The environmental value of the Maker movement

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Abstract

The aim of this paper is to explore the environmental value of the Maker movement, which is driving digital fabrication into the mainstream. Makers are inspiring each other to create smart solutions for all types of individual needs, and address societal and environmental challenges at the same time. They share their creative ideas and solutions in collaborative workspaces and Maker fairs or on social media platforms. Is this grassroots innovation the beginning of the next industrial revolution? In the framework of a case study analysis based on ten different Maker initiatives across Europe, 39 interviews were conducted with Makers and Maker initiatives managers evaluating core questions such as possible environmental impact, value chains and energy efficient behaviours. The paper investigates if the Maker movement is to be considered a valuable resource in tackling most of the 17 Sustainable Development Goals, e.g. clean water and sanitation, affordable and clean energy, responsible consumption and production.

KEYWORDS

Maker movement, digital fabrication, fab labs, maker spaces, environmental awareness

1. INTRODUCTION

Neil Gershenfeld (2012) called the Maker movement the next digital revolution as it placed the means of fabrication on people's desks. Thanks to the affordability of digital technologies such as 3D printers and laser cutters also for private households, the digital fabrication is not limited exclusively to industries anymore but been made accessible for anybody. The number of maker spaces and Fab Labs that make their facilities and digital fabrication tools available to their members are constantly growing in the recent years. Currently there are 1,085 Fab Labs globally[1]. The Maker movement represents a return of interest to the physical side of innovation following an almost exclusive focus on the digital side as it connects "bits and atoms" (Gershenfeld, 2005). We depart from the premise that information systems impact our social and day-to-day life in multiple ways and although in an organisational context the focus lies often on economic aspects, issues around environmental or social implications come to the fore more strongly, as shown in recent debates about technologies' energy consumption (Watson, Boudreau and Chen, 2010).

New techniques and technologies, which are commonly practiced within the Maker community, such as 3D printing have an influence on waste production and energy consumption (Kohtala, 2015; Kohtala and Hyysalo, 2015): For instance, products that are 3D printed are harder to separate when it is demolished and recycled. Nevertheless, it seems that these production methods have a positive influence on the environment as they open up new opportunities for recycling material and they "might increase the awareness on sustainable consumption among consumers" (Millard *et al.*, 2016). Local production of goods may lead to less logistics and transportation and thereby less pollution (e.g. Kothala, 2015; Kothala and Hyysalo, 2015) as the Maker community has the potential to strengthen local production and therefore influence supply chains as well.

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[1] http://www.fabfoundation.org/index.php/fab-labs/index.html

2. CROSS-CASE ANALYSIS OF MAKER INITIATIVES

In the framework of a comprehensive qualitative study focusing on three different broad research pillars on organisation and governance of maker initiatives, peer and collaborative behaviours of makers and value and impact of these initiatives, one research question tackled the environmental value and impact of the Maker movement.

Unlike quantitative research, which tests already formulated hypotheses and requires certain conditions (e.g. such as representativeness of the data and validity of test items), qualitative research methods are best used to explore emerging concepts, where statistical data is not yet available (Silverman, 2016). This has also the advantage to explore in more detail and follow up on topics that seem rich of interpretations. For this purpose, we developed a semi-structured interview guideline, i.e. a set of interview questions that can be used in a flexible manner while still preserving coverage of similar topics across multiple interviews. In other words, the interviewer was requested to ask all the questions but was free to add additional ones in case a topic needed to be explored in more detail. The interviews were recorded and then transcribed for detailed content analysis (e.g. labelling of text snippets according to a coding scheme). In the coding process the researcher was going through the interview material with pre-defined codes and identifying new topics at the same time (Flick, 2014).

We chose 10 maker initiatives in 8 countries, which were very different in nature, from a Mini Maker Faire to Fablabs and maker spaces that were independent or part of a university:

- Happylab Vienna (HLW), Austria
- DTI lab (DTI), Denmark
- Fablab Barcelona (IAAC), Spain
- Arduino, Italy
- HRW Lab (HRW), Germany
- Dezentrale, Germany
- Mini Maker Faire Tartu (AHHAA), Estonia
- Fablab Zagreb (FLZ), Croatia
- Smart Bending Factory (SBF), the Netherlands
- and Create It Real (CIR), Denmark

We interviewed the managers of the different maker initiatives and asked them to point us to three makers resulting in 39 interviews in total (one maker interview was excluded from the analysis since it was not feasible). Since we wanted to collect the data from as diverse makers as possible in terms of regions and types of makers, we each targeted one female maker, one maker with commercial and one maker with social ambitions to get diverse answer patterns, reflecting the conditions of making under different circumstances. The transcript of the interviews were analysed qualitatively (Mayring, 2010) following a deductive and inductive coding approach. The deductive codes applied were derived from the research questions, whereas inductive codes directly evolved from the interview data allowing for the unexpected (Reichertz, 2012). This paper focuses on the potential environmental value and impact of the Maker movement. Specifically, the key research question addressed in this paper is: "What is the environmental impact of Maker communities?"

