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FabLabs: experimenting with technosocial fabrication

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This text represents ongoing work of my PhD project ‘Concrete utopias of an open technology. The practices and futures of open design.’ Comments and feedback are welcome. For more information on my work and myself and the possibility to contact me please visit my blog: http://im-noch-nicht.de

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Introduction

FabLabs[1] ('fabrication laboratories') are a global network of public workshops which make digital fabrication avaialable to individual users to 'make (almost) anything' they want. Such and similar definitions can be read on many homepages of FabLabs, in talks by popular FabLab activists and even in scientific texts that describe FabLabs. And it seems pretty straight forward. By now we are used of thinking in global networks, of public arrangements and of digital technologies that influence our relation to objects. But such a 'snapshot' definition of FabLabs suggests more and less than what FabLabs actually 'are'. More because it suggests that all this, all the networking, all the publicness and the making of anything simply takes place. And less because it takes time out of FabLabs and does not see that FabLabs are literally 'laboratories' that engender creative processes. I try to make productive use of the unfolding, open and temporal character of FabLabs and describe and interpret them as 'real-life experiments' (Krohn & Weyer, 1994a).

Addressing open source practices as an experiment is not absolutely new. Kelty (2008) in his wide ranging study of Free and Open Source Software speaks of it as an experiment in the changing relations of knowledge and power. Yet, besides metaphorically speaking of an experiment, Kelty does not delve deeper into describing the actual processes of experimentation and what makes them possible. Dickel et al. (2014) went further and described FabLabs as real-life laboratories. Whilst drawing on the literature and perspective of real-life experiments, as I do here, they only consider experimentation in FabLabs in two cases. FabLabs themselves their organisation and history are not considered by them as an experiment. In this text I draw on these perspectives and further enlarge them. FabLabs, I argue, from their inception via their first manifestations up to their present form of about 400 labs around the globe, are a real-life experiment in an encompassing sense. This experiment involves, what is being done with technologies in FabLabs, and the processes of organising individual labs and the larger 'network' of them. This also involves experiments with sociality and subjectivity. And FabLabs evolve and change largely through such experiments. FabLabs are experimentation turned on itself.

In this perspective, FabLabs 'are' neither this or that, rather, I emphasise their becoming, their unfolding. FabLabs are 'unfinished' and this openness is what keeps ex-

1 I use the spelling 'FabLab' since we use it in FabLab Karlsruhe. Other spellings such as Fab Lab, fab lab or fablab also exist.

periments with them going on to materialise, define and contest them in the process. To grasp the complexities and elusiveness of this process I use Deleuze and Guattari's concept 'assemblage' to describe FabLabs from the 'local' to the 'global' as a gathering of different and heterogeneous elements in process which never fully determine each other but engage in a 'co-functioning' which has emergent effects (Deleuze & Guattari, 2004). In my description I show how these elements be they discursive, practical or larger formations such as 'the city' have been involved in co-forming FabLabs from their inception and, this is important, even before that. The challenge is to think FabLabs historically, both their past and their future, mediated in a process, in an assemblage that is formed by certain lines which through their assembling enable other and new effects, trajectories and 'lines of flight'. This opaque, uncertain, creative process is well captured by the concept of experiment.

In this text I am not giving much room to typically 'social' dynamics of FabLabs, such as group formations, of struggles for definition and power, of hierarchy or of democracy. Rather I am interested in FabLabs, as 'objects', as particular formations which enable such 'social' processes in the first place. I am more interested in the 'underlying' processes and arrangements, which create the spaces of possibility within which, particular people interact, organise, imagine, contest and so on. What enables FabLabs and their experimentation is the focus of this text. FabLabs here, are thus not simply places for experiments 'with' technology. Rather, I show how FabLabs are genuinely about technosocial experimentation, about processes in which 'technology' and 'sociality' are fused together and are turned in on themselves in a recursive 'techno-logical' loop. FabLabs in this reading are technosocial real-life experiments of an assemblage in TechnoScienceSociety (Maasen, Dickel & Schneider, forthcoming), geared towards having an influence on transformations of this society. FabLabs highlight important aspects of contemporary processes of decentred technologically mediated social life and its changes. And, importantly, FabLabs are experiments with technology for social progress, experiments with public technologies, experiments with common technologies, experiments with technologies for creation by individuals. FabLabs give room for 'concrete utopias' which live in the experiments with trials for a better life (Bloch, 1986).

Action Research

I have a special relation to FabLabs and FabLab Karlsruhe in particular, that should be mentioned right at the beginning. I initiated the establishment of FabLab Karlsruhe in Summer 2013 and I've been engaged in establishing and organising it as an *action researcher* ever since. This gives a special twist to this study and a discussion of principles, methods, histories and justifications of action research, right at the beginning shall prepare the ground for what comes afterwards.

In a paper called 'enacting the social', Law and Urry argued that the social sciences have never been innocent. They participate in and enact a certain version of the social through helping to make particular relational realities and not others. And they do so, the authors argue, mainly in a way that is performative of 19th century realities, e.g. of nation states and of bounded settings for the social. Now, to enact realities appropriate to the 21st century and a contemporary ontological politics, social science and its methods have to change.

> '[W]hich realities? Which do we want to help to make more real, and which less real? How do we want to interfere (because interfere we will, one way

> or another)? Such is the larger purpose of our intervention. The globalizing world is complex, elusive, ephemeral, and unpredictable. It is enacted that way without our help. But, if social science is to interfere in the realities of that world, to make a difference, to engage in an ontological politics, and to help shape new realities, then it needs tools for understanding and practising the complex and the elusive. This will be uncomfortable.' (Law & Urry, 2004, n.p.)

A particular approach to understanding and practising the social differently than in mainstream social science is action research. Action research, however, is neither a unified set of methods, nor a particular use of theory. Action research rather is an attitude that has ontological, epistemological, methodological and socio-political implications for the practice of research (McNiff, 2013). Doing action research means researching a certain field and acting on this field to have an impact for change. This implies not enacting the idea of science as a neutral, distanced and observing activity, but rather seeing it as something engaged in a world of flux (ontology). Such a stance entails a constructivist and situated understanding of knowledge (epistemology). It seeks to entangle knowledge production and research with the social situation in which it takes place (methodology). And it aims to help make certain social realities and not others. It is a normative endeavour aimed at positive social change (socio-political). Obviously, action research breaks with positivist approaches to (social) science. As such, there are many sources that influence action research besides organisation studies where the term was coined in the 1940s by Kurt Levin. Particularly, critical social science such as Marxist, feminist or post-colonial approaches have influenced it strongly. Yet, action research has also been practised in education research or management studies.

Although, sociology mostly has forgotten about action research, there seems to be a wave of renewed interdisciplinary attention to this approach, as the launch of the journal 'action research' in 2003 (Brydon-Miller et al., 2003) and recent handbooks and entries in handbooks on methodology indicate (Dick, 2011). Furthermore, there are diffuse calls for social science and science and technology studies to become more engaged in social reality, to have an impact on change. One can think of the discourse on 'responsible research and innovation' that wants to foster research that helps to transform the ways how modern society has been innovating (e.g., Owen et al., 2013), or the call for a 'public sociology' which is more visible and helps to find conditions for flourishing in dialogue with publics and civil society (Burawoy, 2005). And there are increasingly voices, such as Law and Urry's above, that call for a new creativity with sociological methods to face the contemporary realities and enact a different form of sociology, e.g., to become more 'artful' and 'crafty' as a 'live sociology' (Back & Puwar, 2013) or more mobile to catch up with the flows of globalisation (Büscher et al., 2011).

An example for action research – although the authors don't call it like this – which inspired me strongly is Rabinow's and colleague's 'experiment with synthetic biology' (Rabinow & Bennett, 2012). As anthropologists the researchers were part of a technological centre for synthetic biology and they wanted to find out, in a collaborative manner, what synthetic biology might mean for the near future of human flourishing. And they did this in an interventionist manner that was constantly modified as the experiment moved on to foster learning and exchange between 'human' and 'natural' scientists: 'The core question and challenge of our experiment, then, was this: How might synthetic biology be made to contribute to (and participate in) a mode of prac-

tice guided by—if not uniquely dedicated to—an ethic of flourishing?' (Rabinow & Bennett, 2012, p. 9). What guides them is the ontological question about what things are made and introduced into the world through synthetic biology and how this happens in practice. And they tried to find a collaborative ethical inquiry with the other scientists and stakeholders to mutually reflect on and evaluate the practices they were involved and the ends to which these were dedicated. The experiment, however, failed. Yet, to me the documentation of it shows what is at stake in action research as I'd like to understand and practise it. It is about a mutual engagement in the world together with others, to provide one's own questions and partial answers to collaboratively create new knowledge and influence practices. And of course, this has to be a normative endeavour.

I believe sociology could in many ways be more normative, benefit from this and be even better suited to contemporary transformations. The excited claims against normativity rest on often unreflected dichotomies such as objective/subjective, rational/irrational, descriptive/normative and so on. Sayer deconstructed these and strongly and convincingly argued that 'values are within reason' and they are within social reality; sociology is half blind if it neglects the normative character of social life and its potential to entangle with it. The key is to reflect on values, to observe them and to rationally argue for or against them, and to learn and modify them (Sayer, 2011). And this, in my view, is not about telling other people the 'truth' to which they need to adapt. It is about sharing the particular perspective as a sociologist and person, as an offer for collaboration. It is about 'acting' and 'researching'. I see action research as an inventive approach that might benefit sociology and social reality. Edgar Morin has been arguing that it is time for complex thought in society, where the separated fields of knowledge should be connected together again in a new way, appropriate to a complex world and its necessary transformation (Morin, 2012, 2008). Thus, in a way, I see practising action research as a form of 'concrete utopia' (Bloch, 1986), a way to create new ways of knowing personally and socially, a way to engage in a world of becoming.

