup(ESC_Button, GPIO.IN, pull_up_down = GPIO.PUD_UP)
15 GPIO.add_event_detect(ESC_Button, GPIO.FALLING)
16 GPIO.add_event_detect(ENTER_Button, GPIO.FALLING)
17 def enter():
18     print "Enter Button is pressed"
19     servos2.start()
20     result_enter = qrcode.read().strip()
21     print result_enter
22     if result_enter == "NoValidQRcode":
23         gpiocall.ledFeedback(result_enter)
24         servos2.end()
25     else:
26         result2_enter = urlcallenter.create(result_enter)
27         gpiocall.ledFeedback(result2_enter)
28         servos2.end()
29 def esc():
30     print "ESC Button is pressed"
31     servos2.start()
32     result_esc = qrcode.read().strip()
33     print result_esc
```

```
34    if result_esc == "NoValidQRcode":
35        gpiocall.ledFeedback(result_esc)
36        servos2.end()
37    else:
38        result2_esc = urlcallesc.create(result_esc)
39        gpiocall.ledFeedback(result2_esc)
40        servos2.end()
41 while True:
42        if GPIO.event_detected(ENTER_Button):
43                enter()
44                time.sleep(0.5)
45        elif GPIO.event_detected(ESC_Button):
46                esc()
47                time.sleep(0.5)
48        else:
49                print "Waiting for someone to push the ENTER or ESC button"
50                time.sleep(0.5)
```

Figure 40: python code of the main program "main.py"

Line 7-8:   import of python libraries and subprograms used in the main program

Line 9-10:   declare and initialize variables for the ENTER- and the ESC-Button

Line 11-12:   choose "Broadcom SOC channel" (BCM) numbering scheme for GPIO pins (GPIO.setmode(GPIO.BCM)) and disable warnings (GPIO.setwarnings(False))

Line 13-14:   set GPIO pin 9(ENTER_Button) and pin 11(ESC_Button) as   INPUT with pull down resistor

Line 15-16:   add Interrupt function: detects falling edge on channel 9 (ENTER_Button) and 11(ESC_Button)[55]

Line 17:   *enter()* function is called whenever the ENTER button is pressed

Line 19:   *servos2.start()* function is called in order to drive out the webcam and turn on the blue LEDs

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[55] http://sourceforge.net/p/raspberry-gpio-python/wiki/Inputs/

Line 20: *qrcode.read()* function is called in order to start scanning QR codes for 30 seconds and return QR code result in case a QR code was successfully read, the function *strip()* returns a copy of the string in which all chars have been stripped from the beginning and the end of the string (default whitespace characters).[56]

Line 22: *if query* in case no QR code was scanned

Line 23: *gpiocall.ledFeedback()* function is called in order to turn on the red LEDs

Line 24: *servos2.end()* is called in order to drive in the webcam and to turn off the red LEDs

Line 25: *else query* in case QR code was scanned

Line 26: *urlcallenter.create()* function is called to check if the value of the QR code was a valid member ID by creating a URL with the QR code value and requesting this URL

Line 27: *gpiocall.ledFeedback()* function is called in order to turn on the green LEDs if the value of the QR code was a valid member ID, it turns on the red LEDs if the value of the QR code was not a valid member ID

Line 28: *servos2.end()* function is called in order to drive in the webcam and to turn off the green or the red LEDs

Line 29-40: the *esc()* function is called whenever the ESC button is pressed; it works in the same way as the *enter()* function (see Line 17-28)

Line 41: the *while-loop* makes sure that the main program is constantly running and checking for falling edges on pin 9 and 11

Line 42-44: the *if query* checks for a falling edge on pin 9(ENTER_Button) and if a falling edge is detected then start function *enter()* function. When *enter()* function is done wait for 0.5 seconds

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[56] http://docs.python.org/2/library/stdtypes.html

Line 45-47:   the *elif query* checks for a falling edge on pin 11(ESC_Button) and if
               a falling edge is detected then start *esc()* function. When *enter()*
               function is done wait for 0.5 seconds

Line 48-50:   the *else query* is processed if no falling edge is detected. It outputs
               "Waiting for someone to push the ENTER or ESC button" and after
               that it waits for 0.5 seconds.

qrcode.py:

```
 1 #!/usr/bin/env python
 2 #-*- coding: UTF-8 -*-
 3 """
 4 reads QR-Codes
 5   @ Simon Engelbertz, @ based on code from Stefan Bregenzer[57]
 6 """
 7 import os, signal, subprocess, time
 8 def read():
 9    zbarcam=subprocess.Popen("zbarcam --prescale=320x240 --raw --nodisplay
      /dev/video0 & sleep 30; kill $!", stdout=subprocess.PIPE, shell=True,
      preexec_fn=os.setsid)
10    print "zbarcam erfolgreich gestartet..."
11    while zbarcam.poll() is None:
12         time.sleep(1)
13         qrcodetext=zbarcam.stdout.readline()
14         if qrcodetext!="":
15                 print qrcodetext
16                 print "QR-Code was detected"
17                 break
18    os.killpg(zbarcam.pid, signal.SIGTERM)
19    print "zbarcam erfolgreich gestoppt"
20    if qrcodetext!="":
21         return qrcodetext
22    else:
23         qrcodetext="NoValidQRcode"
24         print "no QR-code was detected"
```

---

[57] http://blog.milsystems.de/2013/08/wie-benutze-ich-die-raspberry-pi-als-qr-code-lesegeraet/

