Redefining the role of designers within an urban community using digital design and localized manufacturing of wearables.

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***Abstract*— The maker culture has created a dynamic in which designers are less responsible for the design and quality of the final product, but for the tools the consumer uses to create their own.**

While additive manufacturing (AM) is gaining acceptance among the general public, it is still seen as a prototyping tool instead of a high quality production technology. This limits its acceptance within co-design and maker culture. The research question is: How to create greater acceptance among the general public regarding the AM technology and its products?

One way to create greater acceptance of digital design and manufacturing is to apply co-design principles on a local scale. By this means the public will be exposed and included in the design and production process, which will ensure the end product is better accepted. In time this could help spark a maker movement within the community. To validate these assumptions a test case was developed in which local design and production of simple wearables, small ready to wear garments like socks or hats, within an urban community will play a major role.

During the research a digital design tool combined with a mobile digital knitting machine was developed to allow for a rapid co-design track. Wearables would be produced by the consumer themselves. The final design of the garment depends on the consumer's choice of material, shape and pattern. A mobile set-up provides the means to test the principle at different locations and allows the consumer to be intensively involved in the maker movement in their own neighbourhood. We implemented a small, low-cost knitting machine that was tested outdoors by park visitors.

The anticipated results for this test case were: increased engagement in the production process, larger acceptance of digital design and an initial maker culture. Although the last result will be difficult to determine as it takes some time to develop. If successful, the maker culture will obtain greater exposure, acceptance and demand for digital design services and products. Even though the maker culture changes the role of the designer will definitely change, their importance to the design process will remain, not as a creator of designs but moreover as a guide to the making of consumer products.

Keywords-component; Co-design, Digital manufacturing, Wearable's, Maker Culture, Sustainablity, Local manufactoring

1. General Introduction

Even though digital design has made big leaps in the last years, most consumers are still very much unaware of its potential. This is limiting the development as more users and cases within the field will help mature the technology. In order to facilitate a greater awareness and eventually acceptance we need to look outside the current scope of the exposure of the technology. How to create greater acceptance among the general public regarding the AM technology and its products? This will be the main question addressed in this paper.

There are several means to try and achieve greater acceptance among the general public however, not all are aimed towards this particular issue. When looking at the general knowledge about the production of user products most people are blissfully unaware. This creates a lot of preconceived notions about the difficulties and also possibilities during the production steps. In order to get a more realistic perception regarding AM it is therefore imperative to expose the general public to its difficulties and more importantly its opportunities.

Even though the freedom created by digital design and manufacturing is not necessarily desired by the consumers, it also allows the design community to develop and define this design space through tools and methodology. This ensures that the users of AM facilitated design and production will be able to freely explore its possibilities without being overwhelmed.

The chosen product group, wearables, was selected for it duality. While on one hand garments and other body orientated products are used as an expression of personal style and preference. Yet at the same time it also follows mass consumer behaviour. These two seem to be in direct conflict with each other.

Another aspect in regards to wearables is product fit (Van Der Velden, Patel & Vogtländer, 2014). While no two people are exactly alike the consumers have to cope with standardized sizes. This in stark contrast to the fact that a correctly fitted product can greatly increase the product satisfaction. As such it is an area well suited to the possibilities of digital design and production, as it allows the users to design and wear made to measure or even bespoke tailored garments. Which in turn should result in a greater product attachment which carries value in the field of emotional sustainability.

To ensure that consumers are aware of the possibilities granted by these technologies and expose them to it in a proper way is a challenge. This creates possibilities for designers to reshape their roles within this dynamic. As designers now get the opportunity to create the tools with which the everyday consumer could design and create their own wearables.

To achieve this the following activities were undertaken to test the public's receptiveness to AM produced clothing. First of all a more detailed overview of the developments in local design & manufacturing will be given, as it defines the scope of the research. Followed by selecting a method of creating this acceptance, it will need to fit the context of not just creating acceptance but also instigating a maker spark in the consumer. This will then be applied to an interaction design to create the desired outcome. This interaction will be tested within a public area to validate its effect on the public. After which it will be evaluated and suggestions for adaptations to further improve its effectiveness are given.