Ontologically, the global FabLab experiment 'makes' many interesting and promising 'things'. As a sociologist, I want to understand how these came and come into the world in practice and what they tell us about certain tendencies in contemporary TechnoScienceSociety. As an activist, I want to contribute to making some of them and have at least a little influence on FabLabs. Actually, it tells quite a lot about the 'thing' FabLab, that a sociologist can start the founding of one in a city like Karlsruhe: FabLabs are not about classical understandings and practisings of technology but rather strive to be a heterogeneous technosocial form in which different technologies and people come together, as I will show in this text. This coming together can be rather complex and is transgressing local settings. I want to describe this by drawing on different forms of empirical material and ways of description. A main source certainly is the data that I collected as an action researcher who has been doing qualitative participant observation during the first one and a half years of FabLab Karlsruhe (summer 2013 until the end of 2014). The founding process did not only create many pages of 'fieldnotes' by myself, but also a massive amount of other documents (emails, texts, homepages, images etc.) which will feature variously here. Besides these 'local' data from Karlsruhe, the chapter will also draw on material which sheds light on other important aspects in the history and present configuration of the global FabLab 'assemblage' (Deleuze & Guattari, 2004), including recent empirical studies on FabLabs. To describe such a heterogeneous complex I will not only analyse texts

here but include objects, organisations, technologies, descriptions of practices and institutions.

One of the individuals I pay particular attention to, has also been a kind of 'action researcher': Neil Gershenfeld, who is often said to be the 'inventor' of FabLabs. In the following part, however, I deconstruct the idea of such a start of FabLabs and locate Gershenfeld within an assemblage that has far older roots.

Visioneering FabLabs

The start of FabLabs is often said to be the Massachussetts Institute of Technology's (MIT) Center for Bits and Atoms (CBA) where the first FabLab was initated by Neil Gershenfeld, the center's director in 2002. While this is certainly true for FabLabs as a particular concept, the discursive and practical roots of FabLabs can be traced to other sources. In the reading I will present here, FabLabs are not a start of a real-life experiment out of the blue, but rather part of a complex history. FabLabs mix, assemble and mobilise different elements in a particular combination. To understand the history and different elements that are mobilised and assembled in FabLabs helps to explain why they had such a vast growth and how they created such high hopes in many aspects. And particularly it explains how the experiment is in the in-between of such arrangements.

The global FabLab experiment did not start by accident, rather it was consciously brought about by particular people and organisations which by now multiplied all over the globe. To start experimentation, however, something like a hypothesis is necessary. Visions of the future are an important enabler of experimentation (Loesch & Schneider, forthcoming). They can enable communication amongst different actors from different backgrounds and thus semantically define a whole technological field (Lösch, 2014, 2010). More generally, visions are cultural resources which open up and constrain spaces of possibility and thus construe different versions of futures (e.g., Appadurai, 2013). Besides simply providing images of a future from particular perspectives and thus never telling, what 'the future' will be like but rather telling, how it is imagined, visions also have a part in constructing futures. Visions have consequences and effects in the presents that they help to shape. I have no intent in this text to separate imagination of the future and practice. Rather, imagination is a practice and there are particular practices full of imagination, imagination is part of a world of becoming (Ingold, 2012). Visions are thus not constrained to linguistic or textual expressions of imaginations, they can be found in objects that have a 'prototypical' character. Organisations might stand for and foster certain visions and even certain practices can point towards particular futures. I will seek 'visions' wherever there is a 'preappearance of the future' (Bloch, 1986) being enacted.

My approach is thus also an effort to move beyond the mainstream approach in the social sciences which investigates how futures are 'thought' and communicated in the present and thus are construed as simply part and effect of the present. Such an approach takes time out of the future and neglects its reality, open and unknown as it might be (Adam & Groves, 2007; Kaiser, 2012). Instead, I approach the future from practices of 'future-making' (cf. Adam & Groves, 2007). Such future-making, I argue, is particularly evident in real-life experiments, processes that actively mediate past and future, what was and what is not-yet (which is much more than what is explicitly imagined) in the present. Such experiments are being arranged in assemblages to foster and engender surprising novelty, although there is no guarantee

for it, experiments are an effect of the future on the present one might say. Future making arranges particular trajectories, historical lines and these also move into the future. They open up and constrain possible ways for continuation or change or continuing change. Such 'lines of flight' as Deleuze and Guattari (2004) called them, lines of which one cannot clearly see the start nor the end, only their movements in between, their flows, however, also mix with or challenge each other and might disappear. Future-making, in my perspective, is participating in tendencies and possibilities (see Bloch, 1986).

For FabLabs a particular line was followed by Gershenfeld and others and at the beginning used for particular ends. Following the historian Patrick McCray (2012), I will analyse Gershenfeld as a 'visioneer'. McCray showed how during the past decades certain technoscientists such as Eric Drexler (crucial for 'nanotechnology') successfully created, mobilised and promoted imaginations of the future to push particular technologies and agendas. They did not only think of a future but built coalitions and networks (e.g. to politicians, business leaders, publics) which together 'could mobilize, explore, and push the limits of the possible' (McCray, 2012, p. 10). Visioneering combines the terms 'visionary' and 'engineering' and is productive of imaginations, social and technical realities – in my argumentation it builds an assemblage. Visioneering, however, is insufficiently grasped if one sees this as an individual's effort, rather, visioneering is a collective and historical activity (Nordmann, 2013). Visioneering, centring around particular technologies, is furthermore an important practice in contemporary TechnoScienceSociety, which is construing its future increasingly in light of technological change, novel technological capabilities and their risks and opportunities (e.g., Dickel, 2011; Grunwald, 2014; Kaiser, 2015; Nordmann, 2010). Gershenfeld is a successful technoscientific visioneer, which is important to understand FabLabs and gives important hints for an interpretation of TechnoScienceSociety. But how were FabLabs initially visioneered? How did FabLabs come into being?

An important source of the FabLab vision came into being in post-WWII USA in a mix of early technoscience and countercultural movements and is analysed by the historian Fred Turner (2006), in what I consider to be an excellent analysis of visioneering activities. I will discuss Turners history in some length, since it also shows how imagining the future is not only in representations and that it can turn into practical making of the future. Turner shows how certain hippies in the late 1960s believed in the power of new 'tools' (computers, narcotics, cybernetic theories etc.) to create a new consciousness and new non-hierarchical communities. He goes on to show, how in particular one of them, Stewart Brand, was successful in creating the 'Whole Earth Catalogue' (its first edition in 1968 subtitled 'access to tools'[2]). Related to this publication, Brand brought into being 'network forums' in which different communities could interact and mix countercultural, scientific, technological and entrepreneurial ideas and practices over the years. This process, which was influenced by visions and modified them, by the late 1980s had created powerful discourse and supporters in the US of an Internet utopianism, which heralded the Internet as a prime source for a new society. This process, however, not simply created certain semantic framings of the Internet but influenced organisations and technologies, its consequences were formed in a transformation form 'counterculture to cyberculture'.

2 Such access to tools in a different sense is nowadays widely called for in the open source culture, where access to information, from Wikipedia to building instructions, is a key principle and value.

> 'Brand’s entrepreneurial tactics, and the now-widespread association of computers and computer-mediated communication with the egalitarian social ideals of the counterculture, have become important features of an increasingly networked mode of living, working, and deploying social and cultural power. Although it is tempting to think of that mode as a product of a revolution in computing technology, I argue that the revolution it represents began long before the public appearance of the Internet or even the widespread distribution of computers. It began in the wake of World War II, as the cybernetic discourse and collaborative work styles of cold war military research came together with the communitarian social vision of the counterculture.' (Turner, 2006, p. 9)

Amongst the people in the visioneering circles Turner describes were people with high influence on computer technologies and discourse surrounding them such as Kevin Kelly, who launched 'Wired Magazine', the US's leading popular journal concerning digitisation, and Nicholas Negroponte who was the founding director of MIT's Media Lab, established in 1980, the organisation that later on would initiate Gershenfeld's CBA. In the 1980s Brand was at the Media Lab for a couple of months and even wrote a book about his experience: '[Brand] depicted the Media Lab and its digital technologies, as well as Negroponte and the corporate and research cultures within which he worked, as prototypes of an emerging socio-technical world. [...] the Media Lab made digital-social hybrids; its culture was itself a hybrid of digital and cultural workers; the world that its research would produce would be infused with such hybrids [...] the Lab demonstrated the way a “wired” world might look' (Turner, 2006, p. 180).

When Gershenfeld started FabLabs, the Media Lab, within which Gershenfeld worked, already had been a central hub in visioneering a technocultural liberating image of digital technologies. Thus, what was the creative process in envisioning FabLabs in particular? In the following I will focus on documents closely related to Gershenfeld in the early times of FabLabs and link them back to other sources that were and are being mobilised in FabLabs. Gershenfeld has been an influential professor at MIT and thus it isn't surprising that the cultural ideals of technoscience were mobilised initially. But this happened with an interesting shift that I will analyse first, taking the MIT news of the launch of the CBA (MIT News, 2001) and Gershenfeld's book (Gershenfeld, 2005) on FabLabs and personal fabrication as prime sources.