The coding process resulted in 63 codes for environmental impact of Maker communities. The clustered topics that emerged in the inductive coding process (following the deductive coding process where we looked for "environmental impact of Maker communities") are "Repairing, Recycling and Upcycling", "Environmental friendly materials", "Environmental friendly production processes", "The impact of local production and supply chains" and "Awareness on environmental issues among the Maker community". Environmental impact can be found on different levels although most of the described sub-codes are interlinked. Some maker initiatives focus on sustainable production processes and consciously use energy efficient machines, while others produce environmental friendly products or products, which actively address environmental challenges. In the following subchapters examples will be given to illustrate and explore the specific environmental value of making. Indirect and direct quotations are integrated to support our interpretation and argumentation. Direct quotations are written in italic followed by the source in brackets (the maker initiative, the role and gender of the interviewed person).

2.1 Repairing, Recycling and Upcycling

Similar to other grassroots movements innovations evolve very heterogeneously (Smith and Ely, 2015). However, a quite common interest among makers is the trend for repairing, recycling and upcycling in the Maker community, which is shown in our cross-case analysis. For some it is really the repairing aspect that brings people to making as the manager of CIR expressed in his interview: "*You can see very interesting things because that's where the innovation really comes from. Someone has a broken part, then you repair it and then you realise you could improve the design, and you improve, and then everyone wants an improved design. You went from having a problem to becoming a maker and believing in your own project*" (manager, male, CIR). We have also detected many examples of makers who upcycled or recycled materials and who showed a great awareness and concern on environmental issues:

According to the manager of AHHAA it is very popular among makers to use, for instance, reclaimed pallets for making different structures "*or just taking some scrap or discarded materials from different industries to make prototypes for bicycles, for instance, or use whatever they had around their homes to come up with clever, ecological solutions for home appliances*" (manager, female, AHHAA). The manager of HRW also emphasised the environmental potential of 3D printing for producing spare parts. He even talked about the option to produce spare parts out of a material mix of bamboo and Polylactide (PLA): "*To use that [PLA], to combine it with natural materials, that is for example our attempt to build things with bamboo and 3D-printing. You can create many resource-efficient things with that. And also the potential to maybe be able to produce spare parts, which are not on the market anymore. To be able to repair things and continue using them which don't exist anymore. The potential is big…*" (manager, male, HRW). Also the manager of CIR stressed the potential of 3D printing in terms of waste production because of repairing: "*There are a lot of reparation societies, we believe 3D printing can help to repair more things and extend the lifetime of products. (…) manufactures will be able to make money by selling the drawings; they wouldn't have to produce it. There would be production just in time to repair the part, and then you have a more sustainable consumption model because people will repair more*" (manager, male, CIR).

Recycling and Upcycling constitutes one of the factors leading to environmental impacts of the Maker movement, even though the impact is yet taking place only on a micro level (Unterfrauner and Voigt, 2017). The level of environmentalism among the makers varies. Some makers do not consciously choose environmentally friendly materials nor do they consider which waste is created due to their making activities. A maker of AHHAA honestly explained: "*(…) I really like to create things out of junk. This is so cool when you can pick up something from the trash pile and make it into something useful again. When I use materials, I sometimes at least think about how much waste I produce (…). But I cannot claim that I make choices between materials based on the environmental impact. But I think this feeling pulls me towards more environmental friendly choices*" (maker, female, AHHAA). Some maker initiatives, like Helioz who developed their prototype of Wadi[2], a tool for water purification, in a Fablab, have a recycling programme in place: "*We have a recycling programme, but we have not sold so many things yet, that it would have been profitable yet. Especially the tools are still in the field, but we aim to follow the slogan: 'give us your old tool, and you get a bonus for the new one'*" (maker, male, Happylab). Besides the repairing, recycling and upcycling approach of many maker initiatives, environmental friendly (or unfriendly) materials play an important role when it comes to environmental and sustainability questions and show the potential for impact in broader terms.