```
25          return qrcodetext
```

Line 7:   import of python libraries needed in this function

Line 8:   *read()* function is called in order to start the QR code scanning

Line 9:   Starts detection for QR-codes as a subprocess, the webcam resolution is set to 320x240 (prescale) and the subprocess is timed to run for 30 seconds. The QR codedetection is based on the libraries *python-imaging* [58], *zbar-tools* [59] and *qrencode* [60] which need to be installed before running the program

Line 11:   the *while loop* is running till the subprocess has stopped *(zbarcam.poll() is None)* [61] or a QR codewas successfully detected

Line 13:   the *stdout.readline()* [62] [63] function reads the output of the subprocess and stores the content in the *qrcodetext* string variable in case a QR code was detected.

Line 14-17:   the *if statement* breaks the *while loop* in case a QR code was detected and stored *qrcodetext*

Line 18:   *os.killpg(zbarcam.pid, signal.SIGTERM)* [64] stops the subprocess which was started in line 9

Line20-21: the *if statement* returns *qrcodetext* in case it is NOT empty

Line22-25:   the *else statement* overwrites *qrcodetext* with the string *"NoValidQRcode"* and returns it in case *qrcodetext* is empty

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[58] http://www.pythonware.com/products/pil/

[59] http://zbar.sourceforge.net/

[60] http://fukuchi.org/works/qrencode/manual/

[61] http://docs.python.org/2/library/subprocess.html

[62] http://docs.python.org/2/library/subprocess.html

[63] http://docs.python.org/2/tutorial/inputoutput.html

[64] http://docs.python.org/2/library/os.html

5.2.3 Case and mechanic components

Apart from a few exceptions the case and the mechanic components of the sign on/off device were all created with the help of the laser cutter[65] and the 3D-printer[66] provided in the FabLab Bremen. The software used for the design of the 2D and 3D files was on the one hand the free and open source vector graphics software "Inkscape"[67] and on the other the free and open source 3D CAD software "OpenScad"[68]. In the following the design as well as the design realization of the most important components of the sign on/off device will be illustrated and contrasted.

Components made with the help of the laser cutter:
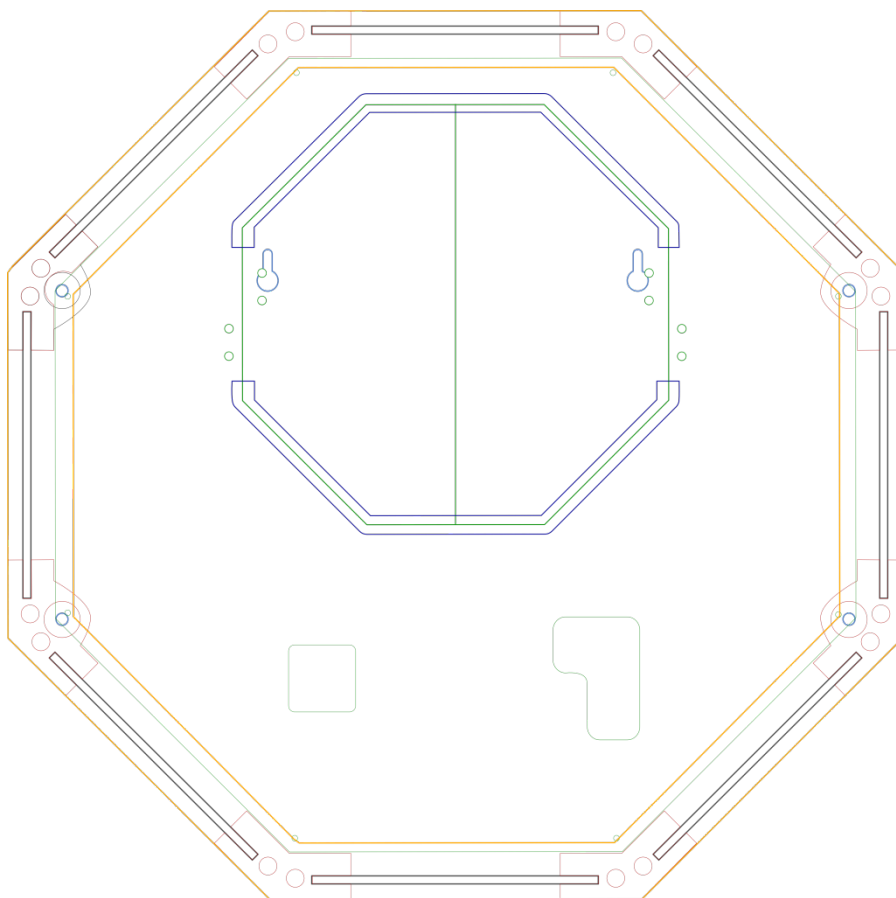
Figure 42: design of the different layers and components of the case illustrated in different colors

[65] http://www.epiloglaser.de/zing_24.htm

[66] https://www.ultimaker.com/pages/our-printers/ultimaker-original

[67] http://www.inkscape.org/en/

[68] http://www.openscad.org/index.html
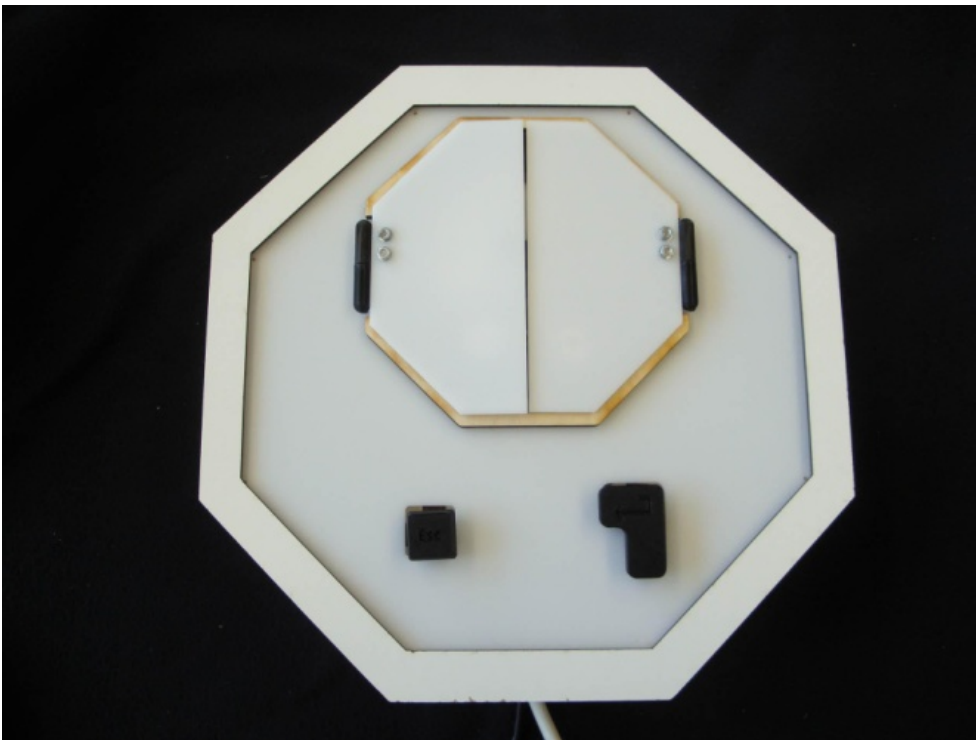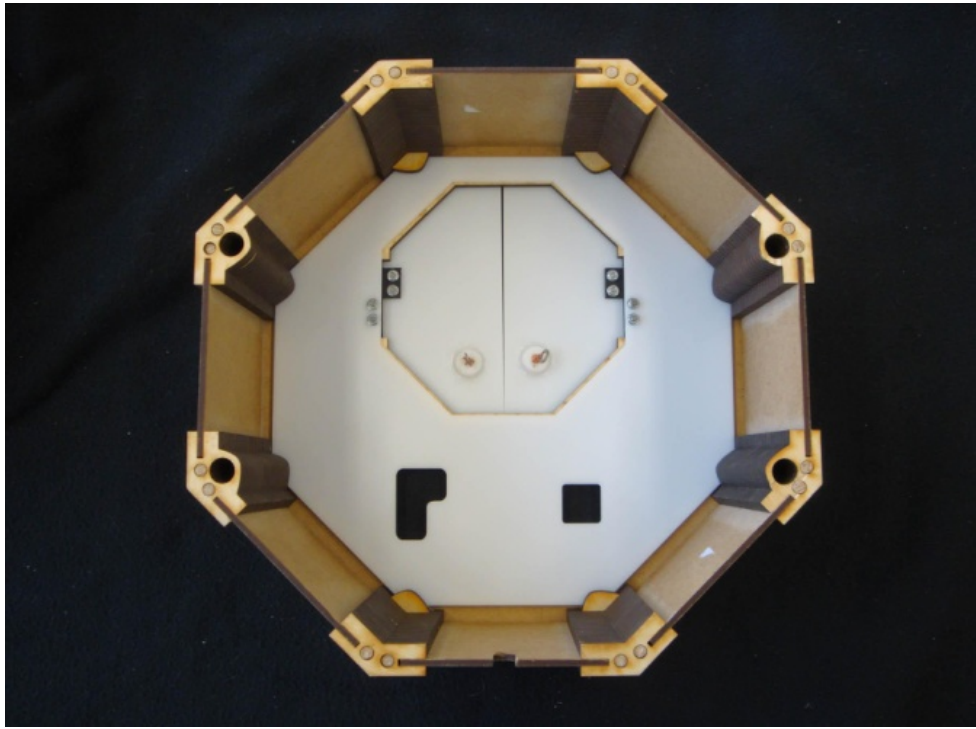
Figure 43: realization of the different layers and components of the case
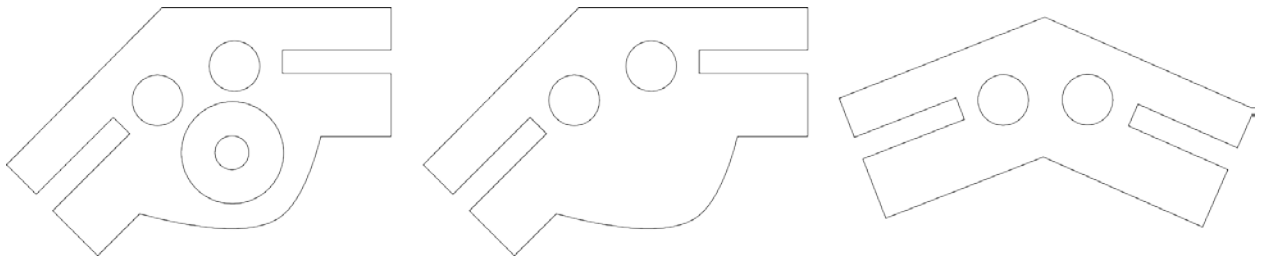
Figure 44: design of the corners connecting the walls of the case

Figure 45: realization of the corners connecting the walls of the case
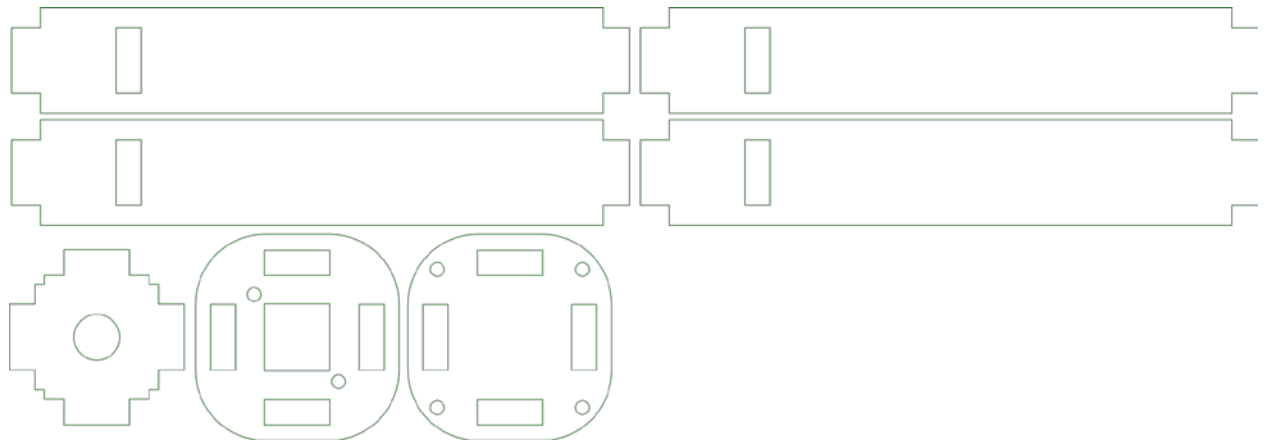
Figure 46: Design of the holders of the ENTER- and ESC-button
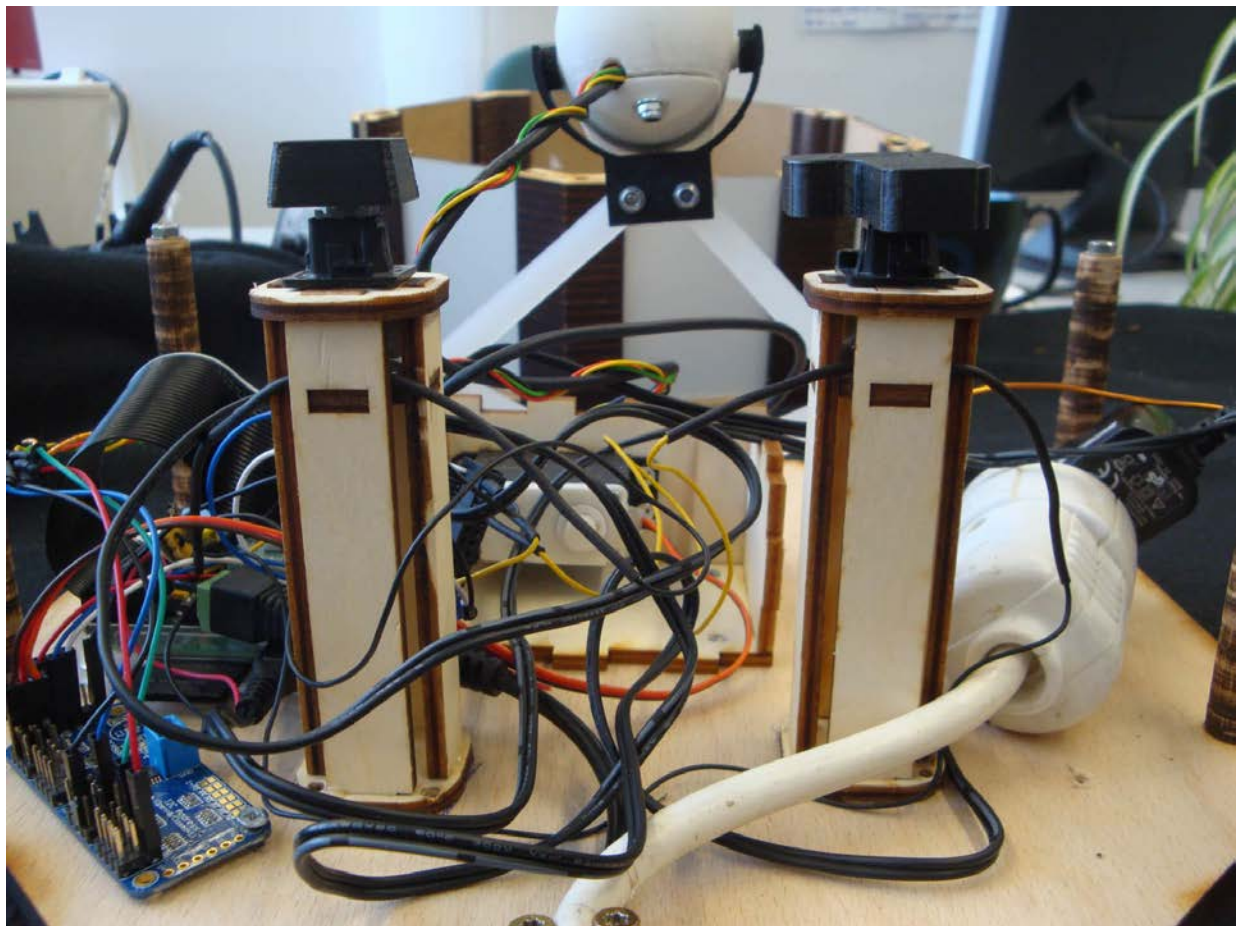
Figure 47: realization of the holders of the ENTER- and ESC-button
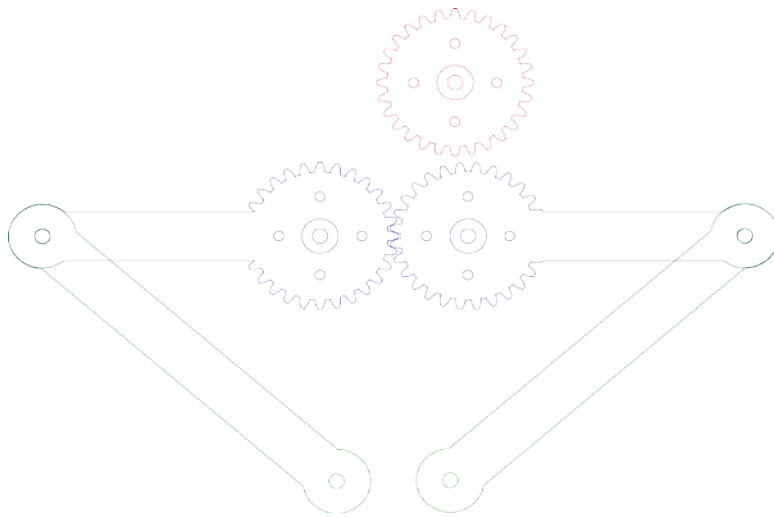
Figure 48: Design of the driving in/out mechanism of the cuckoo respectively the webcam
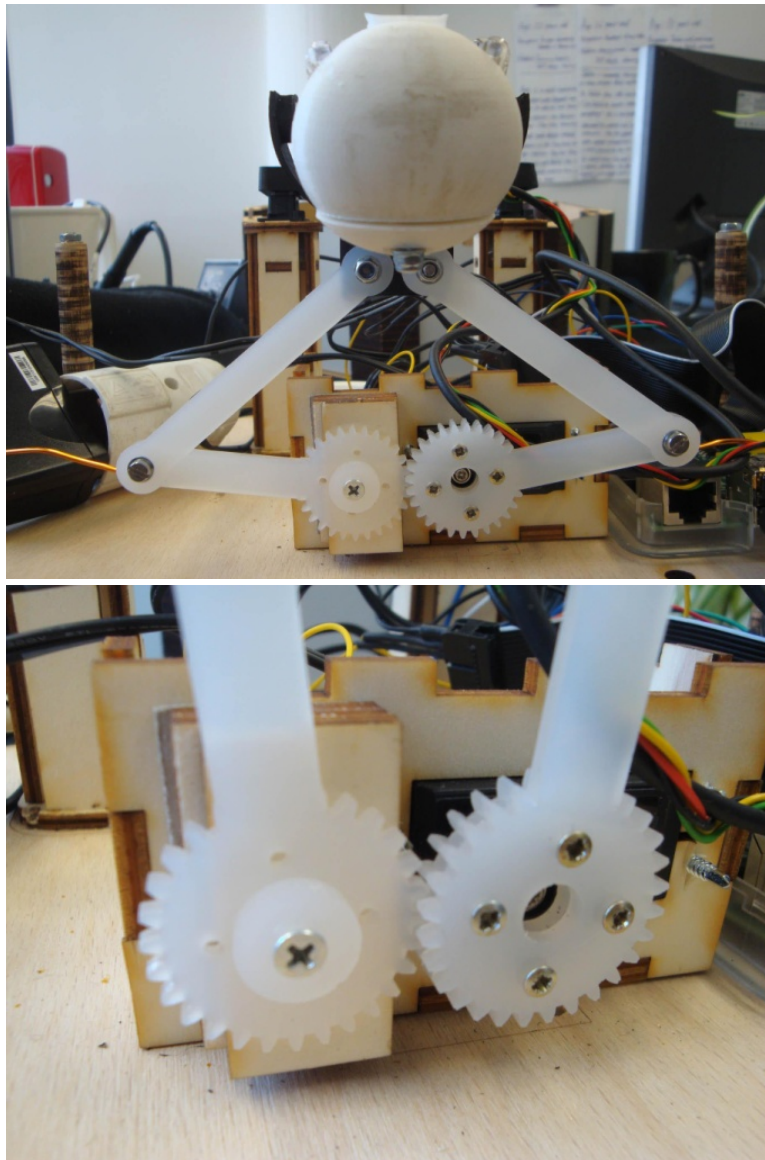
Figure 49: realization of the driving in/out mechanism of the cuckoo respectively the webcam
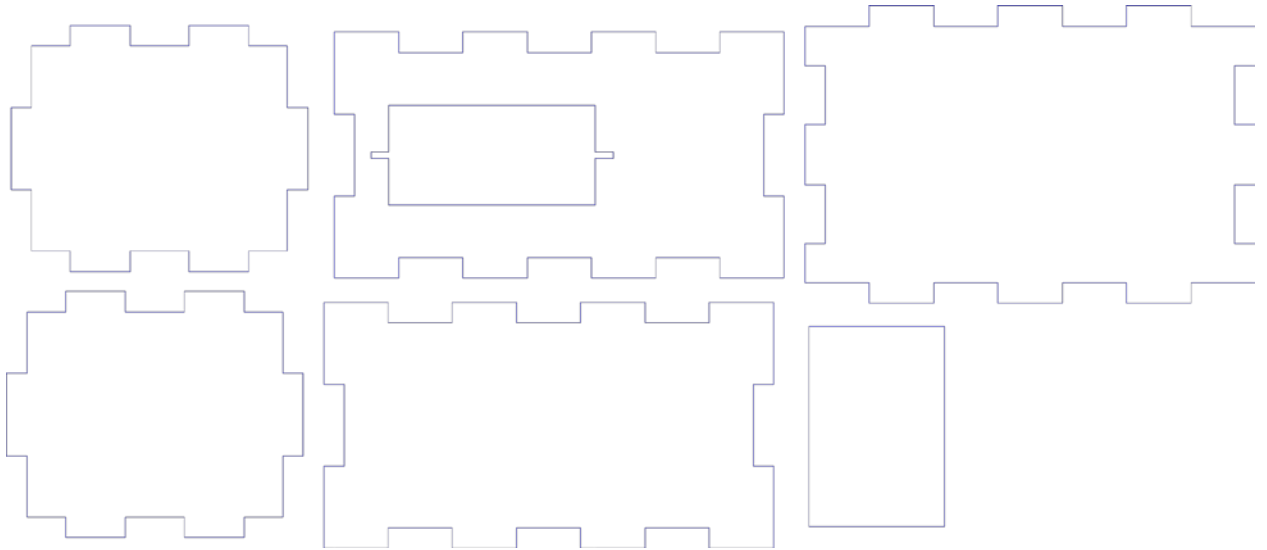
Figure 50: Design of the servo motor holder
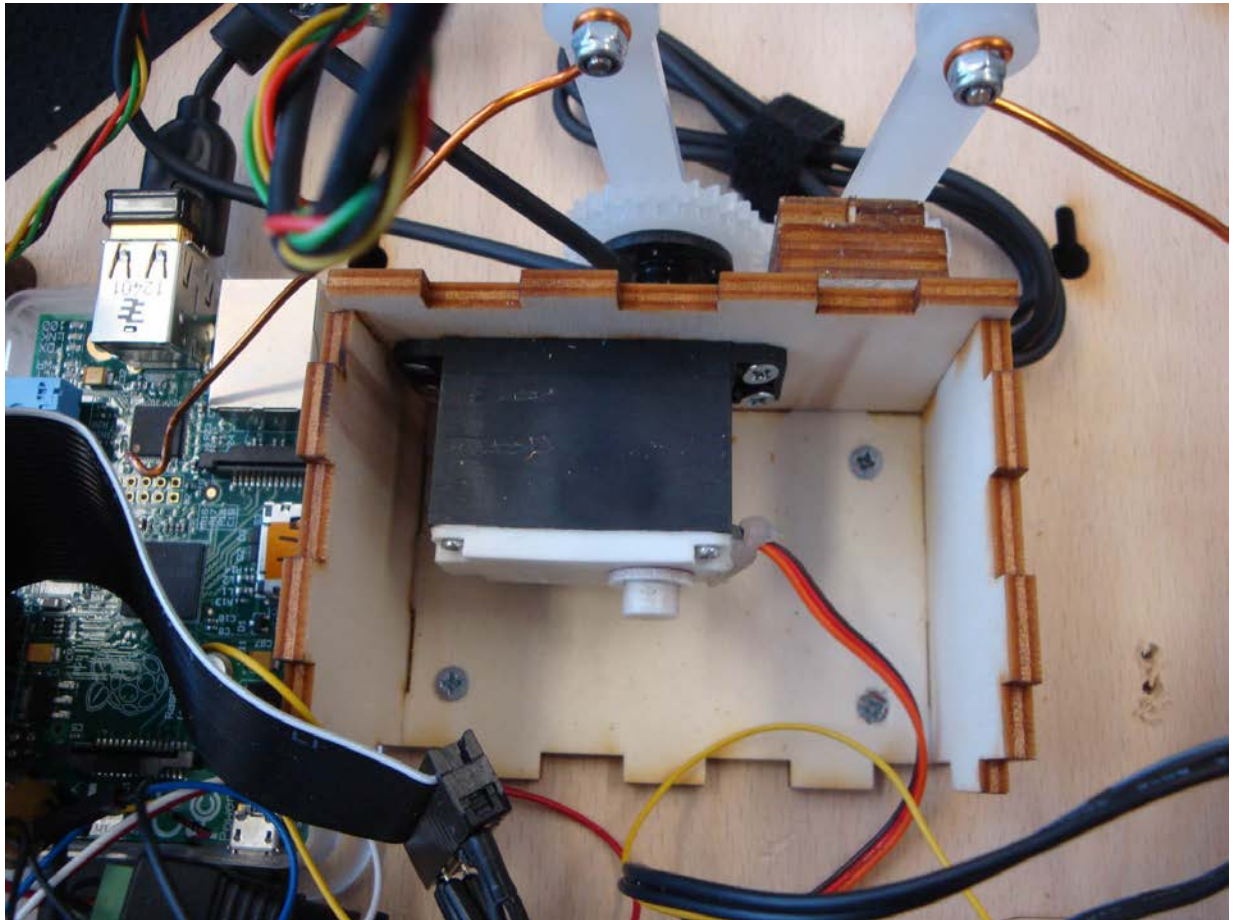
Figure 51: realization of the servo motor holder

Components made with the help of the 3D-printer:
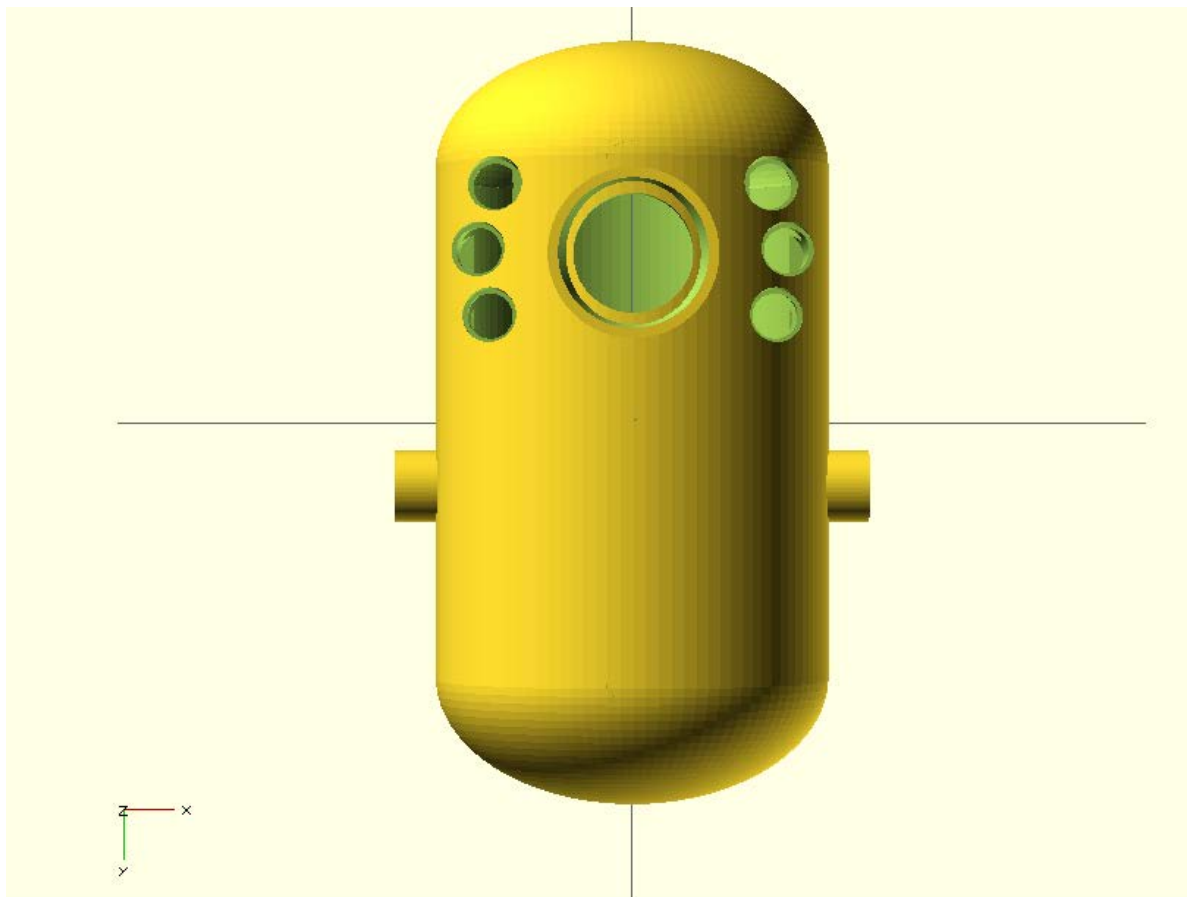
Figure 52: Design of the case for the webcam and the RGB LEDs

Figure 53: realization of the case for the webcam and the RGB LEDs
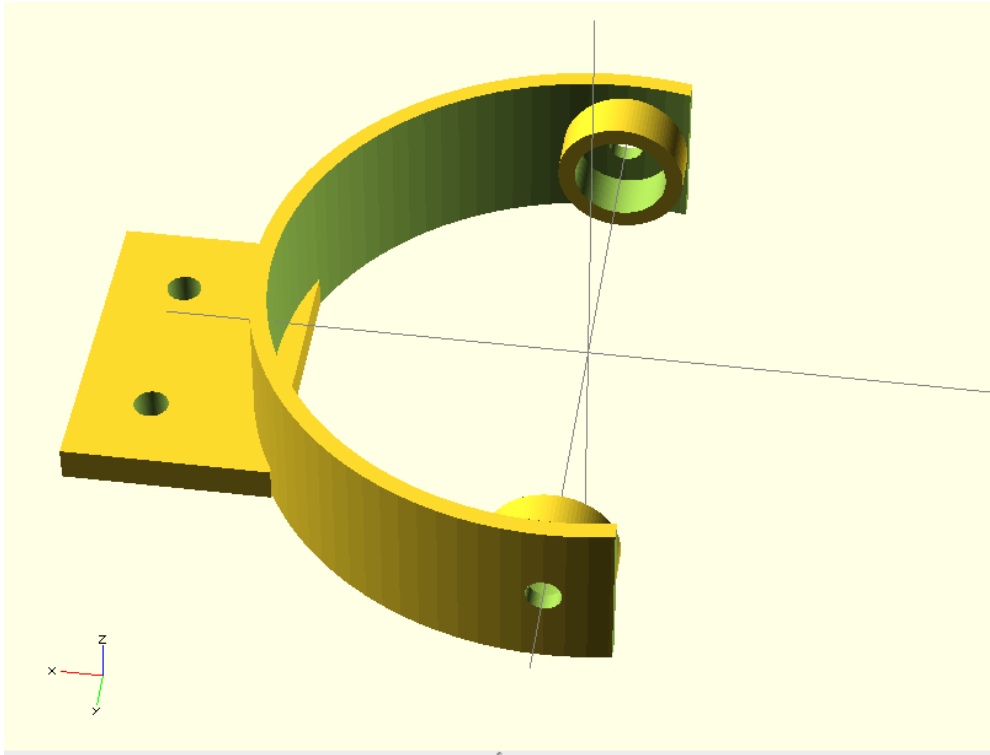
Figure 54: Design of the case-holder
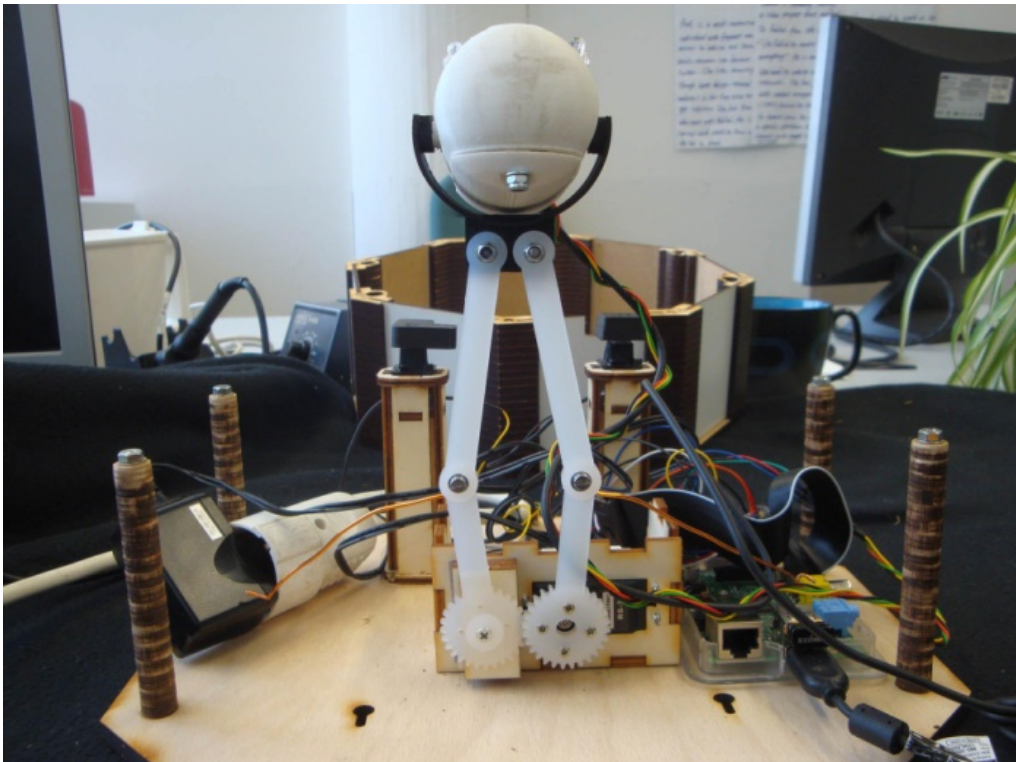
Figure 55: realization of the case-holder
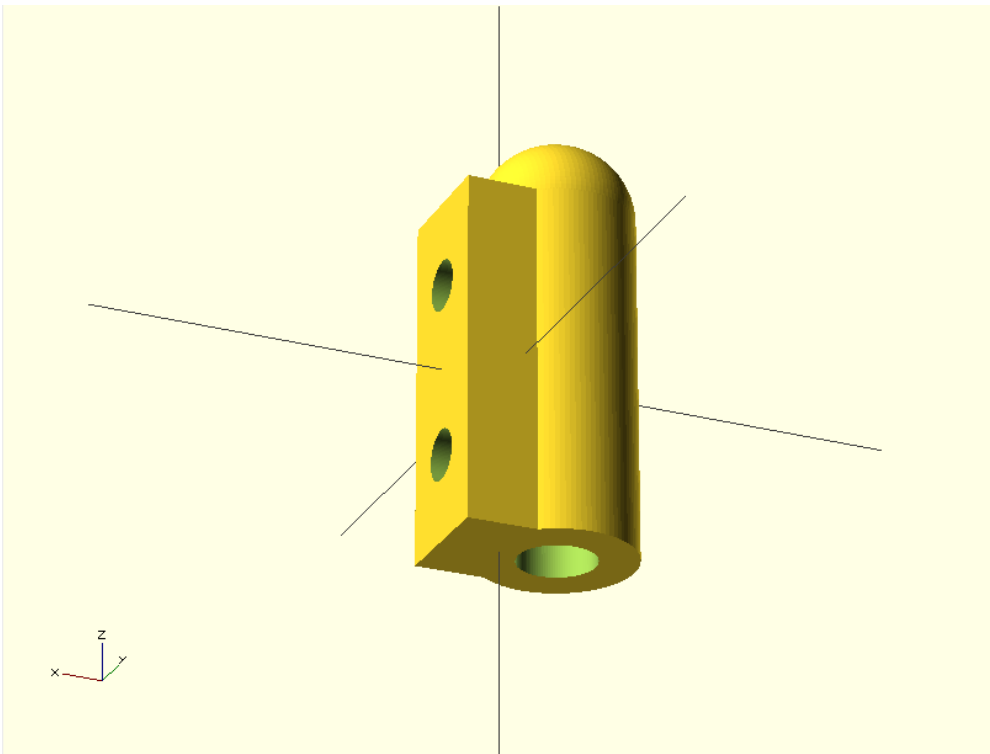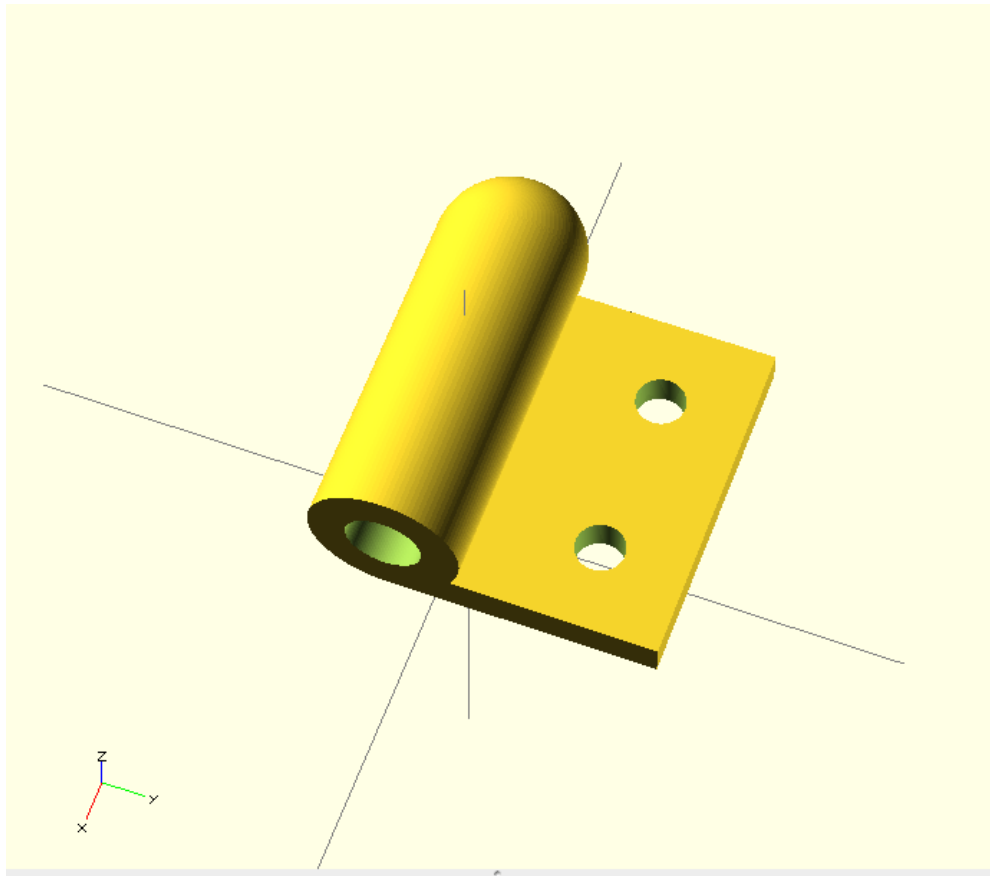
Figure 56: Design of the door hinge
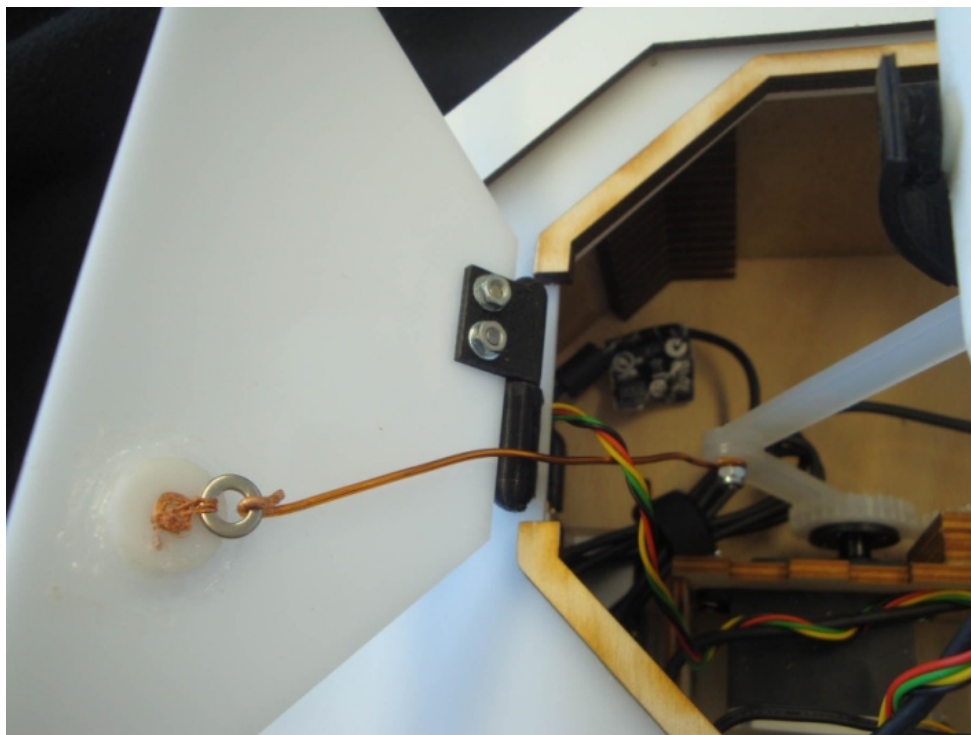