In 2001 Media Lab received a grant by the National Science Foundation (NSF; the US main government organ for science funding) of 13.75 Mio. $ to bring 'nanofabrication, chemistry and biology labs together with rapid mechanical prototyping, electronic instrumentation and high-bay assembly workspaces' in the CBA. As Nicholas Negroponte is quoted in the news article: 'When we started the Media Lab, the interesting question was how bits and atoms differed [...] Today the interesting question is how they are the same, how they come together.' Thus the Center for *Bits and Atoms* aims to investigate and foster the interplay of physical and informational sciences and the 'researchers are seeking radical applications and understandings of information technology. NSF's mission is to support just this type of basic science' (MIT News, 2001, n.p.). Already in this news text, the CBA is clearly positioned within the culture of technoscience as described in the writings of Alfred Nordmann (e.g., 2012, 2011, 2010): The CBA works interdisciplinary and problem-oriented towards the combination of bits and atoms; opposed to 'classical' science, it seeks first, new technological capabilites – using things, 'applications' – and only second, 'understandings' – ex-

plaining things theoretically. That it also seeks to be 'radical' with technology furthermore suggests, that the CBA shall bring about changes through the new technological capabilities – it has an instrumental relation to the 'world'. Technoscience regards research 'as knowing by doing, as a means to create and realize technical potential and thus to construct the world we live in' (Nordmann, 2011, p. 28).

Gershenfeld had already been working on one driver for such radical change, when the news declared that among 'the challenges to be tackled will be developing "personal fabricators" to bring the malleability that personal computers provide for the digital world into the physical world' (MIT News, 2001). To further research on personal fabricators, Gershenfeld and colleagues put together 'millions of dollars worth of machinery' to assemble 'an array of machines to make the machines that make machines' (Gershenfeld, 2005, p. 7, 5). Why this effort? Gershenfeld, at least in his book, is inspired by the visions of nanotechnology. He quotes Eric Drexler's vision of self-replicating nano-machines and the related dream to have a machine that makes 'anything' in a world where in principle everything is programmable. Furthermore, Gershenfeld draws parallels to computing, where small, personal machines replaced the large mainframes for experts – a move that Gershenfeld is sure fabrication technology will also make. The faith in technology and technological progress to bring about radical change is common in technoscience and its visioneering (Grunwald, 2014; McCray, 2012). However, an important source for Gershenfeld's faith have been the massive and ongoing 'objective' processes of digitisation which entangle more and more of reality with digital technology.

But in 1998 the reality was, that the set of machines that were assembled to create personal fabricators were utterly difficult to use. Thus the idea to launch a practical introductory course for graduate students titled 'How to make (almost) anything' to enable them to use the machines for their research. This course should become the birth place of FabLabs. As Gershenfeld describes it, instead of a few graduate students about 100 students from all over MIT were excited to do this course, but not to do research but to use the digital machines to create things. Such 'co-respondence' (Ingold, 2013) of subjects and objects, individuals and machines – excitement about and the opportunities and difficulties of using technical objects – is important beyond MIT to understand the culture of FabLabs. Gershenfeld writes about four surprises these courses created for him and relates them to cultural resources that I will trace here since they have been reappearing in FabLabs throughout their history. They have roots beyond and partly before the US counterculture but can also be traced to there.

The first surprise Gershenfeld narrates is that there was a huge interest by students 'with relatively little technical experience' (Gershenfeld, 2005, p. 6). Whilst this resonates with the interdisciplinary and project centred practices at Media Lab as described by Turner (see above) this also resonates with other cultural developments and elements. On the one hand, the highly specialised and differentiated industrial, technological or scientific systems of modernity produce strong divisions of labour and its corresponding specialised expert subjects (e.g., Giddens, 1991; Mumford, 1970; Noble, 1984). This, however, has been countered with positive valuations of practices that transgress such divisions and of people who are or become 'lay experts' in certain settings (for science Wynne, 1996). Currently, under particular impression of the Internet this became the positive call of the 'wisdom of the many' or the 'wisdom of the crowd'. On the other hand, in TechnoScienceSociety many objects

transgress professional contexts and offer their unfolding to new subjects who find sources of self and sociality in such (technological) objects (Knorr-Cetina, 1997). Gershenfeld's positively depicted surprises in a way also value these new subjects.

The second surprise was that the students weren't there due to professional reasons but it 'was their own pleasure in making and using their inventions' and with this they 'were inventing a new physical notion of literacy [...] for technological expression every bit as eloquent as a sonnet or a painting' (Gershenfeld, 2005, p. 6–7). Here Gershenfeld mobilises what Boltanski and Chiapello call 'artistic critique' which 'vindicates an ideal of liberation and/or of individual autonomy, singularity, and authenticity' (Boltanski & Chiapello, 2005, p. 176). This can be traced back to 19th century romanticism and 'technological expression' was also highly valued in that same century's 'arts and crafts movement' in the UK for example[3]. And of course, Boltanski and Chiapello's argument is that the 'new spirit of capitalism' equally promotes such individuality in workers and consumers – to its own ends. This form of critique was also crucial, however, in the counterculture (see above) and even today it finds enough spheres of social reality where it can identify lacks of that which it strives for.

Gershenfeld's third surprise was somewhat similar to the first, it is about 'what these students managed to accomplish. Starting out with skills more suited to arts and crafts than advanced engineering, they routinely and single-handedly managed to design and build complete functioning systems' (Gershenfeld, 2005, p. 6). In industrial settings, Gershenfeld argues, individuals weren't able to accomplish this, tied as they are to divisions of labour and hierarchical collective processes. Besides this explicit critique of industry, Gershenfeld implicitly appraises the technosocial setting this course enabled where it is possible for people and machines together to individually produce something from scratch. The things, however, produced in Gershenfeld's course and many other FabLabs are not (yet?) of the complexity of industrial objects such as smartphones or cars. But they don't need to be. For Gershenfeld 'personal screaming technology' (Gershenfeld, 2005, p. 7), basically a pillow that records sounds and plays them – also a scream if you want, is one of the examples he gives that is enough to show to him the basic capability of this setting where '*(almost)* anything' can be made, where the potential of particular digital technologies is experienced.

Fourthly, Gershenfeld was surprised by the learning approach the students used. Initial learning by trial and error was followed by mutual sharing of knowledge where the students passed their knowledge on to their 'peers' to do just what they needed or wanted to do. Such a 'teaching on demand' model, Gershenfeld argues, is different to what universities typically do with fixed curricula and much unuseful knowledge (Gershenfeld, 2005, p. 7). Besides the critique of hierarchical institutions, now in its third shape, Gershenfeld emphasises the communitarian ideals of solidarity, sharing and equality and how they almost cybernetically are created in the course's technosocial setting. This again draws on resources brilliantly analysed by Turner (see above), a mix of counterculture and digital technology, beyond the MIT also often depicted as 'peer-to-peer' processes and also influenced by much older anarchist cultural currents (e.g., Benkler, 2013). Whilst this might be an idealisation by Gershenfeld of his students, the massively overcrowded course suggests that there were such learning processes if the students actually got something working out of the ma-

3 See William Morris's 'News from nowhere', published in 1890, as an important form of visioneering for that movement in the form of a novel.

chines.

In 2001 when the CBA started there was accordingly already much going on concerning 'personal fabrication' and experiences with people using prototypical arrangements of such technologies. The funding by the NSF, however, also required 'outreach' elements. And Gershenfeld became the coordinator of 'the technical program for Media Lab Asia, which was established this year in India to explore appropriate information technology for economic and social development. These partner efforts will both ground the center's research and provide channels to bring its results beyond the laboratory' (MIT News, 2001). What should be explored were 'fab labs'. Inspired by the class at MIT Gershenfeld wanted to 'deploy proto-personal fabricators in order to learn now about how they'll be used instead of waiting for all of the research to be completed' (Gershenfeld, 2005, p. 11). With a couple of commercially available machines of together about 20.000 $ ordinary people should be equipped 'to actually *do* what we're studying at MIT instead of just talking about it' (Gershenfeld, 2005, p. 12). Thus in 2002 the first FabLabs were launched in 'rural India, Costa Rica, northern Norway, inner-city Boston, and Ghana' (Gershenfeld, 2005, p. 12). Although this move is encouraged by the governance of the NSF, it was also mobilised through particular cultural resources which are important for FabLabs.

By setting up three FabLabs in poorer countries the CBA entangled with discourse and practice of 'appropriate technology'. Strongly inspired by writers such as Ivan Illich (1973 ‘tools for conviviality’) or Schumacher (1973, ‘Small is beautiful’) this sphere has been aiming at technologies alternative to industrial arrangements and 'appropriate' to local needs. Although this began as a critique of industrial Western society, approaches, practices and experiments with appropriate technology were from the 1980s onwards mainly focused on developing countries (Kaplinsky, 2011). The discourse on appropriate technology, however, was also influential in the Western environmental movement where it was conducive to local and small-scale agriculture or renewable energies, for example. The MIT and Gershenfeld, however, combine their appropriate technology with information and communication technologies. A group, including Gershenfeld, in 2002 present their initial FabLabs in a conference paper: 'At the heart of this idea is the belief that the most sustainable way to bring the deepest results of the digital revolution to developing communities is to enable them to participate in creating their own technological tools for finding solutions to their own problems' (Mikhak et al., 2002 n.p.). Whilst they furthermore give much thought to ICTs and possible designs of technologies suitable for FabLabs they always emphasise that FabLabs shall enable people to actually use these technologies. Whilst there is a techno-progressivist idea that technology shall (and will) do 'good' to societies[4], this is entangled with an emphasis on the social use of technologies and thus points towards an other element that is mobilised initially.