2. State of the Art Local Design & Manufacturing

2.1. Redefining the role

Within the current wearables market the interaction is based on the industrial production of clothing. This results in a gap between designer and end user, with producer, wholesalers and retailers as the stakeholders (Figure 1). This construction has benefits, since each stakeholder has a clear task which can be optimized and perfected. However it also results in a lot of global shipping and a gap between designer and end user. The process also relies on large production numbers in order to function creating the need for standardization.

When looking at the new dynamic that is created though local design & manufacturing (LDM) we see that the stakeholders change and that they take on new roles. This contrasting dynamic creates new opportunities and benefits. The close proximity both physically and structurally allows for different design methods and interactions. It creates room for personal/ one off designs as well as small locally influenced series of products. This new dynamic however does ask for different design tools and methods. As such redefining the role of a designer in this context will be imperative. Localized manufacturing has other benefits regarding sustainability, when looking at shipping and emotional sustainability. As the involvement with the creation of the product grows so will the attachment.

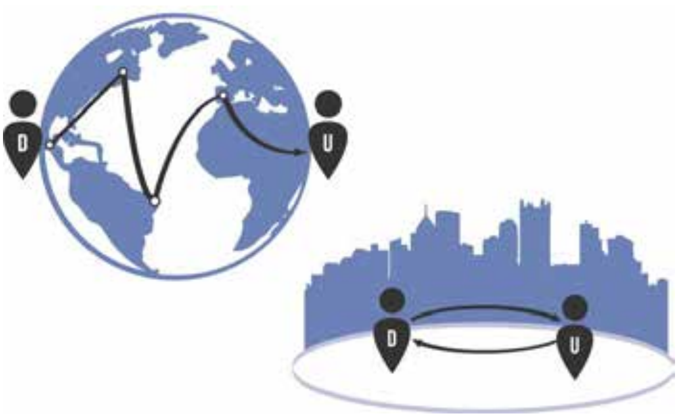

Figure 1. Current interaction and the envisioned interaction between designer and consumer

2.2. Maker culture

One of the main drivers behind localized manufacturing , and a redefining one for designers, is the rise of the maker culture. This cultural shift from mass produced to home-/self-made products is driving a new wave of development in localized manufacturing and design tools and methodology. One of the ways designers can reinvent themselves is to tap into this movement and create the design tools needed for the general public to design and create their own products. While the early adapters have the skills to design and make what they come up with, this will not be the case for everyone. So this leaves a group to design for.

The exposure of this maker culture is something else to consider, the current methods are aimed at the first group. They consist of several facilities/activities:

a) Fablab

The fablab principle is something that fits into the maker culture, as it allows makers to build more complex products for which they do not own the tools or have the expertise to build. These workplaces are stocked with digital manufacturing tools like; 3d printers, CNC machine and laser cutters. These are augmented by the more common tools like; drills, laves and band saws. These spaces are either open to the general public or are linked to educational or artistic institutes. While most major cities around the world have a fablab facility, most are hidden from public view due to location or lack of recognizable markings. This results in a lack of public knowledge about the facilities and as such fails to connect to the general public (http://fablab.org).

b) Makerfairs

These events are generally held in public areas/ buildings and generate more public awareness and attention. While still visited mainly by makers, they also attract people generally interested but not (yet) participating in maker culture. These event help to showcase, educate and create appeal for the results of maker culture. This has a great benefit in helping the movement to grow and develop. As fellow makers can meet and exchange ideas. This is augmented by the physical nature of the event in that the products and tools are there and can be used/touched and explored. Still most of the visitors are already interested in or connected to the movement, creating a new wave of makers from yet unengaged people is not the aim of these events. (http://makerfaire.com/)

c) Digital Maker Culture

One of the effects of the digital design is the ability to share it using digital media. This does not exclude other non-digital designs as tutorials are also wide spread. This helps to create exposure for the products that can be made. While most users of digital and social media will come into contact with maker culture the effect of seeing a picture or movie is not the same as holding the actual product. This gap between exposure and contact is a limiting factor in creating attraction in regards to the final product (Doctorow, 2009).

3. Method

3.1. Co Creation

In order to test the new dynamic between designer and end user it is important to redefine their relation. The freedom created by LDM also creates a larger design space. In order to help guide the end user in this process designers have an opportunity to lend their expertise by means of Co Creation.