Figure 57: realization of the door hinge
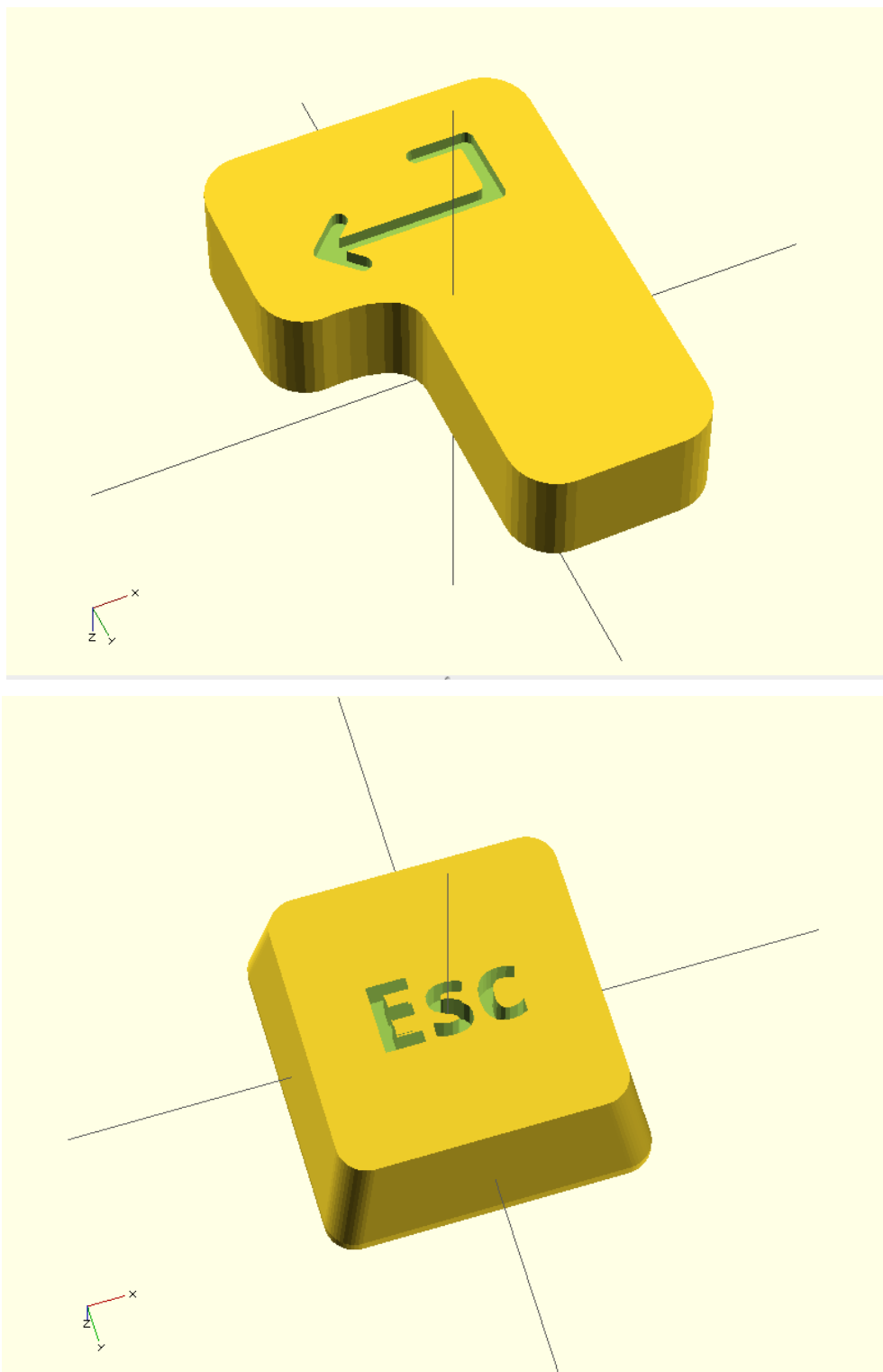
Figure 58: Design of the ENTER-button (top) and Esc-button (bottom)
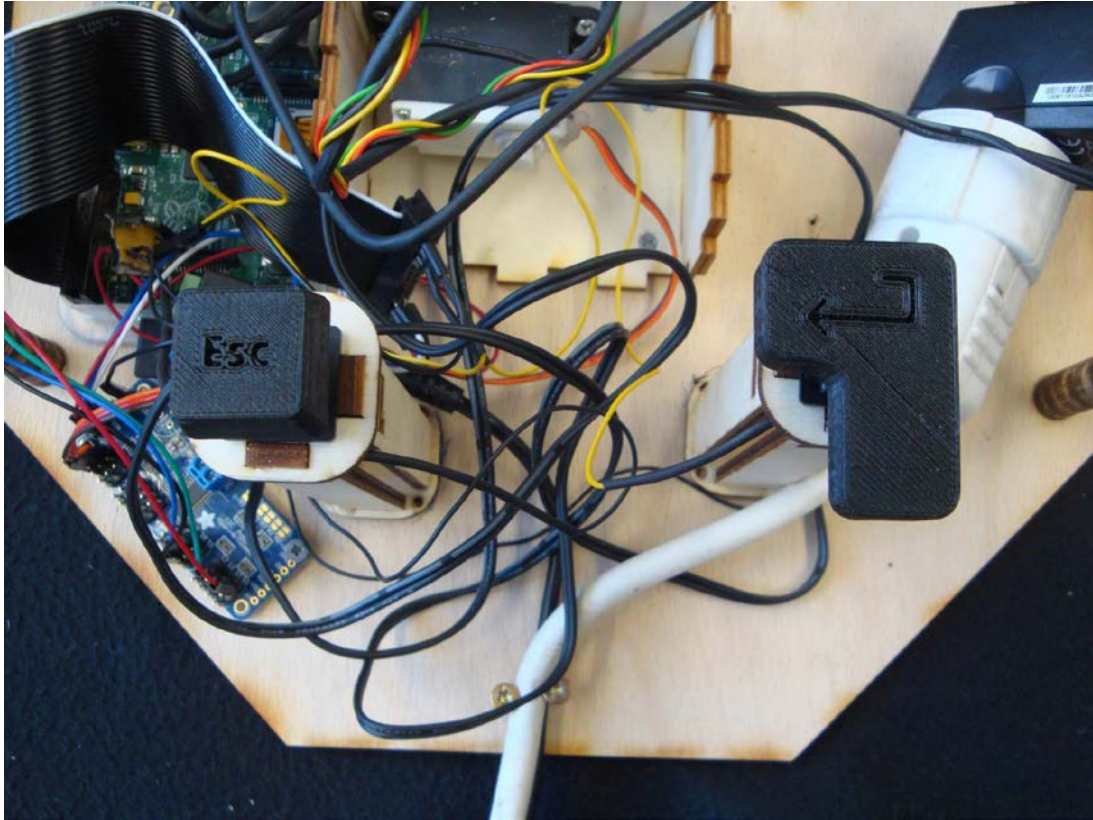
5.2.4 Summary of the sign on/off device

The TransPortal project team succeeded to implement the first version of the sign on/off device. All requirements listed in section 4.3.2 were accomplished:

1. the QR code scanning through the webcam works,
2. all components were supplied with enough power through two power adapters,
3. the Raspberry Pi Model B as "the brain" of the sign on/off device proved that it is capable of processing all the incoming and outgoing data,
4. a reliable wireless internet connection was established through the EDIMAX Wireless USB Adapter and the communication between the sign on/off device and the TransPortal website works flawlessly,
5. the Interaction Design of the sign on/off device was kept to a minimum due to the integration of only two push buttons and the establishing of member IDs which work on the basis of QR codes,
6. a safe case and wall mounting system was included (see figure 62),
7. the RGB LEDs work as a feedback system for the FabLab users and
8. the costs for all components were kept low with a sum of around 160,00 EUROs. Furthermore it was made sure that every component is widely

distributed and easy to use due to a good online documentation for the components.

Yet the interplay of all components within the sign on/off device is not working properly and reliable enough to use it in the daily routine of the FabLab Bremen. The reasons for this problem is assumed to be in structure of the python code (especially in the *qrcode.read()* function) as well as in the connection between the Logitech C270 webcam and the Raspberry Pi Model B. Till the present day the TransPortal project team is working on a solution for this problem. For that reason no user evaluation for the sign in/off device has been conducted yet. This as well as the public sharing with the FabLab network is left to future works.

Finally the following photos show the completed first version of the sign on/off device:

Figure 60: completed first version of the sign on/off device, initial state

Figure 61: completed first version of the sign on/off device, FabLab user pushes ENTER-button

Figure 62: completed first version of the sign on/off device, FabLab user holds member ID with QR code in front of the webcam
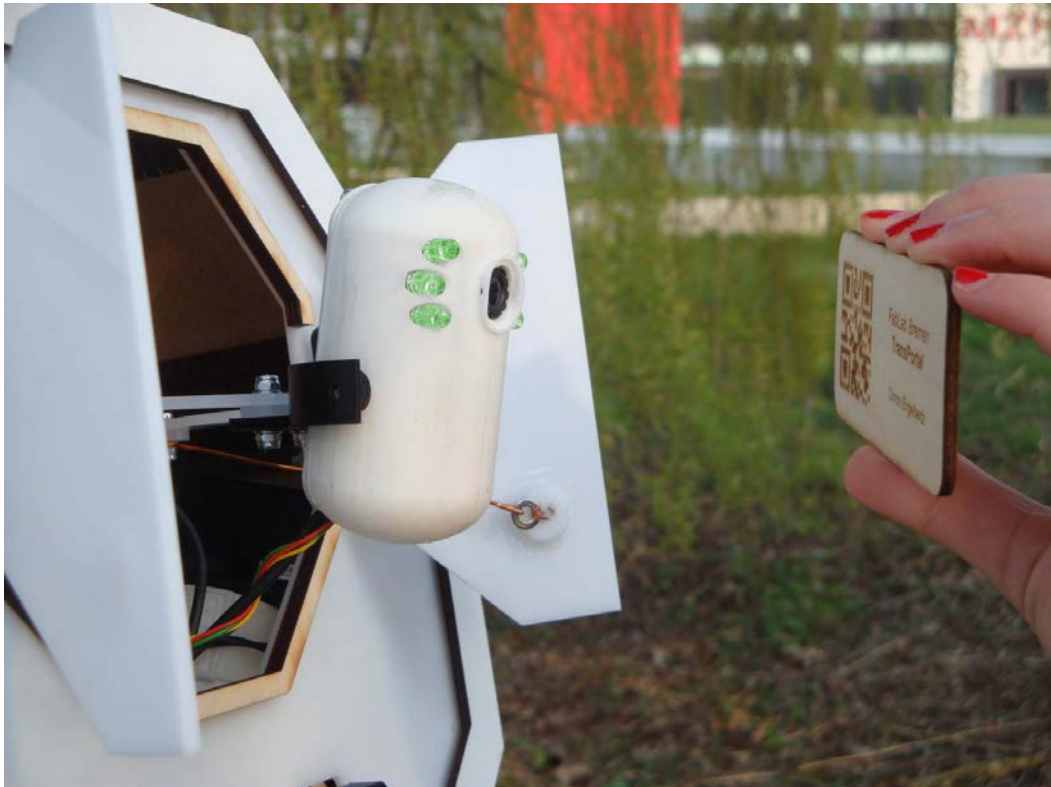
Figure 63: completed first version of the sign on/off device, the green glowing LEDs signal that the entering process was successful

5.3 Sign on/off device-Website communication

What happens between the website and the registration terminal? What functionality does this serve?

To answer the latter; the registration terminal is a card reader, which records the time of the user's arrival/departure to/from the lab. Taking the scenario of a user entering the lab as an example, we can sketch out the following series of actions:

- Interaction between user-terminal:
  - The user presses the "Enter" button
  - The terminal responds by extending the camera's arm - simultaneously opening the door.
  - At this point the camera is on standby until the user presents his readable patch of QR code (in this case, the QR code is carved on a wooden card).
  - The user flashes his card and the software sends a URL request to the server.
  - The URL request is successful and the LEDs on the camera flash green

o The time of the user's arrival is recorded and stored on the database, and the user's status changes to "in lab".
o The arm retracts and the door of the terminal closes.

As it becomes apparent from the example above, the registration terminal plays the "in-betweener's" part of the role in the communication between the user and the website. The inner workings of the communication between the terminal and the web page are summed and explained below:

Parameters	Values	Comments
inLab Status	0, 1	1 indicates that the user is in the lab, 0 indicates otherwise.
QR Code	username + *four random digits*, or admin-defined	read by the terminal's camera.

Table 7: URL parameters

URL format:

```
dk1.informatik.uni-bremen.de/account/qrscan/[inLab Status]/[QR Code]
```

Code:

```
1 public function getQrscan($value, $QRkey)
2   {
3       $user = \User::where('QRkey', '=', urldecode($QRkey))->first();
4       if(!$user)
5       {
6           return View::make('site/account/badqrscan');
7       }
8
9
10      if ($value == '1')
11      {
12          $user->inlab = '1';
```

```
13          $user->enteredlab_at = date("Y-m-d H:i:s");
14          $user->save();
15      }
16
17        else
18      {
19          $user->inlab = '0';
20          $user->leftlab_at = date("Y-m-d H:i:s");
21          $user->save();
22      }
23
24
25      return View::make('site/account/qrscan')->with('user', $user);
26  }
```

Figure 65: AuthController

As described on Fig. 65, the function defined here - named *getQrscan* - is used to realise the inLab status. The GET method sends the encoded information (*$value* and *$QRkey*) appended to the page request. Initially, we declare the *$user* variable, which will scan the users' table on the database and fetch the user with the matching QR-Code ($*QRkey* as defined in the code).

The first "if" clause checks whether the *$user* is empty. In other words, when no user is found. Should this be the case, we redirect to a different page displaying a custom plain message "We are sorry but something went wrong.". Then, the terminal simply interprets this as an unsuccessful login attempt, and resets.   We do this redirection in order to avoid internal errors from asking the column of an empty value later in the part of the view. An internal error would cause an error to the terminal's code and render it momentarily nonfunctional. Naturally, the code below the first "if" clause will run only if a matching user is found.

Furthermore, we ask the *$value.* This binary variable represents two possible cases: a user entering - in which case *$value* is equal to "1" - or leaving (*$value* = "0") the laboratory. As depicted on Table 7, the inLab status corresponds to this *$value*.

When the value of *$value* is equal to "1", then we write in the two columns of the corresponding user's row on the users' table: *inlab* and *enteredlab_at*. More specifically, we change the binary value of *inlab* to "1", meaning he is present at the lab, and we record the actual date and time on *enteredlab_at.* However, if *$value* is "0", the values of *inlab* and *leftlab_at* are set as "0" and the actual date and time respectively. The save function at the end of each clause should be pretty self-explanatory: the data modified are saved.

```
1   @if($user->inlab == 1)
2   Hello, {{ $user->first_name }} you are now in the lab. Welcome!
3   @else
4   Hello, {{ $user->first_name }} you are now exiting the lab. Bye!
5   @endif
```

Figure 66: qrscan.blade.php

As shown on the above figure (Figure 66), we have an "if" clause which checks whether the *inlab* variable of the specific user is equal to "1". Should this be the case, then the appearing message is a greeting to the user with his username. Otherwise, it is a message saying goodbye, again, with the user's username displayed.

Just to clarify, having Figure 65 and 66 in mind, the code at the AuthController is first executed, before the page is generated.

It is noteworthy, that the message displayed on the "qrscan.blade.php" is not important for the user, since, under normal circumstances, the user doesn't get to see that page. Concerning the sign on/off device, however, the message is important because it is used as an indicator of the user's inLab state.

More specifically, there are three python functions on the side of the sign on/off device which do basically three things:

1. create URL according to the content of the QR code that was detected
2. make URL request with the corresponding URL
3. check if the response of the requested URL contains either the clause "Hello, UserXYZ[69] you are now in the lab. Welcome!" or "Hello, UserXYZ you are now exiting the lab. Bye!" or "We are sorry but something went wrong." or any other message (see figure 66)

The two python functions "urlcallenter.create()" as well as the "urlcallesc.create()" take care of the first two points. The former creates and requests the URL for the entering process (inLab Status = 1) and the latter for the exiting process (inLab Status = 0). (see figure 1.0) The python function "gpiocall.ledFeedback()" on the other hand is responsible for the third point. All three functions are called in the main program "main5.py" of the sign on/off device. (see section 5.2.2) In the

---

[69] example for a user name

following the python code of the "urlcallenter.create()" function and the "gpiocall.ledFeedback()" function will be described in more detail. The "urlcallesc.create()" function won't be considered any further though since it works after the same principle as "urlcallenter.create()". For further information in this regard see appendix E.

urlcallenter.py:

```python
 1 #!/usr/bin/env python
 2 #-*- coding: UTF-8 -*-
 3 """
 4 requests TransPortal url for entering the FabLab according to the QR-Code
 5     @ Simon Engelbertz
 6 """
 7
 8 import urllib, urllib2
 9
10 def create(value):
11     exception = "/"
12     errorMessage = "invalid QRcode"
13     print "Url wird erzeugt"
14     params = value
15     if (exception in params) or (not params):
16         return errorMessage
17     else:
18         raw_url ='http://dk1.informatik.uni-bremen.de/account/qrscan/1/'
19         url = raw_url + urllib.quote(params)
20         print url
21         req = urllib2.Request(url)
22         print req
23         response = urllib2.urlopen(req)
24         the_page = response.read()
25         return the_page
```

Figure 67: Python code of subprogram "urlcallenter.py"

Line 8:   import of python libraries which are needed to run the program

Line 10-25:   the *create(value)* function is defined in these lines, this function passes the string value of the QR Code which was detected before by the function *qrcode.read()* in the main program (see section 5.2.2)

90

Line 15-16:   *if query* for the case if the passed value contains a forward slash ("/") or if it is empty, in the case the error message "invalid QRcode" is returned to the main program

Line 17-25:   *else query* for the case if the passed value does NOT contain a forward slash ("/") or if it is NOT empty. In this case the URL for entering the FabLab will be created by combining the variables *raw_url* and *params* which contains the passed value of this functions. (see line 14,18,19) The function *urllib.quote()* makes sure to replace special characters in *string* using the %xx escape. By default it is "/".[70] The next step is the URL request and the opening of the URL which is executed by the functions *urllib2.Request()*[71] and *urllib2.urlopen()*[72]. (see line 21-23) Finally the response of the website is stored and returned to the main program through the variable *the_page*. The *response* command is executed through the *response.read()*[73] function (see line 24-25)

gpiocall.py:

```
 1 #!/usr/bin/env python
 2 #-*- coding: UTF-8 -*-
 3
 4 """
 5   checks response of the TransPortal website and executes feedback according
to the       6 response
 7       @ Simon Engelbertz
 8 """
 9
10 from Adafruit_PWM_Servo_Driver import PWM
11 import time, RGB_Driver, servos
12
13 def ledFeedback(value):
14     VAR = value
15     print VAR
16     #Initialise LED Variables
17     LEDblue = 10
18     LEDgreen = 13
```

---

[70] http://docs.python.org/2/library/urllib.html

[71] http://docs.python.org/2/library/urllib2.html

[72] http://docs.python.org/2/library/urllib2.html

[73] http://docs.python.org/2/howto/urllib2.html

```python
19     LEDred = 15
20     LOGin = "in the lab"
21     LOGout = "exiting the lab"
22     LOGError = "sorry wrong"
23     INVALIDqr = "invalid QRcode"
24
25     print "Feedback"
26
27     while True:
28         if LOGin in VAR:
29             servos.setServoPulse(LEDblue, 0)
30             time.sleep(0.5)
31             servos.setServoPulse(LEDgreen, 2600)
32             time.sleep(1)
33             print "Welcome to the FabLab Bremen"
34             break
35         elif LOGout in VAR:
36             servos.setServoPulse(LEDblue, 0)
37             time.sleep(0.5)
38             servos.setServoPulse(LEDgreen, 2600)
39             time.sleep(1)
40             print "Tschüssikowsky"
41             break
42         elif LOGError in VAR:
43             print "Log In / Log Out failed!"
44             servos.setServoPulse(LEDblue, 0)
45             time.sleep(0.5)
46             servos.setServoPulse(LEDred, 2600)
47             break
48         elif VAR == INVALIDqr:
49             print "Log In / Log Out failed!"
50             servos.setServoPulse(LEDblue, 0)
51             time.sleep(0.5)
52             servos.setServoPulse(LEDred, 2600)
53             break
54         elif VAR == None:
55             print "Log In / Log Out failed!"
56             servos.setServoPulse(LEDblue, 0)
57             time.sleep(0.5)
58             servos.setServoPulse(LEDred, 2600)
59             break
60         else:
61             print "Log In / Log Out failed!"
62             servos.setServoPulse(LEDblue, 0)
63             time.sleep(0.5)
```