The FabLabs in Boston and India alike were about giving public access to the machines arranged and thus also to enable people to use these machines towards their own ends. This resembles the key idea of communism as it developed through the centuries: the community of goods (Eßbach, 2011). As Eßbach also shows, this was initially created in the ancient Greek polis which showed its radical (social and tech-

4 Gershenfeld is in prominent company at the Center for Bits and Atoms: Combining the social and technological utopian forces that Turner describes, Negroponte got a lot of renewed attention in 2006 when he launched the 'one laptop per child' project which aimed at providing children in developing countries with cheap and robust laptops.

nical) artificiality and thus contingency to (some of) its observers. It was considered that the relations to technologies and the political relations to others had an effect on each other. Thus the conscious design of these relations, e.g., shared households, might also lead to an improved community in the city. The community of goods has in many ways during history been an intellectual product and is currently having a fresh wave of support and creativity – the 'commons' and mainly the new internet enabled commons receive much attention (e.g., Benkler, 2006; Bollier & Helfrich, 2012; Gorz, 2010; Hardt & Negri, 2009; Rifkin, 2014). This is, I argue, since with digital technologies and the Internet, the artificiality and thus malleability of technosocial entities is becoming evident again. It almost seems that new forms of social organisation can be created 'with a click' online. And similarly Gershenfeld could harness the flexibility and capability of the digital machines to make them available to non-professionals. Furthermore, the whole experiment was not for profit making but to investigate possible transformations in the relation of 'technology' and 'social' organisation. Curiously, although initially based on the vision of individual 'personal fabrication', FabLabs from the beginning were based on 'communal[5] fabrication', on common instead of private usage of these machines.

So, how did FabLabs come into being, how were they initially visioneered? The visioneering as an imaginative and practical activity that created FabLabs was not an entirely controlled and planned process, as the metaphorical resemblances to 'engineering' falsely suggest. The vision 'FabLabs' was not a starting point that directed a project, rather, this vision itself creatively emerged within a certain arrangement that was mobilised by and itself mobilised particular cultural resources to energise a creative process. At the Media Lab, a place full of 'future-making', Gershenfeld and others pursue a technological vision of personal-fabricators and wanted to find technical arrangements that might foster research on these machines. Very much technoscientists, they were trying to find novel technological capabilities with the support of industrial rapid prototyping machines. The students, however, with their huge appearance and enthusiasm about making stuff, added new meaning to this arrangement of machines. They provided a vague and prototypical glimpse at a future in which 'everyone could make (almost) anything'. Although, the Media Lab historically provided such frames for technology, this comes as a surprise and unveils another potential of these technologies: their potential to make things people want to make, and their potential to be part of arrangements that are not only focused on technoscientific research. Along with the governance of NSF science funding which required 'outreach' to bring results 'beyond the laboratory' the question and idea grow of what would happen if such a technosocial arrangement was set up beyond the confines of MIT. Thus, besides the technoscientific perspective on technological change and capabilities the experiences at MIT resonated with discursive and practical elements that further energised the process. The course 'how to make (almost) anything' and the initial FabLabs enacted ideas of 'lay expertise', 'artistic critique', highly capable non-industrial approaches to technology production, self-governed peer-to-peer learning, appropriate technology and technology as common good.

FabLabs thus are an emergent effect of an 'assemblage' in which people could 'mobilize, explore, and push the limits of the possible' (McCray, 2012, p. 10). Once prototypically emerged, however, the idea, the practice, the concept, the vision 'Fab-

5 The word common shares etymological roots with 'commune', 'communism', 'communal', 'community'. They point towards the social relations that are constitutive of something shared or of something public.

Lab' had its effects on this assemblage as well. A certain intermittent order was found also by entangling FabLabs with older cultural resources that were, however, linked with newer elements in a creative process that is not determined by any element. This early vision of FabLabs, as put forward by Gershenfeld, is spread into the world in different ways, e.g. through Gershenfeld's book in 2005, his popular TED talk in 2006 (Gershenfeld, 2006), MIT's outreach efforts and of course the early FabLabs themselves which even practically embodied this vision and created encounters, images and stories themselves. And it spreads with surprising effects: in 2004 there were already 32 FabLabs, a number which had increased tenfold in 2014 (Troxler, 2014). Indeed, seeing this early growth, Gershenfeld admitted that he is a visioneer: '*fab* [his 2005 book] would not have been written, or been worth writing, if not for the unexpected global growth of fab labs, which has been one of the most rewarding activities I've ever been involved in. [...] [FabLabs are] growing beyond what can be handled by the initial collection of people [...] I/we welcome your thoughts on, and participation in, shaping their future operational, organizational, and technological form' (Gershenfeld, 2005, p. 258, 264).

Yet, to actually get to the collective character of visioneering, a focus on the initial assemblage of FabLabs is not enough. How do this vision and efforts for visioneering practically travel, how are they taken up, how are they embodied in FabLabs, how are they modified? These are crucial questions if one wants to take visioneering as a truly collective endeavour and if one wants to understand the global FabLab assemblage. Such collective visioneering is not only the reproduction of what happened and what was narrated at MIT, it is a creative process that forms around this vision, which is rather like a 'fluid object', stable since it changes (cf. Law & Singleton, 2005). In this context it is interesting to see, how Gershenfeld presents the first FabLabs in his book:

FabLab Boston, 2002, http://opendesignnow.org/wp-content/uploads/2011/05/fablab-boston-copy.jpg, accessed October 2015

What is presented as a FabLab could also be seen as 'just' three desks and three small machines with which people are working. Yet, for Gershenfeld this is enough, they show the actual feasibility, the technosocial capability that was created by FabLabs – the products themselves are not that important: Hardly 'anything' can be

made there. Here, Gershenfeld is truly a technoscientist, interested in controlling novel technological capabilities (cf. Nordmann, 2012). Curiously, the early FabLabs were equipped with rather cheap commercial machines – standard, nothing particularly cutting-edge about them. Although Gershenfeld and others claimed that they wanted to produce cheaper soft- and hardware for FabLabs, one can also ask, were FabLabs from the beginning rather about a novel social form of usage of machines than about the technology of these machines? Such a split doesn't work, of course, FabLabs have been a technosocial arrangement, yet, the creativity seems to be rather on the 'social' side of it. There is furthermore a second curiosity in early FabLab history: Whilst Gershenfeld was driven by the idea of 'personal fabricators', he doesn't talk about 3D-printing, a technology which is crucial to many contemporary FabLabs. And Gershenfeld was only vaguely making references to the open source approach, which would later on feature prominently in guidelines for FabLabs published by MIT in 2007. To understand what happened in this process, one needs to move beyond mere visioneering and approach it as a particular element in 'real-life experiments'.

FabLabs are real-life experiments

Already at MIT, of course, a setting centred on knowledge production, there are signs of experimentation when Gershenfeld and others had set up the course. The students experiment with producing things with the machines and even leave documentation and manuals behind in the process. To Gershenfeld this is a surprise that hints at the technosocial capabilities that were 'discovered' here. Gershenfeld thus has actual experiments in mind in which he wants to see, how personal fabricators might be used in different contexts. These are the first FabLabs and initially there is still close control by the experimenters and MIT. But these rather classical experiments in confined settings are overtaken and overwhelmed by new FabLabs that appear without the MIT starting them – the experiment has become a 'real-life experiment' (cf. Krohn & Weyer, 1994a) involving far more than the researchers at MIT and their experimental settings. In his book, Gershenfeld admits that the practice and technology of personal fabrication cuts across existing institutional boundaries in 'often unplanned ways' (Gershenfeld, 2005, p. 257). Accordingly, this chapter will clarify, why it is fruitful to interpret FabLabs as real-life experiments. After discussing the relevant literature that argues that society has become a laboratory, I show that in TechnoScienceSociety experimentation is based upon new technosocial realties. And FabLabs as a global assemblage are a particularly insightful real-life experiment that creatively enlarges openings of TechnoScienceSociety.

Experimentation is a key principle in modernity. The heightened rate of change, the question for 'innovation' and profit, the rise of modern science, the increase in technologies and potentials to modify them have been creating much experimentation. Modernity has created the experience that 'all that is solid melts into air' (Bauman, 2000; Berman, 2010; Marx & Engels, 1971). At the beginning of this experience, Francis Bacon justified scientific and technological experimentation as a mode to improve society (e.g., Schmidt, 2011). It is noteworthy to remember that 'experiment', 'expert' and 'experience' are semantically closely related. Accordingly, the semantics of experiment can be found in many areas of modernity, such as art, war, science, politics, in both, positive and negative uses (Krohn, 2007).

Emphasising the positive side of experimentation, the Marxist philosopher Ernst

Bloch claimed that the whole world is an experiment in which humans take part (Bloch, 1975). Himself a child of modernity and an advocate of social progress, Bloch argued for an ethics of experimentation. Experiments can be 'concrete utopias' if they strive to improve the human condition, and concrete utopias must provide space for ongoing experimentation. Such an experimental process can neither ground itself in 'universal truths' of the past, nor sketch out blueprints for the future. Trying to help a better world emerge necessarily is a truly creative process with all its contingencies, unknowns, risks and opportunities, a process that might fail and thus needs to be able to learn from the novelties it is creating. The people that engage in concrete utopias try to give them a certain direction and hope for positive results, yet experiments are open processes and might turn out differently than expected. History is creative and (partly) changes ideas, practices, normative judgements, feelings, identities, belongings, powers and socialities. Therefore concrete utopias need to be creative as well, take part and learn from the ongoing entanglement of what is and what is 'Not-Yet'[6] to experiment with improving[7] the world. Bloch called this 'the principle of hope' (Bloch, 1986).