Within this design method designers are moving away from translating the needs of the end user into a product. Instead they are facilitating the creation of this product by the end user (Sanders & Stappers, 2008). This shift not only redefines the role of the designer but does the same for the role of the end user. Since They will have a greater influence on the front end of the design process, and as such on the final product

This coincided with the change in dynamic envisioned for the application of LDM as the method allows for local influences to guide the design process. It is not just limited to the local users but also local materials and cultural heritage. This will be used in combination with the design of wearables, were a correct fit and integration of personal style is valuable.

3.2. Concept testing

In order to evaluate the success of a localized manufacturing process concept testing will be used. The concept will be evaluated on several key aspects; general, features, product, durability and reliability. These aspects represent the desired overall qualities of the concept.

By testing the concept using the intended target group as well as the intended context, the following data can be collected photographs, video and interviews. These will show the general public's overall interaction with the concept as well as offer detailed accounts of individual interactions. These results will then be used to create a concept testing matrix. This will either validate or invalidate the concept as a means to achieve the desired goal of creating greater acceptance and interest.

4. Developing Wally 120

4.1. Preperations

In order to facilitate the localized manufacturing aspect of the test case, a mobile digital manufacturing tool was needed. In order to use the tool within the local context several criteria where listed:

- It needs to be mobile, or light enough to be moved by a single person (less than 10 kg.)
- Big enough to create small garments; socks, scarfs, hats.
- Self-sustained when in use, no external power needed at the production location.
- Allow for a made to measure approach, allowing the user to take his or her own measurements by adapting an existing template.
- It needs to be reliable, as a minor error will ruin a garment.
- The product coming out of the machine should require little to no extra actions, as close to ready to wear as possible.

In order to create clothing without directly using traditional methods there are several options. There are methods that work with regular yarn and use weaving/knitting techniques. Furthermore 3d printing clothing is being considered within the design community as a replacement of these traditional material and production techniques. However the aim of this research is to test ready to wear garments. While 3d Printing allows for great freedom in shape and construction it is seen more as an haute couture fashion technique for example the works of Iris van Herpen. This combined with the long production time makes it unusable for this research as the aim is to create more acceptance a more intermediate step is needed. As such the following possibilities were taken into consideration. Each will be shortly addressed and checked with the criteria.

a) Knitic, manual knitting machine hack

This system is a recent development, where by hacking the old manual knitting machines you are able to create new digital designs. The Knitic design couple is working with this technology using several interesting input signals to create uniquely patterned designs. The machines are reliable as they basically hack into an existing flat knitting machine.

The main problem this creates is the sheer size and weight of these machines. The machine also is not able to knit full garments as it only allows for sheet knitting, this increases the manual workload after the initial knitting.

Although possibly more reliable they are hard to modify. And while an interesting project it seemed unsuited for the current goal of local exposure.

Figure 2. KNITIC digital design knitting machine & pattern example

b) Circular knitting machine

When looking at the criteria most of the selected garments are tubular in shape. One of the fastest ways to knit in this fashion is using a circular knitting machine. These are very reliable as the knitting motion is never interrupted. They also allow for increasing and decreasing needles, which allows the knitting of heels.
However no progress into digitizing this progress on a small scale has been made at this time. This is also likely related to the fact that sizes are only changeable by switching out the complete needle ring for one with more or less needles.

So while good at what it does it can only do so much. The digital knitters are currently in use on an industrial scale but so far have not been scaled down for personal use.

Figure 3. Circular knitting machine manpowered

c) Openknit

This project was created by Gerard Rubio, as part of his graduation thesis. The OpenKnit system is an open source project working towards creating a digital knitting machine. The designs and software are available for free and together with the bill of materials can be built anywhere in the world. The current design uses 3d printed parts, lasercut parts and some vendor parts. This enables anyone who lives close to an fablabs or has a small workshop at home to reproduce it and contribute to the further development of the device. This opens the project up for wide spread testing and exposure. It works by programming the pattern into Arduino which can be modified to the users specifications.

The machine however is bulky and in its early stages of development. It also has some issues regarding reliability. The machine does offer the freedom to create several different types of garments. Currently ranging from dresses to sweaters to beanies. While not ready for complex patterns it does allow for different colours.