2.2 Environmental friendly materials and products

For many makers using environmentally friendly materials is of high relevance, as a maker of AHHAA in short words emphasised: "*My ideas are environmentally friendly and I use reusable materials*" (maker, female, AHHAA). It can be assumed that probably the strongest environmental impact by the Maker community can be found in their creative ideas and products they develop and

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[2] (https://www.trendingtopics.at/wadi-who/)

create to address environmentally relevant questions in a direct or indirect way. A maker at Happylab said in this respect: *"If we have looked only on how much waste we produce every day, this [note author: caring for environmental issues] might not look too important. I think it is an ecological benefit that here are people who search for better and more efficient solutions. This harms the environment less. Based on this, positive ideas and products are created, like what he is doing at the moment: he builds an energy harvesting flowerpot"* (maker, male, Happylab). Besides the energy harvesting flowerpot, for instance, another maker at Happylab, as already mentioned, developed a tool for water purification through solar energy, i.e. Wadi tool (c.f. figure 1).

Figure 1 Wadi for water purification via solar energy, developed by Helioz (https://www.trendingtopics.at/wadi-who/)

Many makers are driven by their constant engagement for finding innovative solutions for environmental challenges as this example shows. This particular maker was aiming at developing containers made out of putrescible plastic, which lasted up to 6 months. In detail the maker said: *"[Now] we use local PET-bottles and don't send any bottles to these countries. But now I am planning to build a container, which is made of putrescible plastic. Therefore we will surely visit Happylab for using the welding equipment. There are bottles, which look like PET bottles, but actually they are made out of this putrescible plastic. They last around half a year. They are not as beautiful as PET (…) that is the reason why you don't find them in the refrigerated section. But for rotting it needs bacteria and temperature. Therefore you have to dig them"* (maker, male, Happylab).

Another makers' project developed alternative materials, which are more ecological, e.g. textiles that have the potential to replace leather. For instance, a maker at IAAC explained: *"In the fab textile lab, I have a specific line that is about bio fabrics, bio plastics, mushroom textiles and natural dying processes. So it is more oriented with the material resources – making your own material and using material that is not harming anyone. But the project itself is based on sustainability, by democratising fashion, embracing custom fabrication and opening access to tools"* (maker, female, IAAC). Another maker at IAAC worked with mycotecture elements, pieces of architecture that are developed based on mushroom materials (c.f. Figure 2).

A project addressing environmental issues was developed in FabLab Zagreb: *"The project is hydroponic composter; so basically a vessel which would contain water and this water would be swirled and moved in a way that it quickly decomposed anything thrown in. So if you have food waste you throw it in and in a couple of days or weeks its completely disintegrated and can be used for watering your plants and making them grow"* (maker, male, FLZ). FLZ makers are further examples of makers working on ideas with environmental impact. They are working on biodegradable decomposable PLA as one maker said: *"We are trying to make a material, biodegradable decomposable PLA, standard plastics for 3D printing. But we would like to infuse it with minerals, which are normally found in spring water. So all the hydroponic systems, which would be made would contain minerals for optimal healthy plant growth. So that is the idea and we are planning on making the facility for the production of such a material in India"* (maker, male, FLZ). These examples show different maker initiatives actively working on environmental friendly materials and further addressing the environmental challenge of plastic garbage. It indicates a strong interest in environmental questions within the Maker community and leads to the assumption that a growing Maker movement can have quite an environmental impact.

Furthermore, the development of sustainable and environmentally friendly materials has a high potential to replace environment-harming materials, which are currently used. Hence, the Maker movement can have a high environmental impact in this respect. Besides developing environmental friendly products and materials several maker initiatives are aware of sustainable material use and try to work with more sustainable materials as the aforementioned manager of HRW and also a maker of CIR who is also using PLA said: "*Right now in my private trash bin, there are filaments rests, of something called PLA, which is better than most plastics. If I use poisonous materials, then I affect the environment. At work we only use PLA, this printing technology, in order not to overload the environment, they're not as demanding*" (maker, male, CIR).