When in the 1980s, sociologists of science and technology started to address the experimental character of technology and innovation processes this was a critical move, emphasising mainly negative aspects of experimentation (central: Krohn & Weyer, 1994b, 1989). A move that was made in an intellectual climate dominated by the 'risk society' that industrial societies have formed (Beck, 1992) and an anti-utopian 'heuristics of fear' (Jonas, 1984)[8]. Conceptually the move was against linear ideas of technological innovation as the mere application of science, against understandings of modern technology as stable and determining, as simply instrumental reason; basically the move pointed towards the 'unruly' experimental character of technology (Wynne, 1988). In many areas, the argument 'society as a laboratory' proceeds, experimental knowledge production, a key to modern science, can no longer be confined to bounded settings 'outside' society, such as the laboratory. Rather, experimentation takes place 'in' and 'with' society because such a confinement doesn't work in many cases where non-knowledge is paramount or 'real-life' situations are more complex than any laboratory could be. Thus, 'real-life experiments' come centre stage and arrange many more diverse elements in a process that puts society at risk than any one scientist could.

About twenty years later, the notion of 'real-life experiment' is having a comeback. Now, however, many authors use it as a positive concept with a problem solving outlook for contemporary society. In the famous report on the European knowledge society the authors advocate 'collective experimentation' to find novel ways of innovating in society beyond the dominant 'regime of economics of technoscientific promises' (Felt & Wynne, 2007). Other authors similarly argue that to successfully deal with emerging technosciences, e.g. synthetic biology, society needs to engage in real-life experiments (e.g. Nordmann, 2014). The discourse on 'responsible research and innovation', adopted by the EU, fosters activities to imagine and practice altern-

6 This is a key term in Bloch's process ontology. The world is full of that which is not yet, a world of becoming, full of potentials, latencies and tendencies.

7 What constitutes an improvement is something to be determined in process. According to Bloch's process ontology, desires, dreams and humans can become different, there are no timeless universals of the 'good society'. Although, in Bloch's Marxist philosophy the good society was a classless society, he didn't sketch out how such a society would look, this would have been making up an 'abstract utopia'.

8 Explicitly elaborated against the 'heuristics of hope' in Ernst Bloch's philosophy.

atives to dominant innovation practices (Guston et al., 2014; Owen et al., 2013). Whilst the diagnosis is still that there is something wrong with society and its technology, real-life experimentation is now being seen as a potential way out, a way to learn and to change society. Real-life experimentation is considered as a procedure able to constructively deal with non-knowledge (e.g., Gross, 2010) and transgress the shortcomings of dualist thought and institutions based on it, which assume strong differences between knowing and acting, theory and practice (e.g., Bammé, 2014; Bogusz, 2012). Somehow, the positive side of experimentation as a way to potentially improve society, argued for by Bloch, seems to have a renaissance. This, however, is also due to the hugely changed conditions in which experimentation takes place nowadays in TechnoScienceSociety.

Many authors have argued that the relations of science, technology and society have been drastically changing during the last decades (e.g., Bammé, 2011; Haraway, 1997; Latour, 2013). Besides the increasing prominence of technoscience, technological systems tightly entangle with the everyday lives of people, with the economy, with politics and so on. The 'age of technoscience' (Nordmann, 2011) is creating massive epistemological and ontological changes in respect to technological processes in contemporary societies. Amongst other changes, there is a prevalence of technoscientific cultures that value the creation of novel technological capabilities (Nordmann, 2012). This often includes visionary discourses that herald novel technologies as saviours of humanity or condemn them as humanities greatest problem (Grunwald, 2014). Such visions, however, point towards a social imaginary of a society, that increasingly sets its politics in terms of the positive or negative possibilities of technologies. Especially the spreading of digital technologies and their messy and changing entanglements with everyday lives is creating a historical-ontological shift in which ever more active and partly autonomous constituents of environments are reshaping subjects and objects (Hörl, 2013b, 2013a). In such a technosocial world, new processes and powers shape subjectivity and sociality (Knorr-Cetina, 1997; Maasen & Duttweiler, 2012). Almost no surprise, that such a technologised society creates many new and messy ways of knowledge production (e.g., Nowotny et al., 2003).

Bruno Latour (2011) claimed that in this contemporary TechnoScienceSociety, everyone has become part of 'collective experiments' as a 'co-researcher'. The issues of our time, such as climate change, are not simply to be dealt with by scientists, rather they involve everyone in their daily lives and they call for a large scale change in how societies operate. Furthermore, Latour claims, there has been a massive diffusion of experimental apparatuses: computers, cars, houses, hospitals and so on are not simply just 'used' anymore, they can easily become part of experimental arrangements. And many more people than the typical 'scientists' are taking part in such arrangements and asking their own questions. Since there is no outside of experimentation any more and since the experiments Latour has in mind concern the the common world, the overarching question that needs to be answered, Latour argues, is whether experiments are well or badly designed – a question that also needs to be answered collectively.

Latour raises two important aspects that are of high relevance when considering FabLabs as real-life experiments. The first aspect concerns the constitution of real-life experiments. They transgress established laboratories, scientists and institutes that simply conduct and control a real-life experiment. On the contrary, FabLabs as real-

life experiments are an ongoing and changing arrangement of heterogeneous elements that form an 'assemblage' (Deleuze & Guattari, 2004) which is energised from many different sources and has emergent effects.

> '[An assemblage] is a multiplicity which is made up of many heterogeneous terms and which establishes liaisons, relations between them, across ages, sexes and reigns – different natures. Thus, the assemblage's only unity is that of co-functioning: it is a symbiosis, a “sympathy”. It is never filiations which are important, but alliances, alloys; these are not successions, lines of descent, but contagions, epidemics, the wind' (Deleuze & Parnet, 1987, p. 69).

The question, how such an assemblage constitutes a real-life experiment, how there is co-functioning in it, is thus crucial – and little research has addressed it so far (e.g., van den Daele & Krohn, 1998). From Rheinbergers study of scientific experiments (1997) one can learn, that unfolding objects, 'epistemic things', and their movement between experimental systems are an important enabler of experiments which manipulate objects and knowledge to create surprise. Additionally, in particular real-life experiments such as FabLabs there is manipulation of sociality and subjectivity since FabLabs are also an organisational experiment in which people actively engage to learn and create individual and social capabilities. The question is thus, how are these arranged, moved and manipulated to create experimentation in and with FabLabs? The second, normative aspect of the evaluation of experiments that Latour raises is important in FabLabs as well. Observers and participants alike often evaluate FabLabs rather positively. This is not only a question of reflecting on FabLabs, rather much of the practices that create FabLabs are entwined with a moral engagement of people in them, many of which try to make certain aspects of the world different. This normative side is a key force to create FabLab experiments. Experiments are consciously conducted processes, with goals, interests and motivations behind them – they are not simply a 'co-evolutionary change' of any sort. And this text will thus also show its sources and enactments.

Seen in the light of the above discussion, Gershenfeld and MIT created the epistemic thing 'FabLab', vaguely defined and in the process of surprising unfolding. The crucial question, that can be learned from Rheinberger's analysis of experimentation, is: How does this epistemic thing get taken up by other 'experimental settings'? What is a 'real-life experimental setting', how do these take the epistemic thing, modify it, bifurcate it and link it up with other epistemic things? What are the people besides Gershenfeld with different questions and the other arrangements that entangle with FabLab? What sense of normativity, of 'positive' change do such experimental processes enact? How has there already been experimentation in which FabLabs could take part? And how is a real-life experiment constituted in and by a global assemblage that involves more than particular experimental settings at certain places?

FabLabs experimented

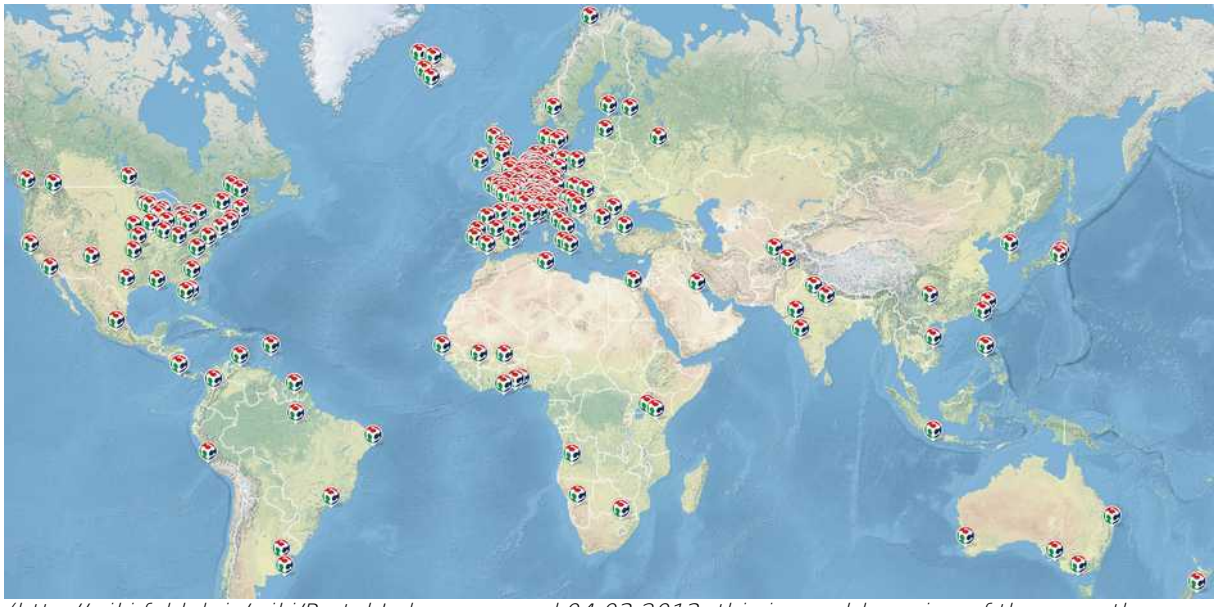
I first encountered FabLabs on Wikipedia, on the encyclopedia's page for 3D-printing in 2012. In search for a topic for my PhD, I was familiar with the writings of André Gorz (Gorz, 2010) and Frithjof Bergmann (Bergmann & Friedland, 2007; Anon, n.d.), two leftist philosophers who promoted 3D-printing as a technology for local and non-alienated high-tech production. FabLabs, from what I could get from Wikipedia and some FabLab's homepages to me reasonated with a vision sketched out by Gorz in