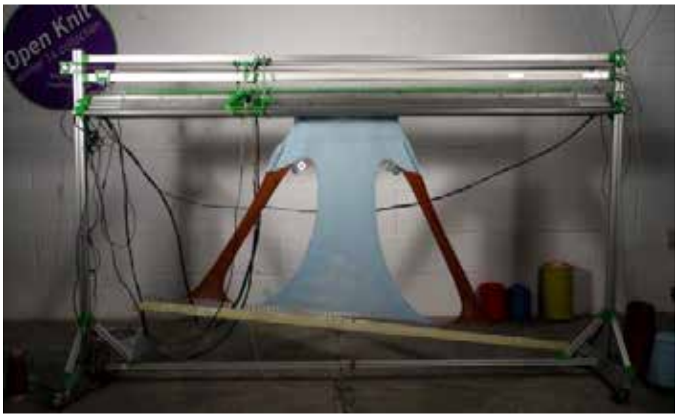

Figure 4. OpenKnit, open source knitting machine

4.2. Developing a mobile solution

The OpenKnit system was selected as it offers a combination of open/digital design combined with an open source machine. This allows end users or communities to create their own machine while also allowing the designers to adapt them to their specific needs. However the current design of the OpenKnit system was not suited for mobile use, several adaptations would have to be made.

Therefore the machine was redesigned to be smaller, lighter and sturdier. Several tests were executed to test the new components durability and reliability, this was done on the main machine. The main components were all tested and (partially) redesigned. This was mainly focused on the carriage and the rack & pinion. The carriage is responsible for both guiding the thread as well as controlling the motion of the needles. Where the rack & pinion is vital to the accuracy of the machine as it creates the input for the software to determine the carriage position on the needlebed.

The resulting machine was mountable on any flat surface using two clamps, weight was reduced to 5,5 kg. Its needle beds have a total of 120 needles, 60 a side. This is sufficient to produce a small wearables. It is battery operated using a 12v battery and converter circuit to power both the stepper motor and servo's which run on 12 and 5 volts respectively.

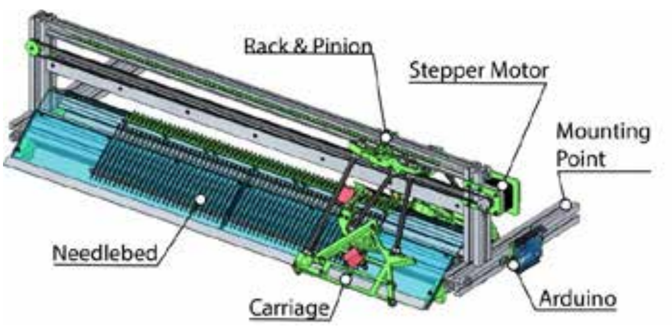

Figure 5. The redesigned OpenKnit machine "wally 120" also shown are the main components if the machine

5. Engaging local community

5.1. Test set-up

When selecting the type of garment to make it was decided to make a beanie. This simple woolen cap design would allow for a quick turnaround during the sessions and would allow the machine to run without interruption for a long period of time without spending too much time on the production of the garment. In total it takes 35 minutes to create.

The following set-up was used, it follows the shown scenario. The test scenario consists of several steps each with their own function. The first step is to set-up the machine on its location, this means attaching the machine to a supporting structure. This can be a structure available on site or one that is brought. Attaching Wally is done with clamps, which ensures a solid connection without damaging the structure. The second step is to hook up the electronics, this consists of connecting the battery and the USB cable to the laptop. For the third step an interested onlooker is approached, a short explanation is given about the purpose of the machine and the general theory. If the person is interested a short production track can be started. This started with the fourth step here we measure the size of the head in order to make a beanie made to measure. This data will be insert into the Arduino software upon which the needlebed is prepared. The fifth step is threading the machine and setting up the first two lines manually. Afterwards the Wally takes over and knits the garment to its desired length. An optional step is to cut and splice a different colour thread during the knitting process. For the last step the garment is closed manually while still on the machine and then removed from the comb and needlebed. It is then ready to wear (Figure 6).

During the knitting of the wearable and afterwards, the users are asked to express the experience and they are given the opportunity to ask any questions they might have.