```
64          servos.setServoPulse(LEDred, 2600)
65          break
```

Line 10-11:   import of python libraries which are needed to run the program

Line 13-65:   the *ledFeedback(value)* function is defined in these lines, this function passes the string value which was returned by the "urlcallenter.create()" and stores it in the variable *VAR*. (see urlcallenter.py line 25) According to *VAR* this function distinguishes which color of the RGB LEDs should light up as a feedback signal to let the FabLab user know whether the entering-/exiting- process succeeded.

Line 28-34:   *if query* for the case if *VAR* contains the words *"in the lab"*. If that is the case the blue LEDs will be turned off through the command *servos.setServoPulse(LEDblue, 0)* in line 29 and the green LEDs will be turned on through the command s*ervos.setServoPulse(LEDgreen, 2600)* in line 31. This is the signal for the FabLab user that the entering process was successfully

Line 35-41:   *elif query* for the case if *VAR* contains the words *"exiting the lab"*. If that is the case the same procedure as in line 28-34 will happen with the difference that this is the signal for the FabLab user of a successful exiting process.

Line 42-47:   *elif query* for the case if *VAR* contains the words *"sorry wrong"*. If that is the case the blue LEDs will be turned off through the command *servos.setServoPulse(LEDblue, 0)* in line 44 and the red LEDs will be turned on through the command s*ervos.setServoPulse(LEDred, 2600)* in line 46. This signals to the FabLab user that something went wrong during the entering or exiting process. Therefore the FabLab user needs to push the ENTER- or the ESC-button again.

Line 48-65:   Line 48-65 does the same as line 42-47. It covers every other case for the value of the variable *VAR*. In any of these cases the red LEDs are turned on so that the FabLab user knows that something went

wrong during the entering or exiting process and that he or she needs to push the ENTER- or the ESC-button again.

6. EVALUATION

This usability test is intended to determine the efficiency of the implemented features from the TransPortal website. Two members of the TransPortal team conducted an onsite usability test on the live version of the TransPortal website opened on the test administrator's laptop. One more laptop was used for screen recording and data logging. Both test administrator and data logger were present in the testing room. Each test session capture the video record from the screen of the laptop that the respondent was using, task completion rates, comments as well as respondent's answer to the system usability scale survey at the end of the session.

6.1 Executive Summary

The TransPortal project team conducted an onsite usability test at the Fablab room in the University of Bremen on 11th March 2014. Two unrelated tests were administered to test usability of different features intended for two different types of user-groups: Registered users and Administrators. From here on, the test for registered users will be referred to as "Test 1" and the test for administrator users will be referred to as "Test 2".

Five respondents participated in Test 1 and another five in Test 2. The number of participants was enough to ensure reliable usability test, according to Neilson (2000). Each test session lasted approximately 30 minutes for both Test 1 and Test 2.

The result from both tests indicated very high success rates of assigned tasks as well as positive feedback on ease of use from respondents. Only minor suggestions and comments are given by the respondents.

The detailed explanation of the result will be presented later in section 6.3.

6.2 Methodology

6.2.1 Sessions

Both Test 1 and Test 2 followed the same recruitment and testing procedures.

The test administrator contacted and recruited participants by sending emails to students within the Digital Media master 2013-2014 program requesting their availability and participants. Two participants were staff members working for

the University of Bremen. Agreements on time and place for the test were made. Each test session lasted approximately 30 minutes. During the session, before the participants started with the tasks, the test administrator explained the purpose of the test and ensured the participants that no personal data from their side would be collected.

The participants were then presented with a laptop with the TransPortal homepage opened. The first test administrator gave the participants the same username and password to log into the account. The second test administrators set up another laptop to monitor and capture the activity of the participants during the test session. The second test administrator would tell the participant what task to do as well as when to begin and stop.

At the end of each task, the participants were asked to rate the easiness/difficulty of the task on a 5-point Likert Scale from "Very Difficult" to "Very Easy" (See appendix D).

While the participants performed the task, the second test administrator who was monitoring the activity of the participants will rate the completion of the task to one of the three criteria:
1. Completed with ease
2. Completed with help
3. Failed to complete

"Complete with ease" means participants were able to carry out the assigned task without having to rely on or ask for help from the test administrator. "Complete with help" means participants were able to complete the task but only after a significantly longer time than average and with the help of the test administrator. "Fail to complete" means participants could not complete the task at all.

When the session ended, the administrator asked the participants to fill in a standardized System Usability Scale (Brooke, 1996) questionnaire which also employed a 5-point Likert Scale from "Strongly Agree" to "Strongly Disagree" in order to measure several subjective points including:
- Ease of use
- Frequency of use
- Learn ability - how easy it would be for most users to learn to use the website

After the participants filled out the SUS questionnaire, the test administrator also asked the participant for his/her overall comments about the look and feel of the design:
- What the participant liked most.
- What the participant liked least.
- Recommendations for improvement.

See appendix B for a complete SUS questionnaire.

6.2.2 Participants

As mention in section "session" above, all except two participants were students of Digital Media master program. Participants for both Test 1 and Test 2 were selected in random manners. Biological information such as age and sex was considered insignificant for the recruitment process. However, the test administrators made an effort to make sure participants were potentials fablab users and fablab administrators. The method for such assurance, however, was not standardized; therefore, the test administrators couldn't claim representativeness of the sample.

There were, in total, ten participants, five participants for Test 1 and five for Test 2.

6.2.3 Test Tasks

Participants of Test 1 and Test 2 were asked to perform different tasks. In Test 1, which intended to test functionality for registered users, participants were asked to complete the following tasks:

1. Log in (username and password provided)
2. Change account settings
3. Change profile photo
4. Hide lab status
5. Create a project (material provided)

Tasks in Test 2, which was intended to test administrative functionalities:

1. add user
2. edit user information
3. remove user
4. add item
5. edit item information
6. remove item

In both tests, after the participants finished all the assigned and timed tasks, they were asked to perform a self-directed task involving navigating the page so that they could provide overall comments.

6.3 Results

6.3.1 Task Completion Success Rate

All the tasks in this both Test 1 and Test 2 have 100% completion rate. None of the participants failed to complete the assign tasks.

Participant	Task 1	Task 2	Task 3	Task 4	Task 5
1	√	√	√	√	√
2	√	√	√	√	√
3	√	√	√	√	√
4	√	√	√	√	√
5	√	√	√	√	√
Completion Rates	100%	100%	100%	100%	100%

Table 8: Completion success rate – Test 1

Only the completion rating from the test administrator varied among the tasks. All participants were able to get "complete with ease" rating in Task 1 (log in), Task 3 (Change profile photo) and Task 4 (Hide lab status). Two participants needed guidance to complete Task 2 (Change account settings) and one participant needed help with Task 5 (Create a new project).
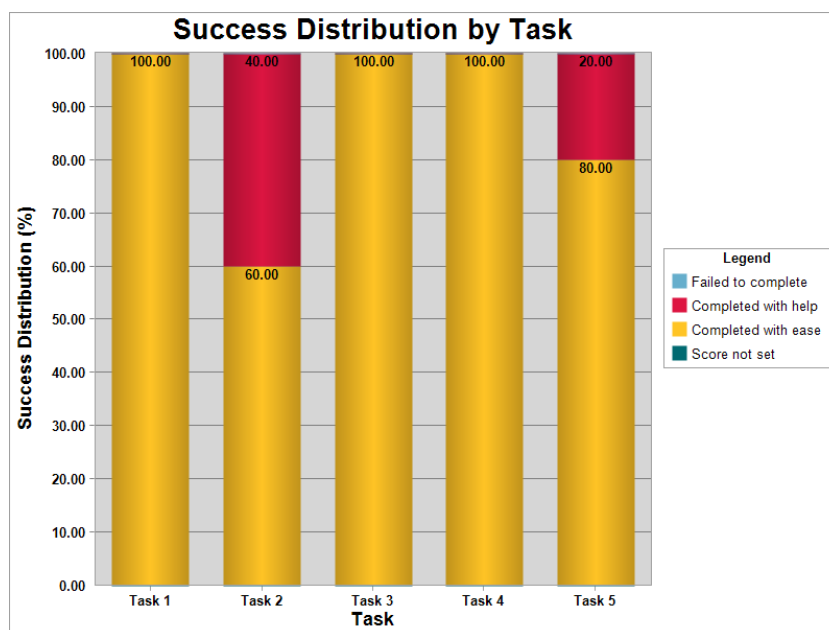
Figure 69: success distribution - Test 1

Participant	Task 1	Task 2	Task 3	Task 4	Task 5	Task 6
1	√	√	√	√	√	√
2	√	√	√	√	√	√
3	√	√	√	√	√	√
4	√	√	√	√	√	√
5	√	√	√	√	√	√
Completion Rates	100%	100%	100%	100%	100%	100%

Table 9: Task success rate in Test 2

Task 2 (Edit user info) and Task 3 (Remove user) were completed with ease; however, 2 participants (40%) need some help with Task 1(Add user), Task 5 (Edit item) and Task 6 (Remove item). One participant (20%) needed help with Task 4 (Add item).
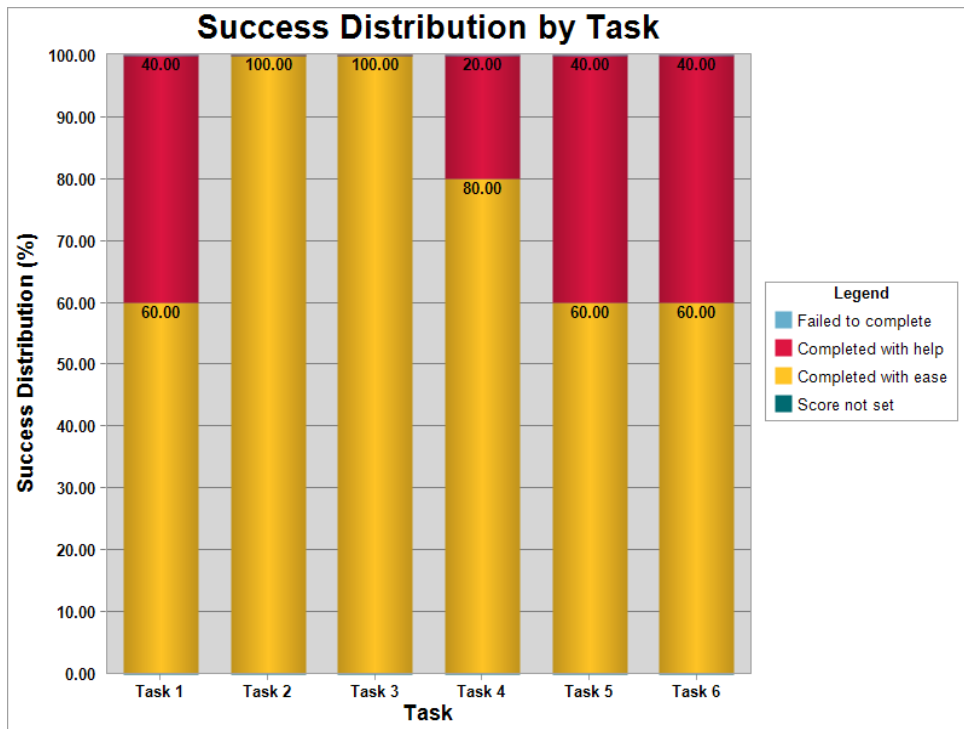
Figure 70: success distribution- Test 2

6.3.2 Task Ratings

At the end of each task, the participants were asked to rate the easiness/difficulty on the scale from 1 to 5, 1 being "Very Difficult" and 5 being "Very Easy". Any task with average score over 4 is considered "easy" while task with average lower 3 is considered "difficult".

For Test 1, all tasks have average score over 4 meaning all participants considered the tasks easy. Task 1 (log in) got the maximum score of 5, while Task 2 (Change settings) has the lowest average of 4.2.

Task	Participant 1	Participant 2	Participant 3	Participant 4	Participant 5	Average
1: log in	5	5	5	5	5	5
2: Change settings	4	4	5	5	3	4.2
3: Change profile photo	5	4	4	5	4	4.4
4: Hide lab status	4	5	4	5	4	4.4
5: Create project	5	5	4	5	5	4.8

Table 10: Task Ratings by Participants in Test 1

In Test 2, all tasks have average score over 4 meaning all participants considered the tasks easy. Task 2 (edit user info), Task 3 (remove user) and Task 6 (remove item) got the maximum score of 5, while Task 5 (edit item info) has the lowest average of 4.2. One participant gave a score of 1 (Very Difficult) to Task 5; however, the other 4 participants gave the same task the highest score of 5 (Very Easy).

Task	Participant 1	Participant 2	Participant 3	Participant 4	Participant 5	Average
1: add user	5	5	4	3	5	4.4
2: edit user info	5	5	5	5	5	5
3: remove user	5	5	5	5	5	5
4: add item	3	5	5	4	5	4.4
5: edit item info	1	5	5	5	5	4.2
6: remove item	5	5	5	5	5	5

Table 11: Task Ratings by Participants in Test 2

6.3.3 Time on Task

The testing software recorded the time on task for each participant. Some tasks were inherently more difficult to complete than others and are reflected by the average time on task.

	Task 1	Task 2	Task 3	Task 4	Task 5
Participant 1	16.59	39.79	19.81	30.2	73.79
Participant 2	22.58	76.01	39.79	40.96	121.03
Participant 3	23.79	177.01	6.58	15.38	105.59
Participant 4	15.2	61.81	55.4	34.4	141.01
Participant 5	30.81	45.18	34.18	72.39	167.23
Average ToT	21.79	79.96	31.15	38.67	121.73

Table 12: Time on Tasks by Participants in Test 1

	Task 1	Task 2	Task 3	Task 4	Task 5	Task 6
Participant 1	130.38	13.19	28.19	124.41	9.99	40.62
Participant 2	113.39	12.41	32.98	94.99	48.98	70.42
Participant 3	348.99	14.82	72.02	83.59	10.8	30
Participant 4	192.99	10.22	22.18	17.59	11	46.19
Participant 5	33.4	5.79	25.4	42.01	18.6	11.6
Average ToT	163.83	11.28	36.15	72.52	19.87	39.76

Table 13: Time on Tasks by Participants in Test 2

6.3.4 System Usability Scale

At the end of each session, the participants were asked to fill out a System Usability Scale survey (Brooke, 1996) which rated 10 overall measures of the site (See Appendix A for the complete survey). The table below shows the average of the score from each participant's survey result.

Participants	SUS Score
1	87.5
2	90
3	85
4	87.5
5	80
Average SUS score	86

Table 14: Average SUS score for Test 1

Participants	SUS Score
1	90
2	90
3	82.5
4	67.5
5	95
Average SUS score	85

Table 15: Average SUS score for Test 2

According to Bangor, Kortum, and Miller (2011), a passable SUS score is 70s. Better systems should score between high 70s and upper 80s. Therefore, our tested features can be safely labeled as usable.

Likes, Dislikes, Participant Recommendations
Upon completion of the tasks, participants provided feedback for what they liked most and least about the website, and recommendations for improving the website.

Liked Most
The following comments capture what the participants liked most:
1. The website structure is very clear and easy to use.

Liked Least
The following comments capture what the participants liked the least:
1. "Hide My Lab Status" setting is not easy to be found, and I have no idea when it use for when I first saw it.

Recommendations for Improvement
1. In "explore tutorial" page, categories with keywords would be a better way for tutorial classification.
2. A library of different materials (cardboard, paper, wood sheet and etc.) parameter settings for laser cutting and laser engraving.
3. User Profile picture should be clickable to link to the page of changing profile picture.
4. More explanation of "The Creative Commons copyright licenses" should be added in "create project" page and "project" page.

5. In "Inventory" page, when user has no borrowed items in his list, it should show information like this: "You have not borrowed any item from Bremen FabLab.", instead of showing blank list.

6. It should provide the function to mail system admin to report problem, like copyright Infringement , trollish comments and so on.

7. In "Account Manage" page, when user click "Save" , feedback like "Change has been saved" should be shown. 9. User name should not be changed after registration.

8. In "Admin" page, "Activity Log" should also show the dates of edit activities.

9. "Enter" (when pressing "Enter" button in keyboard) doesn't work in some pages.

10. In "Admin" page, "Load Item" table cannot be seen until user scroll down, it should be shown when user visit the page.

11. When items of inventory are overdue from users, admin should receive message.

6.4 Discussion

High usability and learnability

It is apparent from the 100% success rate during our test that the features we put to test offer high usability as well as learnability.   It is, however, notable that some tasks required some assistance to complete (Fig. 27 & Fig. 28). From our task logger's note, in Test 1, which tested the registered users' functionalities, 40% of participants had initial confusion in task 2 (Change account settings). Participants went for "Dashboard" rather than "Settings" where the account setting functionality actually resides. However, 80% of the participants rated task 2 as either "very easy" or "easy" and the rest rated "neutral". This confirms the learnability that the system provides. This means that the initial confusion of the task did not jeopardize the ease of use. And any user who uses our system more than once can obviously avoid such confusion. Similar pattern of initial confusion can be observed in Test 2, which measured administrative functionalities. This observation, combined with the rating from participants in both tests (Table: 8 & Table: 9), we can conclude that the system we tested provide high usability although some interface redesigns are needed to avoid initial confusions among users.