Figure 2: Mycotecture- achicture growing out of a mushroom, project by IAAC (http://archive.fabacademy.org/2016/greenfablab/students/365/media/valldaura/Mycotecture.jpg)

Nevertheless, it must be noted that not each decision to use environmental friendly materials for products, which are produced in FabLabs, necessarily roots in an environmental sustainability though, like an interview with a maker from AHHAA reveals, when he explained why he did not use glue or any screws: "*I don't have the environmental problems, that's just a challenge for me to make the details fit together perfectly. Also, you can set the code, that's one of the requirements. If you glue the things together, it makes the box less valuable for me*" (maker, male, AHHAA). However, there are also makers who see the biggest problem in terms of environmental impact of the Maker movement in the materials they use, underlining that there is a need to use more environmental friendly and natural materials: "*I think the FabLabs are great for a lot of things, but there is a huge lack of materials intelligence. We still work with a lot of shitty products, create a lot of garbage, and I think the next revolution within the maker scenario will be materials. We have another FabLab, which is a green FabLab. It is a part of IAAC. The green FabLab has food, wood and bio labs all attacking different things and thinking about the circularity of materials. There is a lot to learn in this aspect*" (manager, male, IAAC).

2.3   Environmental friendly production processes

Besides environmental friendly materials or recycling and upcycling materials there are production processes that have the potential for environmental impact. Some makers focus less on the materials they use, but are aware of the production process and final products, which should not harm the environment unnecessarily (manager, female, AHHAA). As can also be seen regarding sustainable materials there are ideas for sustainable processes born within the Maker community. For instance vertical gardening as a maker of HRW said: "*(…) In the end we want to look how we can use vertical farming effectively in the city without taking valuable room away in the city. (…) And it is about using these unattractive empty buildings and to bring food through a small supply chain into the city*" (maker, male, HRW).

Even though the interviews showed a great awareness regarding environmental impact within the Maker community they also revealed that maker initiatives usually do not measure this impact. SBF, for instance, believes in having a positive environmental effect, but do not have instruments to measure its impact. They are aware of making smart use of their materials and to reach high efficiency in production. Moreover, they use very energy efficient machines as the manager of SBF said: *"SBF does have positive environmental effects, but has not yet worked out what these are or their extent. When manufacturers make smarter use of their raw materials, like plate steel, and achieve a higher efficiency, then there will be less waste, shorter transport routes, etc. The new machines SBF works with are generally 30%-40% more energy efficient than the previous generation of machines. (…) When, later, there is a European network of SBFs, then many more products will be able to be manufactured locally, which will also have environmental benefits"* (manager, male, SBF). As this manager of SBF outlined, supply chains, transport routes and local productions have high impact on the environment and the Maker movement has the potential to positively influence environment in this respect.

2.4 The impact of local production and new supply chains on the environment

The Maker movement has the potential to support and strengthen the local production as the following statements illustrate. Local production in turn has an impact on supply chains and waste production. A maker of Arduino expressed it this way: *"(…) the more people do things themselves, the less you need mass production, and mass production is when you have most waste"* (maker, female, Arduino). Maker initiatives provide options to produce things on demand, meaning when and how they are needed: *"Here we just produce when we need something and not because we need to produce a batch to 1 million pieces and after a while you throw them away because they are out-dated"* (maker, female, Arduino). Further, the makers at Arduino put forward a trend of creating spare parts for household equipment or robots based on the fact that companies increasingly do not produce replacement parts anymore (maker, female, Arduino). In a broader sense also the trend for open access and sharing within the Maker community shows further impact on waste avoidance as this maker continues argued: *"... and there are a lot of people who share the files for these pieces and they save a lot, because they don't need to dispose a robot because a little plastic piece is broken"* (maker, female, Arduino). If the Maker movement would lead to more local production, the supply chain of goods would change dramatically as one maker at SBF said: *"(…) But as from the moment you can eliminate one step in the logistic chain, you eliminate costs and transport movements; in that sense this leads to interesting side effects in terms of value: lower environmental footprint and economic value creation"* (maker, male, SBF).

2.5 Awareness on environmental issues among the Maker community

The interview analysis reveals that there is considerably high awareness on environmental issues within the Maker community. Many concentrate on waste production as an aforementioned maker of AHHAA said, others are aware of the need to use more sustainable materials as the manager of IAAC emphasised or the manager of HRW who talked about a new thinking in respect to materials: *"We are also consciously looking at substituting materials for many things. We work for example with carbon-thread what doesn't make a lot of sense with respect to the environment. But (…) stone basalt, you can also do it with basalt threads for examples. That wouldn't be a problem for the environment, because it's just stone. Many renewable resources like hand-threads and so on. There are many materials that you can use alternatively. And we do have a look whether we find a sensible combination there"* (manager, male, HRW). Also SBF showed a great awareness regarding environmental issues and sustainability. *"SBF makes optimal use of the raw materials and the energy required to run the machines. It also streamlines the transport process, making small numbers of production on demand, locally"* the manager of SBF underlined.