Secondly they are asked to share their expectations and desires regarding the machine and its applications. This ranges from what they would use it for themselves, to what they would eventually want to be able to make with it. This will

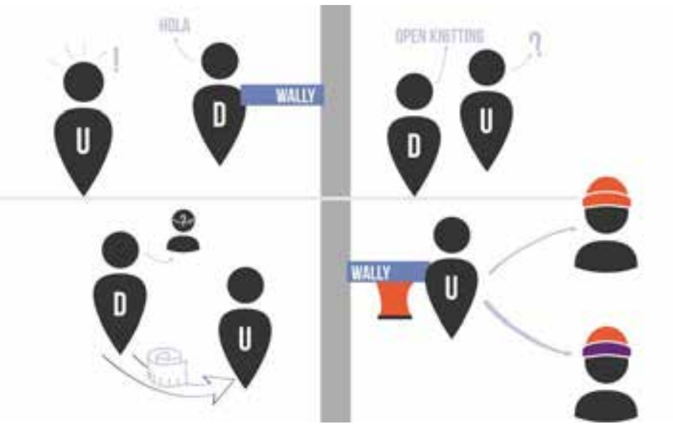

Figure 6. The Test scenario

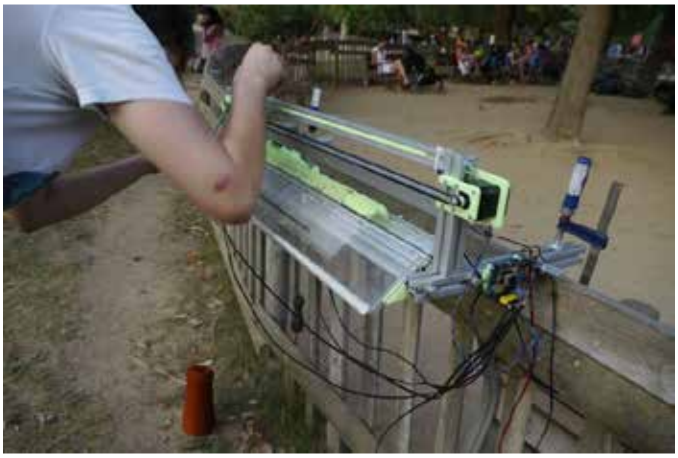

Figure 7. The set-up

give an insight into their standings in relation to the technology and might also illustrate the changes herein, as a result of this new experience.

The sessions will be documented by both video and camera footage. This will later be used to analyse the effect of this new interaction that occurs within the public space. Important is to also document the range of interactions and steps the public goes through.

5.2. Test location

In order to get enough exposure the test location is of significance. While the centre of Barcelona is lively and full of people, the tourist is not the target audience. While people are very open to new things while on vacation the main goal of the test is to see if the general public is willing to accept AM technology and maker culture. To this end the Parc de la Ciutadella was selected, this city park is visited mainly by the local population. The park is still crowded enough to have enough exposure while not including to many tourists into the test group.

The mounting of the machine did limit the selection of the test site as most of the surfaces where unfortunately rounded and therefor unsuited for the chosen mounting system. The chosen site was located near a intersection of the walkways and the playground (Figure 7). Especially the proximity to children was useful lase their curiosity and lack of inhibitions will help pull in more people.

5.3. Results

The results of the test session held in the Parc de la Ciutadella, show a great variety of interest. The session created a good crowd of people looking at the machine at work. The steps described in 4.2 were followed as closely as possible as the installation would allow (Figure 8). As expected the children were first to explore, drawing in their parents and later more bystanders joined to see what was going on. As can be seen in Figure 9 the public was rather mesmerised by the machine. The movement and sound creating interest and upon closer inspection questions start to arise about the project, the overall goals and future use.

Ranging from remarks about the look of the machine to the technical specifications used to create it. This wide range of interest was already very useful. The wonderment seemed to suggest that most people had never seen a machine like this in action, not to mention in the middle of a public park.

Figure 8. Testing the machine (top) measuring the size,(middle) knitting the beanie, (bottom) ready to wear

Figure 9. Some of the gathered audience

The answers to the questions were mixed and varied wildly in detail so in order to get a quantitative overview they were categorized as positive, negative or indifferent. This creates the following overview in regards to the questions, as seen in Figure 10. In total 26 people took the questionnaire during the session. The questions focused on the following aspects of the concept: general impression, available features, reliability of the machine, functionality of the product and the durability of the machine.