System Requirements Analysis

As mentioned in section 3.3, our whole system has four main encompassing requirements. Although not all the planned features for both website and the terminal were implemented, we still would like to compare how much the implemented and test features fulfill the requirements set in our project.

- *R1: Provides documentation capabilities for FabLab users*

The relevant task regarding this requirement is task 5 in Test 1, in which we asked participants to create a project. As results from Table: 6 and Table: 8 show, the task as completed successfully by all the participants; also the task receives rating of 4.8 meaning "very easy". So, we can safely say that R1 requirement is met.

- *R2: Provides sharing capabilities of the documentations within the site network and the Internet*

Our team did not manage to implement all relevant features for this requirement. However, task 1 through task 4 (log in, change setting, change profile photo and hide lab status) are stepping stone in this direction. These tested features gave registered users control over their personal information, a standard practice of any registered site, as well as overview of projects they create. The next logical step would be to provide functionality for these profiles to be able to communication. This feature is already in the work and can be implemented in the next iteration of TransPortal project. So, although this requirement is not fully met yet, it is possible to say that a firm foundation has already been set as evident in the high success rate and good ease of use rating from participants (Table: 6 & Table 8).

- *R3: Provides administrative supports for managers of FabLab*

Test 2 exclusively tested features design to support internal work of FabLab. Although not all the administrative features discussed in section 4.2.1 were implemented and tested, our team did manage to implement functionalities that are fundamental for administrative work (i.e. inventory management and user management). Result from the usability test for these features show high success and ease of use rating (Table: 6 & Table: 8). Therefore, similar to R2, the foundation for this requirement has been met.

- *R4: Provides a modular system with flexibility and upgradability*

Unlike other requirements whose fulfillment is proven through the usability test, the achievement of this requirement is evident in the architecture of our system. By architecture, we mean the development framework Laravel, the components and bundles that come along with it, and certain external extensions, such as Bootstrap. Laravel and Bootstrap are open-source. Updates and modifications to the code of the aforementioned resources can be crowd-sourced, while, in most cases, updated and consequently, approved versions are available to the public.

7. CONCLUSION

7.1 Summary and Contribution

As discussed in section 1.1, TransPortal project sets out to solve two main problems FabLabs usually face: Overwhelming internal works for FabLab staff members and few documentation made by users. We devised initial user study with FabLab staff members which provides lots of relevant information about FabLabs and their working environment. Though only part of the aggregated result was used in our project, the full result is to be made publicly accessible so that others can benefit from it.

With lessons learned from survey and literature review, we formulate requirements for our system. These requirements aim to exploit the current widespread of Internet technology to facilitate works of both the FabLab users and FabLab staff members. To enable and encourage documentation among users, we work on a website that incorporate simple and intuitive interface so that users find it easy and convenient to work on. As for the assistance to the Fablab staff, we plan out an administrative system that provides features we believe imperative to the internal work. All these are built on top of an open-sourced and popular framework to ensure the modularity and highest state of the arts.

These requirements were properly met as proven by the usability test at the end of our project. High ratings on success and ease of use from participants show our features are convenient and easy to learn. High score from the System Usability Scale questionnaire further reassures the usability of our system.

Our idea to create a "sign on/off" device aims to add another dimension to the Fablab experience. Although we haven't managed to fully implement and test the feature, we did manage to create a blueprint for this terminal as well as technological architecture that allows it to communicate with the website. We believe that such attempt is worthwhile and we encourage more work in the direction of improving the FabLab experience.

As we plan to provide all the major documentations of TransPortal project to the public, we believe that the FabLab community can learn from our work and eventually contribute to further betterment of this field.

7.2 Future work

Section 4.2.1 shows specific features/requirements initially set out for the website of TransPortal system while section 6 shows which features are implemented and tested. We summarize this information into a table shown below.

FabLab users	Fablab Administrator	Visitors
Create projects	Manage users	View public project
Set privacy to projects	Manage inventory	Interact with users' posts
Create appointments	Manage appointments by lab users.	Download public project files.
Book lab equipments.	Manage calendar events.	
Borrow lab equipments.	Send and receive emails.	
Implement Sign on/off device	Implement Sign on/off device	
View inventory	Access data on lab usage.	
View and export usage data		
View and comments on public projects		
Reply to comments on own projects.		
■ Implemented	■ In Progress	■ Planned

Table 16: Summary of feature implementation

As discussion in section 6.4 shows, the implemented features can be considered successful with only minor interface changes needed. These changes can be made in later iterations of TransPortal, provided that such work is supported. Also, as shown in Table 16, we have only succeeded in creating very fundamental project sharing site, i.e. the capability for the users to create projects. However, the "sharing" part of the system is still missing. However, some works have already been put into features that will allow such capability. Therefore, the next logical step in TransPortal development would be to pick up on the "in progress" features shown in Table 16 above.

Furthermore, our system requirements, discussed in section 3.3, are drawn mainly from our analysis of FabLab Bremen and the survey which targeted other

FabLab staff members. Although, parts of the questionnaires asked about users consumption habits (see appendix A), the answers provided were from the side of FabLab staff. We encourage later users study to directly involve FabLab users so that such information can be more reliably verified and more accurate system requirements can be formulated.

Two more important aspects regarding the future works are on the one hand, making the work of project TransPortal available to the FabLab network and on the other, bringing the sign on /device to a state in which it can be used in the daily routine of the FabLab Bremen. As stated in section 1.1 and 2.1 sharing knowledge and active participation are two of the most important features of the FabLab network. The project TransPortal aims to contribute to the improvement of the communication and organization and with it the sharing of knowledge and active participation amongst the FabLab network. Therefore it is worthwhile for the TransPortal project team to continue the work on the TransPortal system, especially with the help and contributions of other FabLabs which are interested in the project. As for the sign on/off device the TransPortal project team aims to accomplish a fully functional device in order to be able to test and evaluate if this device has a positive influence on the communication with the FabLab users and the awareness for their responsibilities regarding Safety, Operations and Knowledge in the FabLab. (see section 1.1)

On a more exploratory note, we would like to reintroduce idea that our team touched on during our initial brainstorming. However, we had to shed it behind given the limitation on time and resources. The idea is to extent the use of ID card from just for signing in and out to also unlock certain machines in FabLab. With this feature, timestamp of when the users operate machine can be collected and used in various purposes including personal documentation and lab consumption monitoring.

ID key

Laser cutter

3-D printer

Ultimaker

Inventory System

inventory tools

zing

Material Library for Laser Cutter

plastic1 paper1 Wood 2

plastic2 plastic3 plastic4

zing
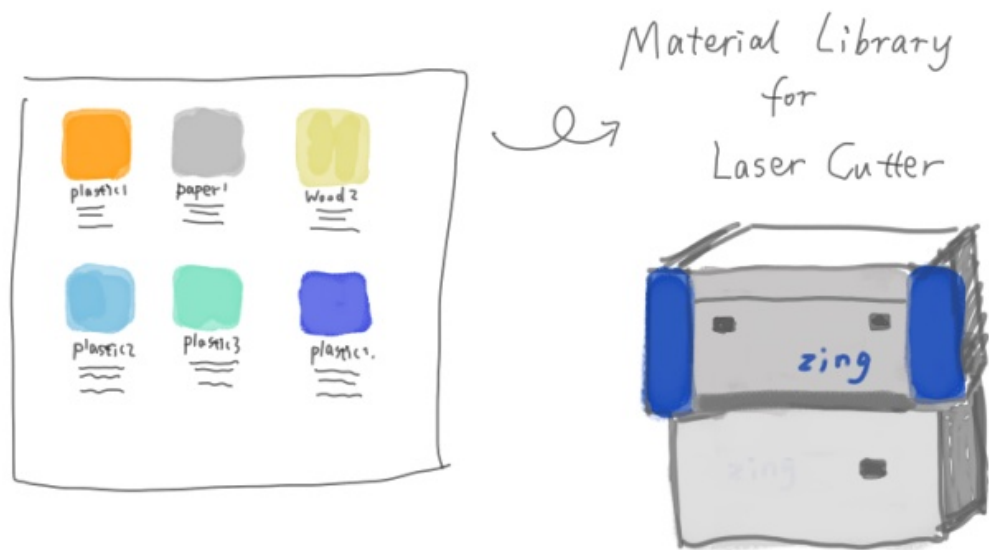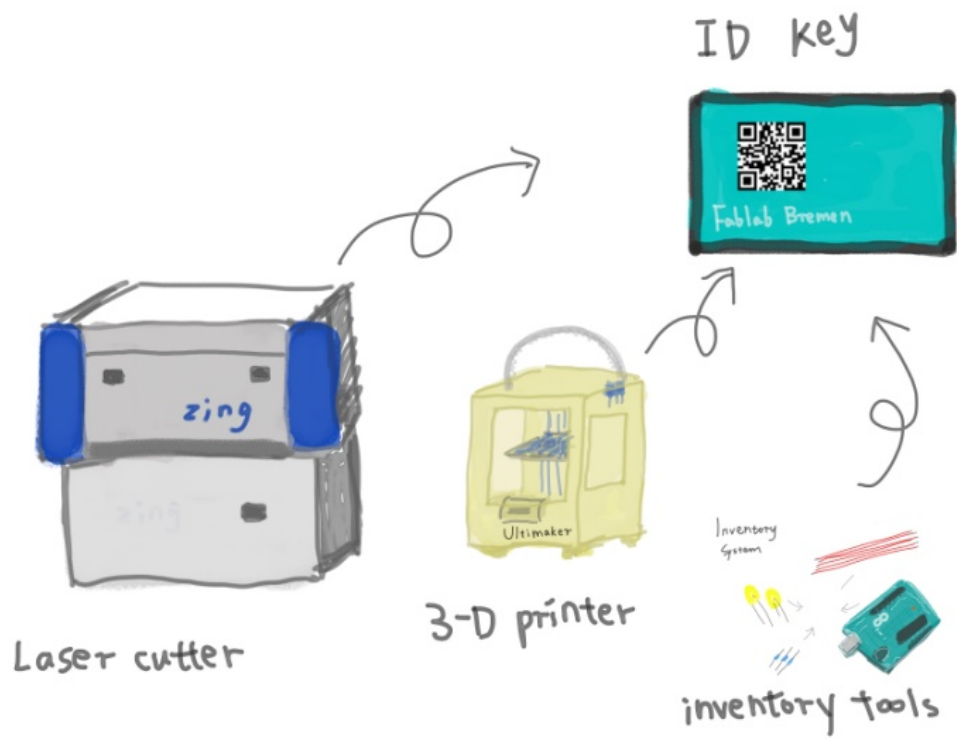
Figure 71: Initial sketches for uses of ID

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APPENDICES

Survey about the organization of FabLabs

Dear FabLab Friends,

we are four Master-Students of "Digital Media" at the University of Bremen. Our names are Xiaofen Peng, Raksmey Meas, Stefanos Trialonis and Simon Engelbertz. The following survey is part of our Master-Project, on which we will work until the end of March 2014. Our supervising lecturers are Sabrina Wilske, Dr. Bernd Robben and Dr.-Ing. Dennis Krannich from the „dimeb" working group at the University of Bremen. Our goal for this project is basically to create an open source „System" which on the one hand, supports FabLab operators/managers in organizing daily tasks and procedures within their FabLab and on the other hand, offers a platform to FabLab Users to document and share their works. Your experiences and ideas regarding the organization of FabLabs would help us to make a valuable open source „System" in the end. Hence we would appreciate very much if you take 10-15 minutes of your time to complete our survey. For further questions regarding our survey we are available at fablabs.bremen@gmail.com

Thanks in advance!

* Required

General/Personal Information

1. **What's your age?** *
   Mark only one oval.

   ( ) 0 -15

   ( ) 16 - 18

   ( ) 19 - 21

   ( ) 22 - 25

   ( ) 26 - 34

   ( ) 35 - 44

   ( ) 45 - 54

   ( ) 55+

   ( ) Prefer not to say

2. **What's your gender?** *
   Mark only one oval.

   ( ) Male

   ( ) Female

   ( ) Prefer not to say

3. **What's your occupation?** *

   ....

Basic FabLab information

4. **What year was your FabLab founded?** *
   Mark only one oval.

   - ◯ 1998
   - ◯ 1999
   - ◯ 2000
   - ◯ 2001
   - ◯ 2002
   - ◯ 2003
   - ◯ 2004
   - ◯ 2005
   - ◯ 2006
   - ◯ 2007
   - ◯ 2008
   - ◯ 2009
   - ◯ 2010
   - ◯ 2011
   - ◯ 2012
   - ◯ 2013
   - ◯

5. **Where is your FabLab located?**
   Mark only one oval.

   - ◯ Afghanistan
   - ◯ Albania
   - ◯ Algeria
   - ◯ American Samoa
   - ◯ Andorra
   - ◯ Angola
   - ◯ Anguilla
   - ◯ Antigua and Barbuda
   - ◯ Argentina
   - ◯ Armenia
   - ◯ Aruba
   - ◯ Australia
   - ◯ Austria
   - ◯ Azerbaijan

- ( ) Taiwan
- ( ) Tajikistan
- ( ) Tanzania
- ( ) Thailand
- ( ) Timor-Leste (East Timor)
- ( ) Togo
- ( ) Tokelau
- ( ) Tonga
- ( ) Trinidad and Tobago
- ( ) Tunisia
- ( ) Turkey
- ( ) Turkmenistan
- ( ) Turks and Caicos Islands
- ( ) Tuvalu
- ( ) Uganda
- ( ) Ukraine
- ( ) United Arab Emirates
- ( ) United Kingdom
- ( ) United States
- ( ) Uruguay
- ( ) Uzbekistan
- ( ) Vanuatu
- ( ) Venezuela
- ( ) Vietnam
- ( ) Virgin Islands
- ( ) Wallis and Futuna Islands
- ( ) Yemen
- ( ) Zambia
- ( ) Zimbabwe

6. **Which city? (Optional)**

....

7. **What is the form of organization of your FabLab?** *

   Mark only one oval.

   ◯ Part of a school

   ◯ Part of a university

   ◯ Independent Fablab (e.g. club)

   ◯ Other: ....

8. **How many staff members do you have?** *

   Mark only one oval.

   ◯ 0

   ◯ 1

   ◯ 2

   ◯ 3

   ◯ 4

   ◯ 5

   ◯ 6

   ◯ 7

   ◯ 8

   ◯ 9

   ◯ 10

   ◯ More than 10

9. **How do the users access FabLab?** *

   Mark only one oval.

   ◯ Every user has his own personal key

   ◯ Users must borrow keys from staff members

   ◯ Users have to make an appointment with staff members

   ◯ Open FabLab days for free access

   ◯ Other: ....

10. **What is your FabLab's area of interest?** *

    *You can choose more than one answer.

    Check all that apply.

    ☐ Entrepreneurship

    ☐ DIY / Hobby

    ☐ Design

    ☐ Engineering

    ☐ Educational

    ☐ Other: ....

11. **Which is your main intended audience for the FabLab?** *

    *You can choose more than one answer.

    Check all that apply.

    ☐ Entrepreneurs

    ☐ DIY people / Hobbyists / Tinkerer

    ☐ Designers

    ☐ Engineers

    ☐ Students

    ☐ Other: _____

12. **How does your FabLab promote events (e.g. workshops, open lab day, …, etc.)?** *

    *You can choose more than one answer.

    Check all that apply.

    ☐ Social media

    ☐ Web page

    ☐ Radio

    ☐ TV

    ☐ Flyer

    ☐ Poster

    ☐ Newsletter

    ☐ None

    ☐ Other: _____

Specific Questions Regarding Organization

13. **Does your FabLab have a webpage?** *

    Mark only one oval.

    ◯ Yes

    ◯ No

14. ***If your answer was Yes, what is the address of your FabLab´s webpage?**

    _____

15. **Does your FabLab have a registration system for its users?** *

    Mark only one oval.

    ◯ Yes

    ◯ No

16. ***If your answer was Yes, what kind of registration system do you have?**

   ....

17. **Do you use any particular platform in your FabLab for users to document and publicize their work? ***
   Please skip the next two questions if your answer is "No".
   Mark only one oval.

   ◯ Yes

   ◯ No

18. ***If your answer was Yes, what is the name of the platform?**

   ....

19. **Do users make use of your default platform for documenting and sharing? ***
   Mark only one oval.

   ◯ Yes, all of them

   ◯ Yes, most of them

   ◯ Yes, a few of them

   ◯ No, none of them

20. **How do you network/cooperate with other FabLabs? ***
   *You can choose more than one answer.
   Check all that apply.

   ☐ Video conference

   ☐ E-mails

   ☐ Online community/forum

   ☐ Conventions

   ☐ Meetings

   ☐ We don't network/cooperate

   ☐ Other: ....

21. **Does your FabLab use a system for scheduling appointments with users and making reservations of equipment/tools? ***
   Mark only one oval.

   ◯ Yes, for both scheduling and reservations

   ◯ Yes, for scheduling appointments only

   ◯ Yes, for making reservations only

   ◯ No

22. **Does your FabLab have an inventory system, which keeps track of the status of equipment and tools? ***

Mark only one oval.

◯ Yes

◯ No

23. **Do you collect important usage data of your FabLab equipment and make it available to the public (e.g. Laser Cutter values, ..., etc)? ***

Mark only one oval.

◯ We collect and make available to the public

◯ We collect, however we don't make available to the public

◯ We do not collect

24. **Please evaluate the importance of the following organizational tools and aspects from a scale of 1 to 5, in regards to the operation of your FabLab ***

* 1 is the most important and 5 is not important at all.

Mark only one oval per row.

	1 (Most important)	2	3	4	5 (Not important)
Web page	◯	◯	◯	◯	◯
Registration system	◯	◯	◯	◯	◯
Scheduling system	◯	◯	◯	◯	◯
Inventory system	◯	◯	◯	◯	◯
Documentation system (for the works of FabLab Users)	◯	◯	◯	◯	◯