The awareness on environmental issues is sometimes coupled with ethical standards and social issues of production. A maker using Happylab in Austria produced a tool for water purification in an ecologically sustainable way, avoiding harm to the environment. He was aware of producing waste and still tried to follow ecological standards. When his enterprise was visited by one school, a pupil asked in detail and wondered about all the chips used, how they were developed, by whom, and how ecological sustainable all these things were. "*I really liked that. Luckily we have all seals of approval and so on, this ethically important for us, to go in this direction. That's why we also use this bag of putrescible plastic. We are want to act ethically and socially responsible in various directions*" the Happylab maker told.

3. CONCLUSIONS

The interview analysis reveals that there is considerably high awareness on environmental issues within the Maker community. Many concentrate on solving environmental problems and issues like waste production, others are aware of the need to use more sustainable materials or use environmentally friendly materials. Still the level of environmentalism among the makers varies. Some makers do not consciously choose environmentally friendly materials nor do they consider which waste is created due to their making activities. But by upcycling they act environmentally friendly. As outlined the recycling and upcycling trend is one of the factors leading to environmental impacts of the Maker movement. Recycling and upcycling shows a rather high awareness of environmental questions in the Maker community and their potential for an environmental impact even on a higher level if scaled up. Nevertheless, its impact might be rather small measured on a global scale. Also the main intention is rather the use of already existing resources that is in the foreground of the making, not the environmental protection though. Besides the repairing, recycling and upcycling approach of maker initiatives, environmental friendly (or unfriendly) materials play an important role when it comes to environmental and sustainability questions. The potential of possible impact need to be considered on a broader level. For many (but not all) makers the use of environmentally friendly materials is of high relevance. Probably the strongest environmental impact and also potential by the Maker community can be found in their creative ideas and products they develop and create to address environmentally relevant questions. Still, some makers do not (consciously) choose environmentally friendly materials nor do they consider which waste is created due to their making activities.

The Maker movement has the potential to support and strengthen the local production and decrease mass production since maker initiatives provide options to produce things on demand, meaning when and how they are needed. Indeed, a high effect of the movement: its ability to draw production back into the cities where consumption occurs. This can have profound economic, social and environmental benefits by decreasing traffic and transport of goods. Some makers focus less on the materials they use, but are aware of the production process and final products, which should not harm the environment unnecessarily. The question is rather on how the Maker movement will emerge as one source of providing environmental solutions and find ways to build processes around their creative activity. Realising this opportunity to use the Maker community for environmental issues will – on a long run - probably require re-thinking and redesigning our approaches and processes of day-to-day living towards a sustainable environment, innovating also the way we consume. It will require the re-shape of the current systems towards a more effectively integrate distributed production by smaller entities. The shifting focus towards more individualised solutions for society, moving away from mass production will change also the value creation.

To give the Maker movement on a global perspective highest impact, some conditions still need to get further developed. Makers and (small) businesses will need to come together, both in urban areas and in virtual communities, driven by the need to exchange and create innovative solutions for environment. New, transformed systems will need to be further elaborated that allow participants to combine and recombine as necessary to exchange skills, capital or learning to create a network that supports the decentralisation of some activities, including innovation and some types of production, currently done within large enterprises. As for now, the increasing figures of makers and maker communities show that this movement will have significant impact,

also on the environmental sector. While some of the innovations are specially dedicated to environmental issues, others might address other social issues. However, it can be expected that this new maker system will have sufficient environmental awareness to understand the need for sustainable environmental solutions. Given the needed transformation further investigations will have to tackle the creation of instruments for measuring the (environmental) impact of Maker products. For many Makers the evaluation of the impact of their ideas has only a secondary role. In almost the same manner as industrial revolution changed the way we lived and consumed, so will the Maker movement change our lives. With the raise of the Maker movement we are hopefully fast moving into a new revolution, as indicated by Neil Gershenfeld (2012), whereby mass production will evolve into environmental friendly mass customisation including recycling and fixing as well as further creative ideas that will help to solve our environmental challenges.

ACKNOWLEDGEMENT

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