2007 – and I doubt that he was familiar with FabLabs – which intrigued me a lot:

> 'Existing tools or tools currently in development, which are generally comparable to computer peripherals, point towards a future in which it will be possible to produce practically all that is necessary and desirable in cooperative or communal workshops; in which it will be possible to combine productive activities with learning and teaching, with experimentation and research, with the creation of new tastes, flavors and materials, and with the invention of new forms and techniques of agriculture, building, and medicine, etc. Communal self-providing workshops will be globally interconnected, will be able to exchange or share their experiences, inventions, ideas, and discoveries. Work will be a producer of culture, and self-providing will be a way to self-fulfillment. […] I do not say that these radical transformations will come about. I am simply saying that, for the first time, we can wish them to come about. The means exist, as well as the people who are methodically working towards their realization' (Gorz, 2010, p. 12–13).

Gorz's vision to me got particular strength in light of his brilliant early analysis of the tensions of knowledge (which thrives if it is common) and value (which needs scarcity) in contemporary capitalism and of open source as an alternative economic paradigm. Within a few days, after encountering 3D-printing and FabLabs online, my PhD topic was set. This was what I wanted to investigate and contribute to.

In 2012, the sources I could find spoke about 150 to 200 FabLabs worldwide – in 2014 the number being circulated is 350 (Troxler, 2014) at the beginning of 2015 a report counts 440 labs (Hielscher et al., 2015a). Actually, there is no 'official' number due to the decentralised spread of the labs. And a map that is still being created by the FabLab 'community' using a wiki showed their global distribution:



(http://wiki.fablab.is/wiki/Portal:Labs, accessed 04.03.2013; this is an old version of the map, the image by now looks differently and shows more FabLabs).

The global spread of the workshops Gorz described – with significant concentrations in the US and especially Europe, global centres of technological society – seemed to have already gained traction. Yet, besides showing the feasibility of such a global network of workshops, the rather fast global spread of FabLabs raises the question of how the knowledge about FabLabs spread so quickly. As Thrift (1999)

showed in his analysis of the history and travel of metaphors of complexity, ideas travel through time and space in entanglement with milieus, as part of 'actor-networks' or as I would have it, as part of assemblages. They involve people, media, practices, objects, organisations, meetings, images, texts and so on. Two historical examples of visioneering briefly exemplify how an analysis of FabLabs also has to include such travel of knowledge and the new historical conditions that significantly change it.

The Communist Manifesto, after initial impact in German around the revolutionary time of 1848 became almost out of sight until around 1865 when German working-class parties reprinted it. Significant translations and editions appeared from the 1870s onwards and its spread during the following 40 years was closely entangled with the spread of the socialist labour movement, yet with its main impacts in central Europe. Thus, whilst the manifesto by now is one of the most significant texts in modern political history, it took decades for it to have its effects (Hobsbawm, 2011, p. 102–7). The Whole Earth Catalogue, the prime defining medium of the new communalism in US counter culture started in 1968 with 1000 copies and was ended in 1971 with an edition of one million copies. Whilst by then it was available in book stores and could be found in suburban homes, actual experiments and enactments of the ideas presented in the catalogue was largely confined to the circles of hippies, artists and some scientists in the US, especially in California and the East Coast. These ideas, in modified versions had their strongest impact in the 1980s and 1990s when they produced an almost utopian imaginary of digital technologies (Turner, 2006, esp. ch. 3).

These examples show that it is not enough to simply state that FabLab 'travels' through the Internet, although this is utterly significant. Rather, this text also seeks to show what the 'milieus', the cultures, the practices and the organisations are that have been fostering the quick uptake of FabLabs. FabLab Karlsruhe will be the prime example and highlight in detail how a FabLab is being assembled locally by entangling with a global assemblage. I present this process not in a strict chronological order but around certain characteristics, events and objects that highlight the dimensions of experimentation of the arrangements FabLabs, and FabLab Karlsruhe in particular, have been co-producing.

In spring 2013, a few weeks before I invited people to join in creating a FabLab in Karlsruhe, there was a media hype of 3D-printing and the 'maker movement', clearly visible in Germany (z. B. Anon, 2013; Otto, 2013). Also noticed by some of my colleagues at the Institute of Technology Assessment and Systems Analysis (ITAS), where I have been working on my PhD, talks about my PhD tended to move towards the more general potentials of 'making' and 3D-printing as seen and speculated by my colleagues. Spring 2013 was also the time when the ITAS project 'Quartier Zukunft – Labor Stadt' (www.quartierzukunft.de, engl. 'District Future – Urban Lab') was in its early phase and looking for interesting projects in the city of Karlsruhe to collaborate with. Quartier Zukunft is a transdisciplinary project with the long-term goal to transform a district of Karlsruhe towards sustainability and is cooperating with the municipality, the KIT, business and civil urban society. When I explained my PhD topic to Andreas Seebacher, a researcher in the project, and briefly turned to FabLabs, he readily suggested that a FabLab might fit well in Quartier Zukunft. Besides such motivation by colleagues I knew of a mailinglist (of by the time 16 people) at KIT about 3D-printing and FabLabs. I've been to a talk about 3D-printing by one key per-

son of this group – who should also become strongly involved in FabLab. And a visit to Karlsruhe's Chaos Computer Club showed me that there is an active hacker scene but rather closely related to software (for a geneaology of ‘hackerspaces’: maxigas, 2012). Yet, taken together, these things affected me and I thought there is potential for a FabLab in Karlsruhe and maybe even growing interest – I slightly assembled with a vague assemblage that was already present.

I present these initial times that turned me into a 'visioneer' in some detail since I want to emphasise something which is important for the processes of global FabLab 'becoming'. Visioneering these experiments is not about making up plans in the 'mind' and then to realise them. Rather, as the phenomenologist and anthropologist Tim Ingold puts it, life is lived in 'correspondence' of the trajectories of organisms and materials and thus to 'imagine [...] is not so much to conjure up images of a reality “out there”, whether virtual or actual, true or false, as to participate from within, through perception and action, in the very becoming of things' (Ingold, 2012, p. 3). Imagination is a distributed and emergent result of assemblages together with which it is being formed. Thus the following will draw out particular formations of the assemblage that foster and influence the also imaginative processes of organising and experimenting FabLabs and FabLab Karlsruhe in particular.

An assembly forming FabLab Karlsruhe

In June 2013 I sent an email inviting people to join the process of creating a FabLab in Karlsruhe to the above named 3D-printing mailing list, the Chaos Computer Club, thanks to a contact to the students of the Design School in Karlsruhe and to a student group at KIT interested in 3D-printing that I was pointed to. The email read that it was planned to establish a FabLab in Karlsruhe as a project within Quartier Zukunft and that everyone is welcome to join the process. Within three days more than 20 people replied, many familiar with FabLabs and 3D-printing, and showed their interest such that I soon started to organise a first meeting and to find a date for it – all via email. A month later around 30 people gathered in the seminar room of ITAS in an evening. Amongst them many people that emailed me, many who didn't but have heard of it somewhere else and two colleagues from Quartier Zukunft. This exciting evening, with introductions of the people and their interests, an introduction to Quartier Zukunft, with questions about what FabLabs actually are, with partly heated debates of what to do first and how fast, ended with arranging a second meeting and adding 'FabLab Karlsruhe' to the wiki of the global FabLab movement with the label 'planned' (http://wiki.fablab.is/wiki/Portal:Labs, accessed 03.03.2015). From then onwards, a somewhat changing group of people met every fortnight at ITAS to establish FabLab Karlsruhe. From this 'birth' of FabLab Karlsruhe I want to point out five assemblages that have been linking up with FabLabs and have a huge significance for them: research, the city, the social practices of commoning, imaginaries of 'crowds' and 'communities' and open source 3D-printing.