Collection and publishing of usage data	◯	◯	◯	◯	◯

25. **Concerning the organization within your FabLab, what do you think is missing?**

....

....

....

....

....

26. **Additional comments, ideas, suggestions, critiques... etc.**

....

....

....

....

....

System Usability Scale for Transportal site

According to your experience using the system, please provide answers to the following statements.

1. **1. I think that I would like to use this system frequently**
   Mark only one oval.

	1	2	3	4	5	
Strongly disagree	◯	◯	◯	◯	◯	Strong agree

2. **2. I found the system unnecessarily complex**
   Mark only one oval.

	1	2	3	4	5	
Strongly disagree	◯	◯	◯	◯	◯	Strong agree

3. **3. I thought the system was easy to use**
   Mark only one oval.

	1	2	3	4	5	
Strongly disagree	◯	◯	◯	◯	◯	Strong agree

4. **4. I think that I would need the support of a technical person to be able to use this system**
   Mark only one oval.

	1	2	3	4	5	
Strongly disagree	◯	◯	◯	◯	◯	Strong agree

5. **5. I found the various functions in this system were well integrated**
   Mark only one oval.

	1	2	3	4	5	
Strongly disagree	◯	◯	◯	◯	◯	Strong agree

6. **6. I thought there was too much inconsistency in this system**
   Mark only one oval.

	1	2	3	4	5	
Strongly disagree	◯	◯	◯	◯	◯	Strong agree

7. **7. I would imagine that most people would learn to use this system very quickly**

   Mark only one oval.

	1	2	3	4	5	
Strongly disagree	◯	◯	◯	◯	◯	Strong agree

8. **8. I found the system very cumbersome to use**

   Mark only one oval.

	1	2	3	4	5	
Strongly disagree	◯	◯	◯	◯	◯	Strong agree

9. **9. I felt very confident using the system**

   Mark only one oval.

	1	2	3	4	5	
Strongly disagree	◯	◯	◯	◯	◯	Strong agree

10. **10. I needed to learn a lot of things before I could get going with this system**

    Mark only one oval.

	1	2	3	4	5	
Strongly disagree	◯	◯	◯	◯	◯	Strong agree

APPENDIX C

38 responses

Summary

General/Personal Information

What's your age?
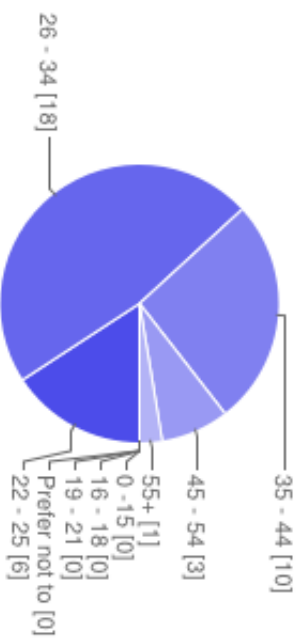
0 - 15	0	0%
16 - 18	0	0%
19 - 21	0	0%
22 - 25	6	16%
26 - 34	18	47%
35 - 44	10	26%
45 - 54	3	8%
55+	1	3%
Prefer not to say	0	0%

What's your gender?

Basic FabLab information

What's your occupation?

coordinator of the fablab   Architect   Software Developer   IT Specialist   mechanical engineer   it architect   Prof. Mechanical Engineering   CAD & 3D-Visualisation-Operator   Fablab Manager   Communication manager   Student   Manager Fablab   fabmanager designer maker   Fab Lab Manager   university lecturer, fablab CEO   ferfger   Engineer   Teacher   physicist   director of Fab Lab Polytech   FabLab Manager   Web developer   Executive Director   Fab Manager   architect   Urbanist/Computer Scientist   Designer / Developer   CCO Scientist   FAB LAB MANAGER   IT sevice manager   Designer   Mechanical Engineer

Male	**32**	84%
Female	**5**	13%
Prefer not to say	**1**	3%

What year was your FabLab founded?

1998	0	0%
1999	0	0%
2000	1	3%
2001	0	0%
2002	0	0%
2003	0	0%
2004	0	0%
2005	0	0%
2006	0	0%

Where is your FabLab located?

2007	1	3%
2008	1	3%
2009	1	3%
2010	3	8%
2011	11	29%
2012	9	24%
2013	11	29%
	0	0%
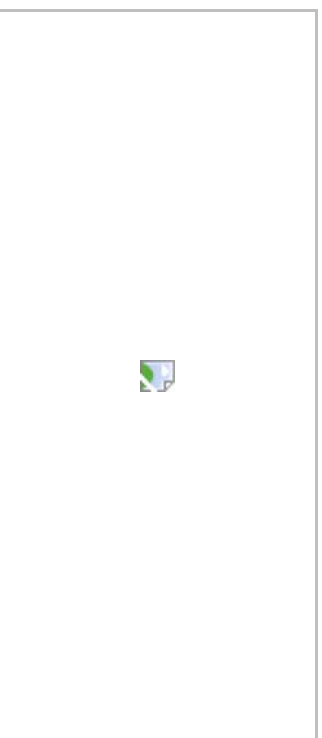
Afghanistan	0	0%
Albania	0	0%
Algeria	0	0%
American Samoa	0	0%
Andorra	0	0%
Angola	0	0%
Anguilla	0	0%
Antigua and Barbuda	0	0%
Argentina	0	0%
Armenia	0	0%
Aruba	0	0%
Australia	0	0%
Austria	0	0%
Azerbaijan	0	0%
Bahamas	0	0%
Bahrain	0	0%
Bangladesh	0	0%
Barbados	0	0%

Country		
Belarus	0	0%
Belgium	1	3%
Belize	0	0%
Benin	0	0%
Bermuda	0	0%
Bhutan	0	0%
Bolivia	0	0%
Bosnia-Herzegovina	0	0%
Botswana	0	0%
Bouvet Island	0	0%
Brazil	0	0%
Brunei	0	0%
Bulgaria	0	0%
Burkina Faso	0	0%
Burundi	0	0%
Cambodia	0	0%
Cameroon	0	0%
Canada	3	8%
Cape Verde	0	0%
Cayman Islands	0	0%
Central African Republic	0	0%
Chad	0	0%
Chile	2	5%
China	0	0%
Christmas Island	0	0%
Cocos (Keeling) Islands	0	0%
Colombia	0	0%
Comoros	0	0%
Congo, Democratic Republic of the (Zaire)	0	0%

Which city? (Optional)

Bucharest Potsdam Berlin Taipei 39100 Cologne Wellington Liège Barcelona Riga Groningen Copenhagen

Palermo Frelisburg Fundão feffewfew Tulsa LEON Berne New York turin Santiago Leipzig Orsay Budapest

Windhoek Munich Amersfoort BREST St. Petersburg Zurich Aachen Lisbon Montreal Nancy

United Kingdom	0	0%
United States	2	5%
Uruguay	0	0%
Uzbekistan	0	0%
Vanuatu	0	0%
Venezuela	0	0%
Vietnam	0	0%
Virgin Islands	0	0%
Wallis and Futuna Islands	0	0%
Yemen	0	0%
Zambia	0	0%
Zimbabwe	0	0%

What is the form of organization of your FabLab?

Independent [16]

Part of a uni [7]

Part of a sch [3]
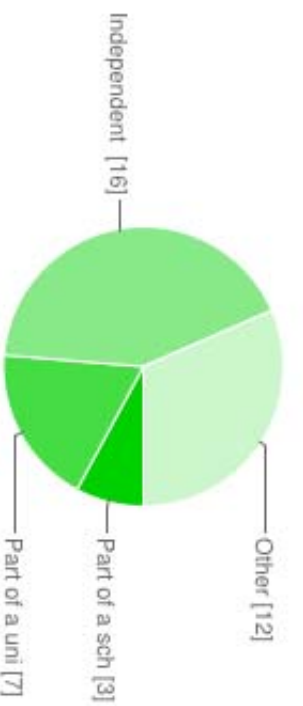
Other [12]

Part of a school	3	8%
Part of a university	7	18%
Independent Fablab (e.g. club)	16	42%
Other	12	32%

How many staff members do you have?
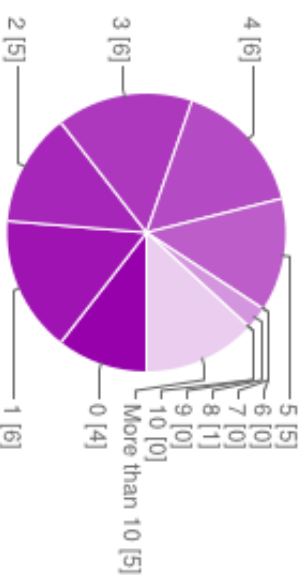
0	4	11%
1	6	16%
2	5	13%
3	6	16%
4	6	16%
5	5	13%
6	0	0%
7	0	0%
8	1	3%
9	0	0%
10	0	0%
More than 10	5	13%

Pie chart labels:
4 [6], 3 [6], 2 [5], 1 [6], 0 [4], More than 10 [5], 10 [0], 9 [0], 8 [1], 7 [0], 6 [0], 5 [5]

How do the users access FabLab?

Pie chart labels:
Open FabLab [13], Other [7], Every user ha [0], Users must bo [1], Users have t [17]
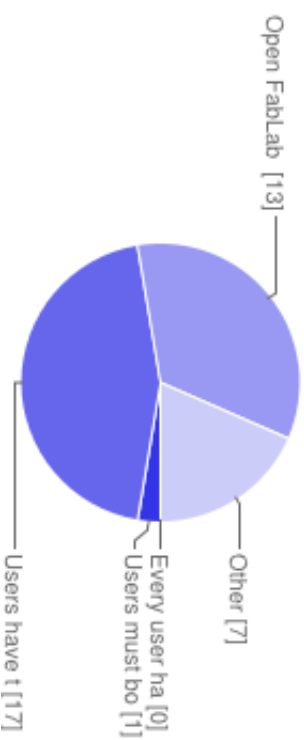
Every user has his own personal key	0	0%
Users must borrow keys from staff members	1	3%
Users have to make an appointment with staff members	17	45%
Open FabLab days for free access	13	34%
Other	7	18%

What is your FabLab's area of interest?

Which is your main intended audience for the FabLab?
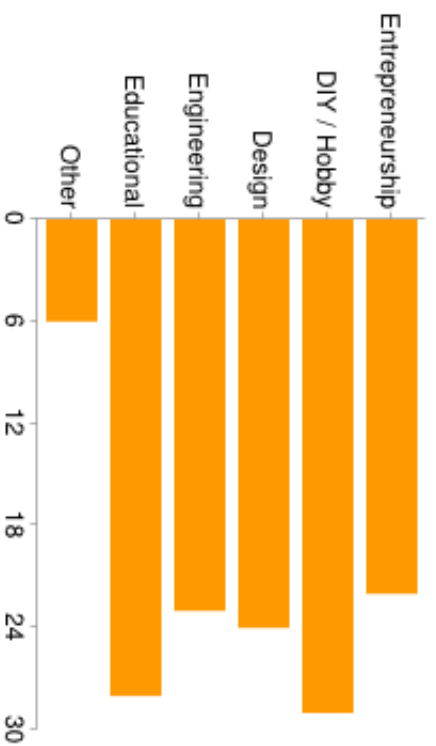
Entrepreneurship	22	17%
DIY / Hobby	29	22%
Design	24	18%
Engineering	23	17%
Educational	28	21%
Other	6	5%

How does your FabLab promote events (e.g. workshops, open lab day, …, etc.)?
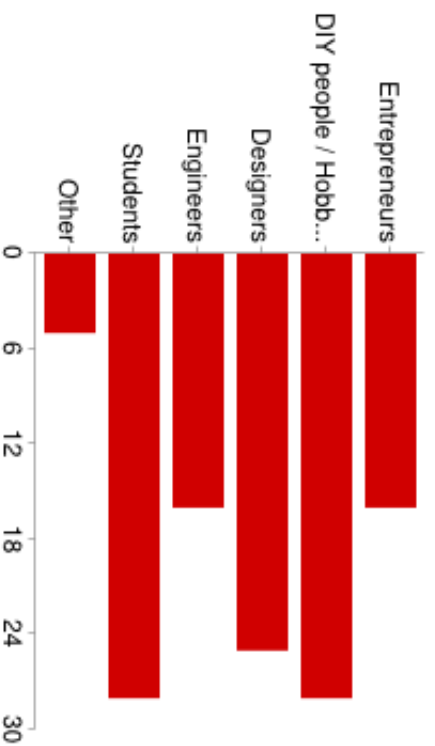
Entrepreneurs	16	14%
DIY people / Hobbyists / Tinkerer	28	24%
Designers	25	21%
Engineers	16	14%
Students	28	24%
Other	5	4%

Specific Questions Regarding Organization

Social media	34	28%
Web page	33	27%
Radio	4	3%
TV	2	2%
Flyer	13	11%
Poster	13	11%
Newsletter	20	16%
None	0	0%
Other	4	3%

Does your FabLab have a webpage?

Yes [37]

No [1]
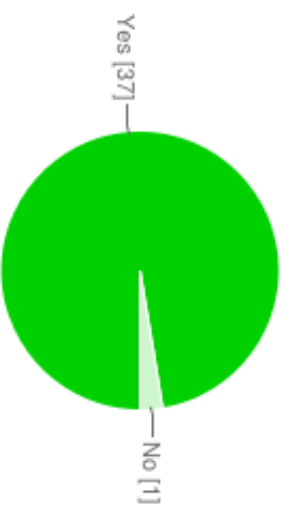
Yes	37	97%
No	1	3%

*If your answer was Yes, what is the address of your FabLab's webpage?

www.dingfabrik.de   www.fablabamersfoort.nl   www.llcb.pt   www.fablab-leipzig.de   http://fablabpalermo.org   WWW.fablableon.org
www.echofab.org   fablab.uchile.cl   http://bit.ly/ProtoListes   http://www.relab.be   www.demoslab.org   fablabnamibia.blogspot.com
fablab1.org   www.machbar-potsdam.de   copenhagenfablab.dk   www.fablabtorino.org   tyfab.fr   www.fablab-muenchen.de   funlab.ch
http://www.biznesainkubators.lu.lv/fablab/   https://www.facebook.com/GSILab   fablabtaipei.org   www.fablab.ro   echofab.org
http://www.fablab-berlin.org   http://www.fablabbcn.org   fablabwgtn.co.nz - under construction   www.fablabgroningen.nl
fablabbudapest.com   www.fablab-net-iki.org   www.garage-lab.de   fablabbern.ch   www.fablablisboa.pt   www.fablabtulsa.com

Does your FabLab have a registration system for its users?

No [23] ——

—— Yes [15]

Yes	**15**	39%
No	**23**	61%
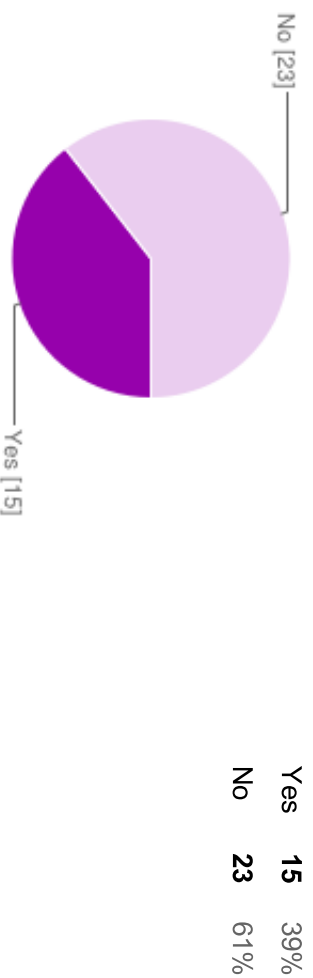
*If your answer was Yes, what kind of registration system do you have?

S2 Member   Drupal website   form   Simply Book me (only for students)   our own with a Joomla motor   google calendar   manually filling out a form   forum   Google spreadsheet (in development)   Currently Access, but seriously looking for something else   wordpress   a form

Do you use any particular platform in your FabLab for users to document and publicize their work?

Yes [28]

—— No [10]

Yes	**28**	74%
No	**10**	26%
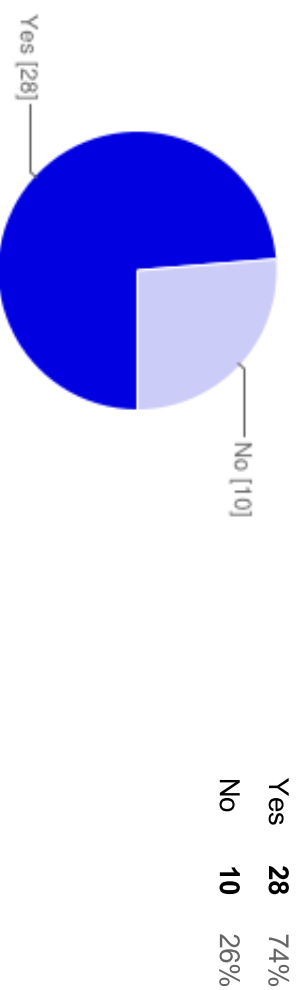
*If your answer was Yes, what is the name of the platform?

www.dingfabrik.de   Drupal   Wiki   wiki.fablab.is   Not yet, but will do posts on the blog via member names   Website posts   Custom (opensource) Drupal module and configuration   google docs   wiki   Blog, Forum, Wiki   Wordpress   knowable   Blog and wiki   facebook   thingiverse, internal system, developing all systems   media wiki   Media Wiki   Instructables- group FabLab Leon   wordpress   Based on MediaWiki and Thingiverse   Facebook & Fabmoments website   dokuwiki   github   Confluence Wiki

Do users make use of your default platform for documenting and sharing?
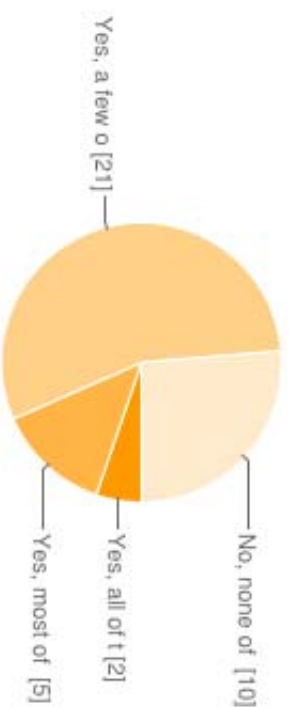
|		
Yes, all of them	2	5%
Yes, most of them	5	13%
Yes, a few of them	21	55%
No, none of them	10	26%

How do you network/cooperate with other FabLabs?
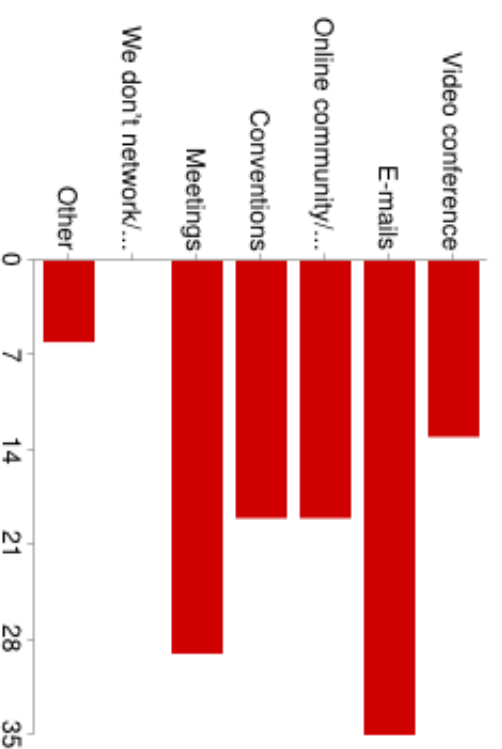
Video conference	13	11%
E-mails	35	29%
Online community/forum	19	16%
Conventions	19	16%
Meetings	29	24%
We don't network/cooperate	0	0%
Other	6	5%

Does your FabLab use a system for scheduling appointments with users and making reservations of equipment/tools?
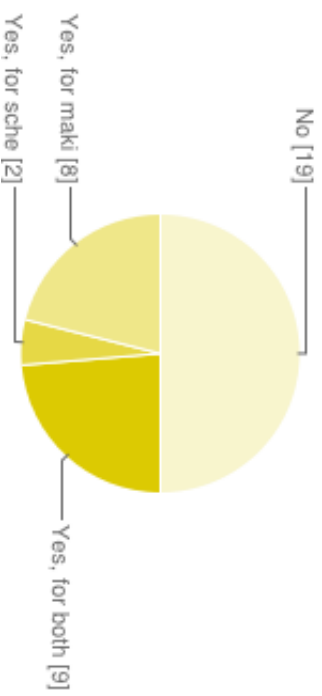
Yes, for both scheduling and reservations	9	24%
Yes, for scheduling appointments only	2	5%
Yes, for making reservations only	8	21%
No	19	50%

- No [19]
- Yes, for maki [8]
- Yes, for sche [2]
- Yes, for both [9]

Does your FabLab have an inventory system, which keeps track of the status of equipment and tools?

Yes	12	32%
No	26	68%

- No [26]
- Yes [12]

Do you collect important usage data of your FabLab equipment and make it available to the public (e.g. Laser Cutter values, ..., etc)?
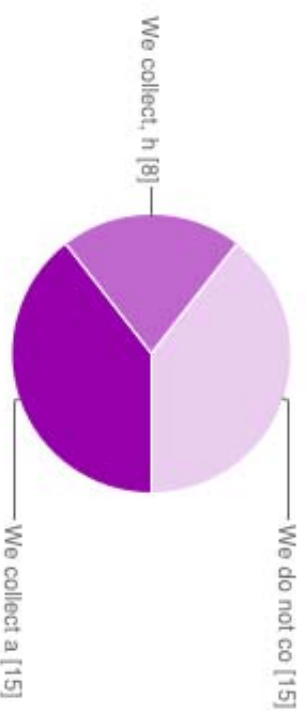
We collect and make available to the public	15	39%
We collect, however we don't make available to the public	8	21%
We do not collect	15	39%

- We collect, h [8]
- We collect a [15]
- We do not co [15]

Web page [Please evaluate the importance of the following organizational tools and aspects from a scale of 1 to 5, in regards to the operation of your FabLab]

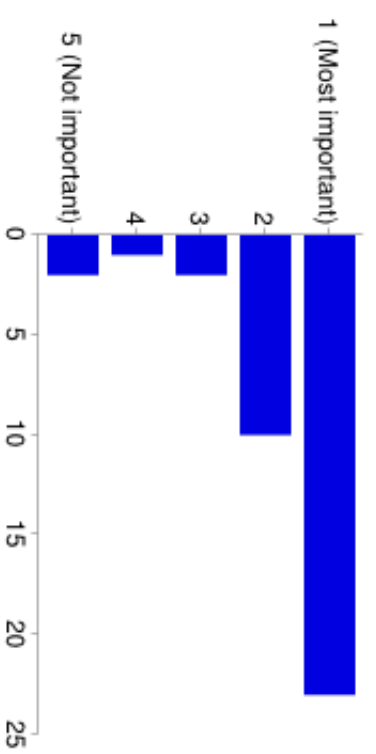|		
1 (Most important)	23	61%
2	10	26%
3	2	5%
4	1	3%
5 (Not important)	2	5%

Registration system [Please evaluate the importance of the following organizational tools and aspects from a scale of 1 to 5, in regards to the operation of your FabLab]
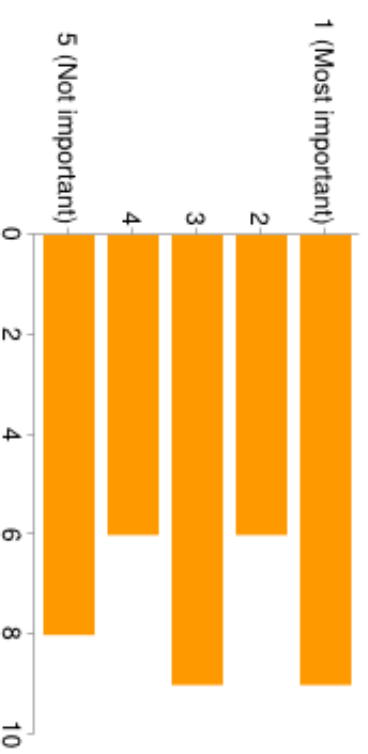
1 (Most important)	9	24%
2	6	16%
3	9	24%
4	6	16%
5 (Not important)	8	21%

Scheduling system [Please evaluate the importance of the following organizational tools and aspects from a scale of 1 to 5, in regards to the operation of your FabLab]

Inventory system [Please evaluate the importance of the following organizational tools and aspects from a scale of 1 to 5, in regards to the operation of your FabLab]

1 (Most important)	8	21%
2	11	29%
3	13	34%
4	2	5%
5 (Not important)	4	11%

Documentation system (for the works of FabLab Users) [Please evaluate the importance of the following organizational tools and aspects from a scale of 1 to 5, in regards to the operation of your FabLab]

1 (Most important)	5	13%
2	9	24%
3	18	47%
4	4	11%
5 (Not important)	2	5%

Collection and publishing of usage data [Please evaluate the importance of the following organizational tools and aspects from a scale of 1 to 5, in regards to the operation of your FabLab]
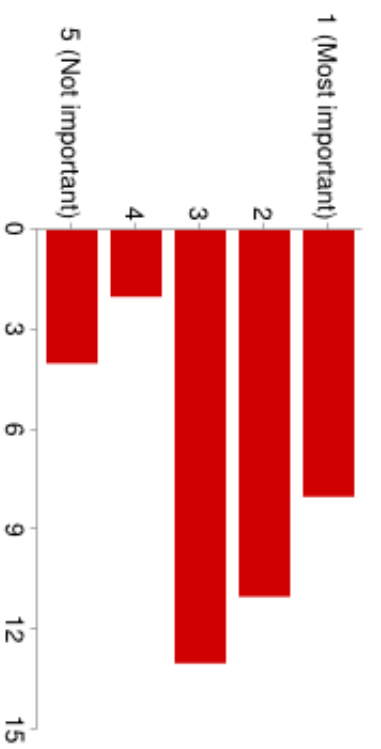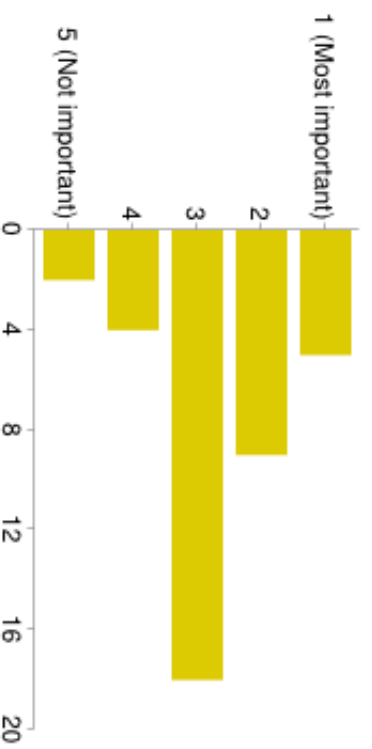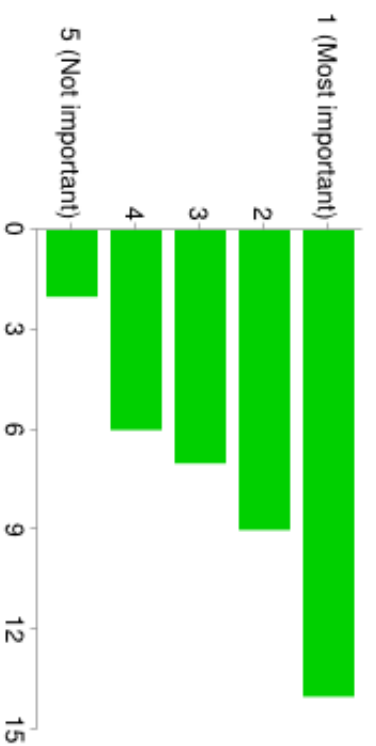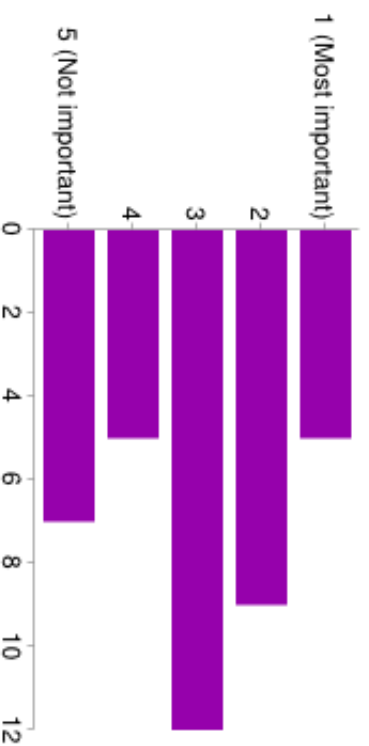

1 (Most important)	14	37%
2	9	24%
3	7	18%
4	6	16%
5 (Not important)	2	5%

1 (Most important)	5	13%
2	9	24%
3	12	32%
4	5	13%
5 (Not important)	7	18%

Concerning the organization within your FabLab, what do you think is missing?

- real good documentary system - scheduling system for different kind of persons   exactly what you're working one, a tool to let user share their work easily.   Appropriate communication plan Interesting projects/events   A more automated way of know who is using what (usage data statistics)..... We use an internal wiki and sometimes is difficult to get people really making good use of it.   Scheduling system   It is a Mini-Fablab, nothing missing   Simple tools with video tutorials for every single functionality to decentralize organization. Non-techies dislike to login in different tools and to use tools, techies dislike to communicate with clear benefit to their certain problems.   Tools, equipment and financing.   A goof booking system for machines   Internal Organization   A good efficient way to document projects.   A tool for keeping track of alternative suppliers (than the US-centric Fablab "hardware specification") and sharing this with other fablabs in the same global region. A micro-mill and

Shopbot tool-bit date/use/replace system?   We need a booking system with integrated payment service for our workshops   Money. Good documentation plateforme   More human resources, More funds More visibility and better organization of the projects that are developed in order to trigger more and better projects   un outil simple et efficace pour documenter ce que l'on fait   A sceduling system synced with the web page would be nice.   A way to promote long projects and to document them, most people go there for a certain issue and we never see them again.

As we are only in our 2nd year, our systems are still developing. I have just employed a part time person which will make a big difference. We are working on shifting the paper-based booking systems into a web-based system and will be testing this in the next two months. That's the main thing that is missing, a visible calendar and booking system for internal and external users.   (Semi-)Automatic billing system and user registration   Money for a full time FabLab manager Entrepreneurs who cooperate with FabLab in a win-win situation   standard plug-ins for WP or Drupal (or made in PHP, etc.) that allow people to start easily with a package of basic service   Time for students to freely explore and tinker. We're a pretty new fablab, its keep improving but still have a lot of work need to be done.   dfergferfgergerge   gerarchy

Additional comments, ideas, suggestions, critiques... etc.

Good luck.   yeah, if you need any help I'd be glad to ! My area of expertise is web design / HTML / CSS / JS / wordpress. Good luck ! Integrate us in the international Fab Lab Organisation   I think this is a GREAT idea! I really hope you succeed in your project - which would be a great asset to the Fablabs.   International fablab portals already exist, no need do create another one. See http://www.fabfoundation.org/   What is meant with registration system? Because of protection of personal data we have no system to register at our entrance but of course we have a form to get an official club member. Via our mailing lists we do most of our intern communication.   - international repository of projects, that must be accessible, opensource, and free - standard process to be legally protected against possible patent done by enterprises copying an open source project   Ill email you guys about the system we use to share knowledge.   Cheers   efgergergerger   More grassroot Fab Lab!   I look forward to seeing what you all discover about Fab Labs   As I read somewhere, the fablab global network interaction is being incredibly difficult since each fablab is busy with its own problems, which is even more critical in places with low fablab densities as south-america. Also, most people aren't willing to learn most of the things required to do things in a fablab, instead they prefer to pay someone else to do it for them.

Number of daily responses
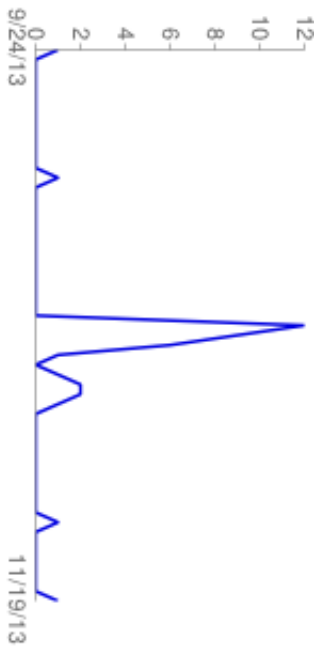
APPENDIX D

Task Rating after each task

Based on your experience with the task you just completed, Please answer the following question.

---

1. Overall, this task was