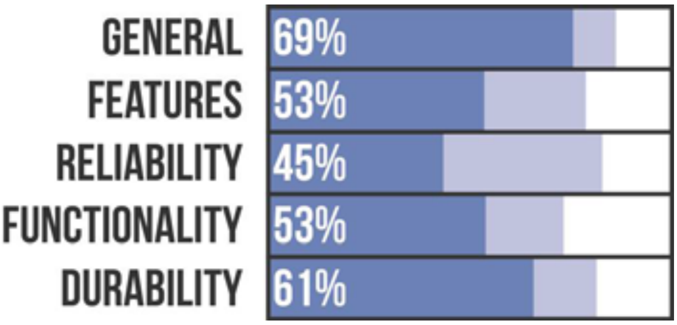

Figure 10. Quantative overview of the questionaire positive/negative/indifferent

When discussing their possible future use of this technology, the responses were categorized as well. This question was aimed to determine the likelihood they would use this machine or something similar in the future. The responses ranged from; definitely, possibly & never. This resulted in the following overview:

Figure 11. Possibility of future use definitely/possibly/never

With regards to the type of desired use the following categories were given: small wearables/ Simple sweaters, dresses & vests/ Hoodies, buttoned & other complex garments. This was to see what type of garment they want to create should they use the machine themselves. They were told to ignore size or current technological limitations in this answer. The results were as followed:

Figure 12. Percentages off desired use for Small/Simple/Complex garments

When asked why they would use the machine instead of buying readymade garments their response were mainly focused around the following properties; better fitting clothes (72%), more freedom in creation/personal style (45%) and lower price (30%). This was in within the context of made to measure patterns. Were they can enter their measurements and select patterns/colours freely.

6. Discussion

When looking at the results of the engaging local community test case seems to check all the boxes in regards to the successful realisation of greater acceptance. However when looking at the test set-up and general several issues came to light.

First, the test location in combination with the time the test was held at. The test was carried out during the late afternoon early evening 18:00 -20:15. This might have an effect on the results in that the public could be tired, on their way home. In order to exclude these and other factors from the results a second session at a different location and time of day would be needed.

Secondly, while the machine performed well it struggled due to the method of placement. The gate it was attached to resulted in an off level position which created a greater strain on the system then initially anticipated. In order to prevent this in future tests either the mounting system or mounting location will need to be addressed. As the struggling machine has effect on the perception of durability and reliability as mentioned by one of the participants; "It seems to struggle a lot, especially going towards the edges of the beanie, does it always do this?". In order to create a positive image for AM technologies the reliability will need to be increased.

Another effect of the Wally 120 system that limits the testing at this point is the lack of interface design integrated into the system. In order to let the public use the machine by themselves, an interface will need to be developed. This also ties into the limitations currently attached to the machine as it is still not able to decrease needles, needed to be able to do short stitching. This is still under development and once completed will greatly increase the range of designs the Wally 120 could handle.

Also there was the matter of language. Even though a Spanish native was present during the testing the researcher himself did not speak Spanish this created some difficulties explaining the machine and answering the questions. While this did not affect the general insights into the effect of the machine it did limit detailed discussions.

7. Conclusions

. The concept of introducing a localized manufacturing tool into an urban community resulted in a positive response from the general public. When looking at the results it is clear that when confronted with AM technologies in a urban context general interest is increased.

Looking at the Attention Interest Desire Action or AIDA model the following can be concluded. The Attention was created, the Wally drew in a large crowd before it was even turned on. The Wally was considered intriguing, because of the colour, sound and overall shape that stood in stark contrast with its surroundings.

Attentiveness was high, 70% of the people that stopped to take a longer look asked questions, made pictures or were talking amongst themselves about the machine. When looking at the answers in regards to future use the crowd was positive. 64% of the participants of the questionnaire would use this machine if it would function similarly to the test conditions.

53% of the participants would use the machine for complex garments, while 87% of them would use it for small simple garments. This shows significant interest and desire in regards to using the machine.

Action was not addressed in this test as the machine is still in development. However the initial responses regarding the Wally 120 were positive and several machines are currently under construction around the world.

A important thing to notice is their need for better fitting clothes as 72% of the participants claim this as a reason to start using this type of clothing manufacturing. It seems that even though the standardisation of clothing is able to facilitate the industrial production of clothing it does not seem to fill the needs of the users.

When looking at the role of the designer in this process, it can be concluded that this has been altered. The designer is no longer just creating products that fill the needs of the consumers. Instead we see a new task taking shape, designing and defining the tools and design space for the end user. This is partially done with a co creation process at this time. However this can be further developed to let the users freely design and manufacture their products without any direct contact. The contact between user and designer will then be through the design space created by the designer.

8. Acknowledgment

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