Above I showed how FabLabs came into existence at MIT due to technoscientific cultures and wider cultural practices. Whilst MIT still is an important element in the global FabLab assemblage, other research institutions and practices of research have taken part in it. Two of Europe's oldest, largest and certainly most visible FabLabs have close entanglements with research. FabLab Amsterdam is run by the Dutch 'Waag Society' which investigates new media and emerging technologies to foster cultural and social innovation (www.waag.org, accessed 10.04.2015). FabLab Bar-

celona is founded by the 'Institute for Advanced Architecture of Catalonia' (www.i-aac.net, accessed 10.04.2015). There are many other examples and the aims of these connections reach from giving students access to the FabLab to using the FabLab itself as a medium of social, technological or design research. Yet, one mustn't preclude that FabLabs are dominated by research, there are many other organisational forms and business and community run FabLabs as well. And I will show the organisational 'openness' that enables this.

In Karlsruhe I established a link to ITAS, which did not only host the initial meetings but created cooperations in some instances. And furthermore, it didn't seem absurd to the people that joined the process that a sociologist starts a FabLab – relations to research are within the scope of possibility that the FabLab culture entails. Thus, Quartier Zukunft has been conducting its much larger real-life experiment with FabLab as one element – here, the resonances FabLabs have with decentralised and communal (self-)production, I showed above, fit into certain cultures of sustainability. Yet, what 'is' there in FabLabs that attracts research? Two things are particularly important: FabLabs technosocially explore emerging technologies and are thus 'socially' and 'technologically' interesting and partly new. Secondly, FabLabs are geared towards knowledge production and knowledge sharing which are key principles of science and research – as is experimentation. Where the connections thus established are sufficiently strong, there is furthermore an influence on the FabLab assemblage that shows that FabLabs need not necessarily be profit oriented organisations.

'FabLab Karlsruhe' this name was not a coincidence, rather it actualised the general pattern of name giving of FabLabs which is 'FabLab *name of city*'. There are some exceptions but they only confirm the rule (see: http://wiki.fablab.is/wiki/Portal:Labs and www.fablabs.io, accessed 10.04.2015). Most FabLabs are in cities and not in rural areas. Cities are key to modernity, which has been especially strongly experienced in processes of urbanisation (classic: Berman, 2010). Cities are condensed places of flow, exchange, encounter, difference, conflict, interaction and innovation as such offer much potential for creativity. They provide a fruitful milieu for FabLabs, and be it only in that there are large numbers of people in one place such that there are enough who are interested in participating in FabLabs. There is a strong sense of place in the global FabLab assemblage. This is significant since although highly influenced by digital technologies and cultures, FabLabs do not recreate the 'non-places' of 'cyberspace' (Augé, 1995), which is an increasingly insufficient term suggesting a parallel world of digitization, which no longer exists. FabLabs on the contrary thrive on entangling 'online' and 'offline' interactions, technologies and cultures and therefore are also strongly localised.

There is, however, a further sense in which FabLabs entangle with cities and their becoming. The neoliberal city model with its privilege of private investment and consumption in designing cities and a very unequal distribution of the cities infrastructures (central: Graham & Marvin, 2001) is increasingly being challenged. Particularly important here are discourses on sustainability – see Quartier Zukunft. Discourse and practice of the 'creative city' (e.g., Florida, 2003) is fostering business and non-business forms of creativity and innovation in cities. Explicitly drawing on such an agenda Karlsruhe has created an area for small businesses and cultural and artistic work in an old abattoir and the municipality has offered FabLab Karlsruhe a subsidised space to rent there. There is furthermore a diffuse set of discourses highlighting digitisation in changing the city, e.g., 'smart cities'. Part of this parcel is discourse on a 'third in-

dustrial revolution' which suggests a re-localisation of production through increasing global digital connections and technologies (exaggerating but influential: Rifkin, 2014). Combining all of this – and probably more – Barcelona in Summer 2014 announced to become the world's first 'Fab City' during the annual FabLab conference (www.fab10.org/en/symposium, accessed 08.04.2015, Smith, 2015). Here are strong differences to the utopian communes of the US counterculture, so influential for the cultural imaginary of digital technologies, which settled in the country, in exile, 'outside' society (Turner, 2006). Now, FabLabs are resonating with certain tendencies 'within' society and cities – to me this is a sign of FabLabs, although influenced by 'cyberutopianism', having become 'concrete utopias' (cf. Bloch, 1986).

There is a third, more political sense that links FabLabs and cities: the 'citizen' aspect[9]. From antiquity onwards, the city has also been a political entity with those participating in politics being the citizens (Eßbach, 2011). During history the politics of these citizens has taken many different forms, yet also involved self-organisaton and the creation and maintenance of commons (Harvey, 2012). Recently, Hardt and Negri emphatically announced that 'the metropolis is to the multitude what the factory was to the industrial working class' (Hardt & Negri, 2009, p. 250, italics omitted). In their political theory the commons play a key role in enabling and creating new forms of subjectivity and sociality of a multitude in becoming that shall learn to self-organise life beyond 'market' or 'state'. Whether or not people in FabLabs share the political aspirations of the two neo-Marxist authors, many FabLabs are and explicitly present themselves as community-based workshops; as organisations run by citizens for citizens and thus also as 'political' organisations fostering and experimenting with self-organised technosocial arrangements. The political sense of FabLabs was clearly felt during the first meeting, when the gathering of some researchers and about 30 'citizens' showed the will and the commitment to together launching a FabLab. A central, not only political aspect, of FabLabs is thus the social practice of 'commoning' which 'produces or establishes a social relation with a common whose uses are either exclusive to a social group or partially or fully open to all and sundry' (Harvey, 2012, p. 73). The character and extend of this relation (concerning the group and the common, both in formation) is itself being contested and experimented with in the practices of FabLabs as I show and thus in their relation to cities as entities and in themselves FabLabs enact a politics of the commons.

During the first meeting, a group came into being that intended to form the FabLab as a common. Such forming of groups together with commons is at the centre of a notable imaginary of the Internet: the 'crowds' and 'communities' that pervade the Internet and the hopes and fears that entangle with it. And this imaginary, along with digitised practices of organisation, has an impact beyond mere 'online communities'. It is part of the culture that fosters FabLabs. These are normative notions, and besides describing certain aspects of Internet based sociality they also entail how this should be – especially in discourse fostering a 'web 2.0'. On the one hand, 'crowd' points towards the diffuse agglomerations of people online that might add up small individual contributions to form large results, such as a 'crowdintelligence' or 'crowdfunding' replacing banks. 'Everyone', it is often heralded, can and should be part of such crowds. On the other hand, the old term 'community', since its modern inception as something other to the abstractions and complexities of 'society' (e.g., Ferdinand Tönnies), points towards mutual relationships between people, a sense of com-

9 This aspect is also emphasised in discourse on 'citizen science' which is also used to address FabLabs.

mon identity and even solidarity.

Whilst there certainly are different concrete versions of such forms of sociality, even in research the 'ideals' and aspirations of 'crowds' and 'communities' and the actual constitution of them are often being conflated (for example in: Benkler, 2006). Recent empirical research has shown, however, that of course 'online' 'peer-to-peer' collectives are structured and organised in sometimes hierarchical and powerful ways and that there is not only 'openness' but also 'closure' (e.g., Benkler, 2013; Bruns, 2012; Karpf, 2011). One should not, however, give in to too much empiricism and keep in mind, that the ideal, or the vision, of 'openness' is powerfully inscribed in many aspects of particular Internet cultures. 'Opening' surrounds and fosters the practices of many such communities although they might only realise limited openness, which is always a relative term. Yet, this 'ideal' is also having an influence to new forms of organisation partly beyond Internet platforms. And this is not only due to discourse but also due to digitised networking practices enabled by the Internet, affecting many and also political forms of contemporary collective organisation (Castells, 2012). Thus, the forming of a FabLab 'community' in Karlsruhe started with me sending emails to the 'crowd', and thus what was an idea in my and other's heads, rapidly turned into a social project defining a collective. And since then the 'openness' of the community is a defining self-description and an experimental challenge in the process of being defined and defining the community. Below I show how this is being realised in practice and how the ideal of 'opening' also fosters experimentation.

Communities and collectives in general have to be produced and reproduced, they don't simply exist. One of the main producers of the FabLab Karlsruhe community and of many other FabLab collectives is the assemblage of open source '3D-printing'. This assemblage, which 'started' with the RepRap project in 2005 (http://en.wikipedia.org/wiki/RepRap_Project, accessed 14.04.2015) dramatically changed what '3D-printing'[10] actually meant. The project started after a patent on 'fused deposition modeling' expired, one of many technologies used for 3D-printing, which adds small layers of heated and thus docile plastic on top of each other to create three dimensional form. Drawing on the open source approach and a strong vision to make technology self-replicating the project has created a large community and is definitely one of the main projects of open source hardware. RepRap dramatically lowered the cost for the creation of 3D-printers. Yet, besides this economic aspect, RepRap pulled 3D-printing out of industrial contexts, where it had been used form the 1980s onwards. With RepRap, 3D-printing has become enacted as radically networked, open source and as a technology for personal fabrication (instead of 'rapid prototyping' in companies). By now the open source 3D-printing assemblage includes commercial versions (some open source, some not), many of which are based on RepRap designs, which all benefited from this initial opening of this culture and 'market' by RepRap. I thus stick with calling such low-cost, individual, do-it-yourself or 'consumer' oriented 3D-printing 'open source'. This has to be differentiated from 'industrial' 3D-printing which involves far more complicated and expensive machines and a typical 'industrial' way of social organisation of these technologies. Unfortunately, this differentiation is often overlooked by commentators. The recent hype about 3D-printing (around 2012 in Germany) was strongly fuelled by the open source assemblage since this not only showed the 'technology', but also the new 'social' formations that en-

10 More technically correct is the term 'additive manufacturing', as opposed to subtractive manufacturing which is the dominant way of mass producing industrial goods.

tangled with it: 3D-printing had become the meeting point of decentralised and open Internet cultures and novel forms of material fabrication.