```
              1   2   3   4   5
Very Difficult  ○   ○   ○   ○   ○   Very Easy
```

Close

APPENDIX E

```python
#!/usr/bin/env python
#-*- coding: UTF-8 -*-
"""
Main Program

"""
#Import of python libraries and subprograms used in the main program
import RPi.GPIO as GPIO
import time, gpiocall, qrcode, urlcallenter, urlcallesc, servos2

#declare and initialize variables for the ENTER- and the ESC-Button
ENTER_Button = 9
ESC_Button = 11

#Choose "Broadcom SOC channel" (BCM) numbering scheme for GPIO pins
GPIO.setmode(GPIO.BCM)
GPIO.setwarnings(False)

#set GPIO pin 9(ENTER_Button) and pin 11(ESC_Button) as INPUT with pull down resistor
GPIO.setup(ENTER_Button, GPIO.IN, pull_up_down = GPIO.PUD_UP)
GPIO.setup(ESC_Button, GPIO.IN, pull_up_down = GPIO.PUD_UP)

#Interrupt function: add falling edge detection on channel 9 (ENTER_Button) and 11(ESC_Button)
GPIO.add_event_detect(ESC_Button, GPIO.FALLING)
GPIO.add_event_detect(ENTER_Button, GPIO.FALLING)

#enter() function is called whenever the ENTER button is pressed
def enter():
    print "Enter Button is pressed"
    #call servos2.start() function in order to drive out the webcam and turn on the blue LEDs
    servos2.start()
    #call qrcode.lesen() function in order to start scanning QR-codes for 30 sec.
    # and return QR-code result if a QRcode was successfully read,
    #The method strip() returns a copy of the string in which all chars have been stripped
    # from the beginning and the end of the string (default whitespace characters).
    #see: http://docs.python.org/2/library/stdtypes.html
    result_enter = qrcode.read().strip()
    print result_enter
    #do if no QR-code was scanned
    if result_enter == "NoValidQRcode":
        #call gpiocall.ledFeedback() function in order to turn on the red LEDs
        gpiocall.ledFeedback(result_enter)
        #call servos2.end() in order to drive in the webcam and to turn off the red LEDs
        servos2.end()
    #do if QR-code was scanned
    else:
        #call urlcallenter.create() function to check if the value of the QR-code was a valid
member ID
        # by creating a URL with the Qr-code value and request that URL
        result2_enter = urlcallenter.create(result_enter)
        #call gpiocall.ledFeedback() function in order to turn on the green LEDs if
        # the value of the QR-code was a valid member ID, turn on the red LEDs if the the
        # value of the QR-code was not a valid member ID
        gpiocall.ledFeedback(result2_enter)
        #call servos2.end() in order to drive in the webcam and to turn off the green or the
red LEDs
        servos2.end()

#esc() function is called whenever the ESC button is pressed; works the same way as the enter()
function
def esc():
    print "ESC Button is pressed"
    servos2.start()
    result_esc = qrcode.read().strip()
    print result_esc
    if result_esc == "NoValidQRcode":
        gpiocall.ledFeedback(result_esc)
        servos2.end()
    else:
        result2_esc = urlcallesc.create(result_esc)
        gpiocall.ledFeedback(result2_esc)
        servos2.end()

#While-loop makes sure that the main program is constantly running and checking for falling
edges on pin 9 and 11
while True:
```

```python
        #check for falling edge on pin 9(ENTER_Button)
        #if falling edge is detected on pin 9 start function enter()
        #when function enter() is finished wait for 0.5 seconds
        if GPIO.event_detected(ENTER_Button):
                enter()
                time.sleep(0.5)
        #check for falling edge on pin 11(ESC_Button)
        #if falling edge is detected on pin 11 start function esc()
        #when function enter() is finished wait for 0.5 seconds
        elif GPIO.event_detected(ESC_Button):
                esc()
                time.sleep(0.5)
        #if no falling edge is detected print "Waiting for someone to push the ENTER or ESC
button"
        # and after that wait for 0.5 seconds
        else:
                print "Waiting for someone to push the ENTER or ESC button"
                time.sleep(0.5)
```

```python
#!/usr/bin/python
#-*- coding: UTF-8 -*-

import RPi.GPIO as GPIO
from Adafruit_PWM_Servo_Driver import PWM
import time, RGB_Driver

# ==========================================================================
# Control servos and RGB LEDs
# ==========================================================================

# Initialise the PWM device using the default address
# bmp = PWM(0x40, debug=True)
pwm = PWM(0x40, debug=True)

#Initialise LED Variables for channel 10(=blue), 13(=green) and 15(=red)
LEDblue = 10
LEDgreen = 13
LEDred = 15

#Initialise servo
servo = 1

# Min pulse length, us (tick 184/4096)
servoMin = 800
# Max pulse length, us  (tick 430/4096)
servoMax = 2025
# Midpoint pulse length, us
servoMid = servoMax - ((servoMax-servoMin)/2)
# cycle length, Hz
cycle = 60
pulseLength = 1000000 / cycle
# 12 bit resolution
tick = pulseLength / 4096

# we need to convert us pulses to 12 bit ticks
def setServoPulse(channel, pulse):
    pwm.setPWM(channel, 0, pulse/tick)

pwm.setPWMFreq(cycle) # Set frequency

def start():

    # Turn On Blue Light
    pwm.setPWM(LEDblue, 0, 4080)

    #Servo start position
    setServoPulse(servo, servoMin)
    time.sleep(0.2)
    setServoPulse(servo, servoMax)
    time.sleep(0.2)
    setServoPulse(servo, 0)
    time.sleep(0.2)

def end():
    # Servo starts moving out
    setServoPulse(servo, servoMax)
    time.sleep(0.2)

    # Endposition
    setServoPulse(servo, servoMin)
    time.sleep(0.2)

    #Turn off servos
    setServoPulse(servo, 0)
    time.sleep(0.1)

    #Turn off LEDs
    pwm.setPWM(LEDblue, 0, 0)
    time.sleep(0.1)
    pwm.setPWM(LEDgreen, 0, 0)
    time.sleep(0.1)
    pwm.setPWM(LEDred, 0, 0)
```

```python
#!/usr/bin/env python
#-*- coding: UTF-8 -*-
"""
reads QR-Codes

"""

import os, signal, subprocess, time
def lesen():
    #Starts detection for QR-Codes as a subprocess, webcam resolution is set to 320x240
(prescale) and the subprocess is timed to run for 30 seconds
    zbarcam=subprocess.Popen("zbarcam --prescale=320x240 --raw --nodisplay /dev/video0 & sleep
30; kill $!", stdout=subprocess.PIPE, shell=True, preexec_fn=os.setsid)
    print "zbarcam erfolgreich gestartet..."
    while zbarcam.poll() is None:
        time.sleep(1)
        qrcodetext=zbarcam.stdout.readline()
        if qrcodetext!="":
                print qrcodetext
                print "QR-Code was detected"
                break

    #Stop zbarcam subprocess
    os.killpg(zbarcam.pid, signal.SIGTERM)
    print "zbarcam erfolgreich gestoppt"

    #Return QR code content according to wheather or not a QR-code was detected
    if qrcodetext!="":
        return qrcodetext
    else:
        qrcodetext="NoValidQRcode"
        print "no QR-code was detected"
        return qrcodetext
```

```python
#!/usr/bin/env python
#-*- coding: UTF-8 -*-
"""
requests TransPortal url according to the QR-Code

"""

import urllib, urllib2

def create(value):
    exception = "/"
    errorMessage = "invalid QRcode"
    print "Url wird erzeugt"
    params = value
    if (exception in params) or (not params):
        return errorMessage
    else:
        raw_url = 'http://dk1.informatik.uni-bremen.de/account/qrscan/1/'
        url = raw_url + urllib.quote(params)
        print url
        req = urllib2.Request(url)
        print req
        response = urllib2.urlopen(req)
        the_page = response.read()
        return the_page
```

```python
#!/usr/bin/env python
#-*- coding: UTF-8 -*-
"""
ruft url auf

"""

import urllib, urllib2

def create(value):
    exception = "/"
    errorMessage = "invalid QRcode"
    print "Url wird erzeugt"
    params = value
    if exception in params:
        return errorMessage
    else:
        raw_url = 'http://dk1.informatik.uni-bremen.de/account/qrscan/0/'
        url = raw_url + urllib.quote(params)
        print url
        req = urllib2.Request(url)
        print req
        response = urllib2.urlopen(req)
        the_page = response.read()
        return the_page
```

```python
#!/usr/bin/env python
#-*- coding: UTF-8 -*-

from Adafruit_PWM_Servo_Driver import PWM
import time, RGB_Driver, servos

def ledFeedback(value):
    VAR = value
    print VAR
    #Initialise LED Variables
    LEDblue = 10
    LEDgreen = 13
    LEDred = 15
    LOGin = "in the lab"
    LOGout = "exiting the lab"
    LOGError = "sorry wrong"
    INVALIDqr = "invalid QRcode"

    print "Feedback"

    while True:
        if LOGin in VAR:
            servos.setServoPulse(LEDblue, 0)
            time.sleep(0.5)
            servos.setServoPulse(LEDgreen, 2600)
            time.sleep(1)
            print "Welcome to the FabLab Bremen"
            break
        elif LOGout in VAR:
            servos.setServoPulse(LEDblue, 0)
            time.sleep(0.5)
            servos.setServoPulse(LEDgreen, 2600)
            time.sleep(1)
            print "Tschüssikowsky"
            break
        elif LOGError in VAR:
            print "Log In / Log Out failed!"
            servos.setServoPulse(LEDblue, 0)
            time.sleep(0.5)
            servos.setServoPulse(LEDred, 2600)
            break
        elif VAR == INVALIDqr:
            print "Log In / Log Out failed!"
            servos.setServoPulse(LEDblue, 0)
            time.sleep(0.5)
            servos.setServoPulse(LEDred, 2600)
            break
        elif VAR == None:
            print "Log In / Log Out failed!"
            servos.setServoPulse(LEDblue, 0)
            time.sleep(0.5)
            servos.setServoPulse(LEDred, 2600)
            break
        else:
            print "Log In / Log Out failed!"
            servos.setServoPulse(LEDblue, 0)
            time.sleep(0.5)
            servos.setServoPulse(LEDred, 2600)
            break
```

APPENDIX F

The Fab Charter

What is a fab lab?

Fab labs are a global network of local labs, enabling invention by providing access to tools for digital fabrication

What's in a fab lab?

Fab labs share an evolving inventory of core capabilities to make (almost) anything, allowing people and projects to be shared

What does the fab lab network provide?

Operational, educational, technical, financial, and logistical assistance beyond what's available within one lab

Who can use a fab lab?

Fab labs are available as a community resource, offering open access for individuals as well as scheduled access for programs

What are your responsibilities?

safety: not hurting people or machines
operations: assisting with cleaning, maintaining, and improving the lab
knowledge: contributing to documentation and instruction

Who owns fab lab inventions?

Designs and processes developed in fab labs can be protected and sold however an inventor chooses, but should remain available for individuals to use and learn from

How can businesses use a fab lab?

Commercial activities can be prototyped and incubated in a fab lab, but they must not conflict with other uses, they should grow beyond rather than within the lab, and they are expected

to benefit the inventors, labs, and networks that contribute to
their success

draft: October 20, 2012