Many of the key persons that have or had been part of establishing FabLab Karlsruhe came to FabLabs via open source 3D-printing. Having built such machines themselves or wanting to build or to access one, they became familiar with FabLabs and had the wish to share their 'hobby' with each other and/or to make the technology available to others. Most of them enjoy tinkering and do-it-yourself practices and 'hacking' and many would agree being 'makers', the recent umbrella term which got its prominence amongst other things together with the advent of FabLabs. A 'maker movement' has emerged, as it is often said. This movement and FabLabs are fostered by open source 3D-printing (and other open source projects, especially in 'hardware'). This on the one hand, lowered the cost for the technical infrastructure of FabLabs and on the other hand, has been creating a culture of experimentation with these technologies, including visions of disruptive change through 3D-printing and enthusiasts promoting them. In Karlsruhe, 3D-printing is also the main motivation of many visitors who want to see a printer in action. FabLabs and open source 3D-printing partly assembled with each other and have since been on a trajectory of 'co-becoming'. Whilst in the initial FabLab model there was no 3D-printing, a few years later 3D-printing came to define the core of many FabLabs, including FabLab Karlsruhe. Below I describe, however, how there is much more going on in FabLabs apart from 3D-printing.

Visioneering FabLabs II: spreading the possibilities

Besides the 'milieu' described above which fostered the start of FabLab Karlsruhe, there have been other changes before in the FabLab assemblage which enabled what happened in Karlsruhe. Troxler (2014) describes how in the Netherlands in 2007 a FabLab Foundation was set up, with the agreement of MIT, that started FabLabs without taking part in MIT's outreach programme, which until then had formal relationships, involving a fee, with the FabLabs established. The FabLab model, however, still involved setting up a Lab with a budget of about 100.000 €, as promoted by MIT. In 2010 this changed, when a group of artists in Aamersfort, the Netherlands, inspired by community organised formats and visions of a 'peer-to-peer society' set up their FabLab with about 5.000 € and cheap machines, often self-built open source versions (Hielscher et al., 2015a, chap. 4). This was the first 'grass roots' FabLab, followed by many others which caused a massive 'deterritorialisation' of the FabLab assemblage, opening up its centralisation around MIT and in turn creating new 'lines of flight', 'lines of becoming', possible trajectories for it to unfold. Gershenfeld and MIT, with only limited personal resources couldn't keep up with the mushrooming of further FabLabs without formalised relations to MIT and only slowly adopted 'low cost' FabLabs into their online documentations of what a FabLab 'is' in their view (Hielscher et al., 2015a, p. 23–24; Troxler, 2014). Since a couple of years, thus, FabLabs have moved beyond the experimental setting that MIT established; nowadays, 'high' and 'low cost' FabLabs spread around the globe, assembling with different settings and together defining the real-life experiment and its further unfolding. This raises the important question, however, of how a 'FabLab' actually moves, how is it defined, localised and known, how is a 'local' experiment set up, especially if the MIT's 'blueprint' isn't followed?

To answer these questions the first half year of FabLab Karlsruhe is instructive.

Without money, without a room, with very little equipment (one 3D-printer was quickly offered as a donation by one of the founders), yet with around 15 to 20 people that met regularly in a meeting room at ITAS the FabLab was conceived, partly contested and began to manifest itself in different forms. Actual personal encounters with FabLabs were rare. I had been to a summer school in FabLab Lisbon in 2013 and no one in the initial phase recounted strong links with other FabLabs. There have, however, been other 'channels' that moved knowledge about FabLabs to Karlsruhe, three of which I want to emphasise.

First, some people were 'hackers' and were interested in and familiar with 'hacking' things, i.e. building prototypes and creating creative arrangements of mainly electronics and software technologies (for a thorough exploration of hacker culture: Coleman, 2012). Such 'projects' were brought along sometimes to show the others what one was doing and in turn giving a glimpse of what might be done in the FabLab in the future. The hacking culture has many, also commercial, platforms (such as magazines or open source projects) which foster hacking as a social practice, as something to establish relations to others via making things, sharing with and learning about technology from each other. Via such projects the FabLab was conceived to be a place for sharing this 'hobby' or practice. Yet, this also suggested that a FabLab is similar to a 'hackerspace' or a 'makerspace', which already were familiar to some people in the group. 'Hackerspaces' developed from the 1990s onwards and by now there are also many hundreds around the globe. In contrast to FabLabs, they don't have the aspirations for strong global networking and there hardly exist hackerspaces which have an inventory of expensive machines, such as the 'high cost' FabLabs and strong organisational support such as by a university. Considering grass roots FabLabs there are many overlaps, however, in the practices within these organisations (for hackerspaces: Hielscher et al., 2015b; maxigas, 2012). In Karlsruhe, there even was a vote at the beginning, whether to start a FabLab or a hackerspace and in an email discussion a year later 'FabLab' vs. 'hackerspace' turned up again. Some in the FabLab group, however, explicitly stated that they think FabLabs are more open, socially and technologically such that they are also a place for children or traditional crafts. Besides the implicit closures of the hacker culture (mainly male and technology focused), the semantics of 'fabrication laboratory' also express more openness than the often negatively perceived 'hacker'-space.

Second, many FabLabs and MIT have been circulating images and texts in the Internet and other media, although the self-created content on the Internet is particularly important. In Karlsruhe many of the founders actively searched such content and browsed through many resources online. The MIT's Fab Foundation and other FabLab-organisations (more about them below) have been publishing definitions of FabLabs, guidelines, lists of machines for FabLabs and the 'Fab charter', a guide for the ethics of FabLabs. But besides this, many if not most FabLabs are eager to present themselves and their activities online. Via pictures and videos of workshops, projects or events for example. Some have texts, describing their intentions and visions. And there are platforms such as a wiki run by FabLab Iceland as a resource for all FabLabs to learn from and to contribute to (http://wiki.fablab.is/wiki/Main_Page, accessed 04.04.2015). This is also the place where the community created FabLab map was hosted, showing the FabLabs around the world. On the one hand, this shows, that within FabLabs there is an extensive culture of visibility, of making 'oneself' seen via various social media and of seeing and observing others, of comparing one Fab-

Lab to another and of taking part in a community of mutual observation[11]. This has taken on new levels in the past years through digital technologies and social media which allow many people to easily create and circulate images and texts. On the other hand, along with this visibility there is knowledge exchange, inspiration and comparison. This is crucial for experimentation in FabLabs as it shows explicit and intended knowledge sharing, enabling the 'imitation' of particular experiments by others. Imitation is central to the movements of creativity (Barry & Thrift, 2007) and it more appropriately captures what is going on in the FabLab real-life experiment than the stronger 'repetition' as a key principle in scientific experimentation.

Third, discourse and the dynamics of framing FabLabs in terms of situated goals, values and ambitions are equally important in realising FabLabs. As I already indicated, MIT and the Fab Foundation, created in 2009 to provide a structuring organisation within the quickly growing FabLab assemblage, provide a particular definition as to what a FabLab is and should be (http://www.fabfoundation.org/fab-labs/fab-lab-criteria/, accessed 13.04.2015). These are documented online and as in the case of the 'Fab charter', which exists in a 2007 and revised 2012 version, are expected to be followed if a FabLab wants to be a real FabLab (http://wiki.fablab.is/wiki/Fab_Charter, accessed 13.04.2015). There is, however, no sanctioning mechanism and the governance relies on the cooperation and the voluntary following of other FabLabs. This defining discourse names three ingredients for a FabLab. First, open access to machines for digital fabrication, such that individuals are enabled to 'make (almost) anything'. Second, there is a changing core set of such machines that all FabLabs should aspire to provide, such that there is a similarity between them. And third, FabLabs should form a global network for sharing knowledge. Besides these, there are no other aims and restrictions 'officially' declared and thus FabLabs are rather openly framed by the MIT. Although, one can only speculate why there is such open framing, in my view, the initial idea to experiment with digital fabrication has contributed to it: 'let's see what happens'. Furthermore, when in 2007 the first Fab charter was drafted, many other FabLabs had already co-defined FabLabs and thus shown the need for providing a definition in the first place (for many examples how the spread of FabLabs was a surprise for many in early FabLab history: Hielscher et al., 2015a). Such openness has been central to spreading FabLabs that quickly and widely, the local conditions and organisations that set up their FabLabs have much space in co-defining what a particular concrete FabLab is or shall be. There is interpretative flexibility in FabLabs.

In Karlsruhe one of the first group activities in the planning phase was to draft a 'manifesto' for FabLab Karlsruhe, which should describe what FabLab Karlsruhe in particular is or would be. In a collaborative writing process, supported by a wiki, surveys and a group of writers in which I participated, the text had been drafted to reflect certain aims people in the founding group held for the FabLab. The headlines of the final text read: 'technology for everyone', 'open source', 'diversity, cooperation, equality',

11 Creating arrangements of visibility is central to many different forms of modern sociality: Foucault (1995) describes the disciplinary effects of surveillance and of thinking that one is seen by others and how this creates normalisations of the subject. Sloterdijk (2004, chap. 2 C) points out how 'collectors' such as national assemblies, sports stadiums, parades and congresses create an enactment of communities, when participants see the many others invested in the same activity. Szerzinsky and Urry (2006) show how different forms of visibility create a sense of citizenship and how due to increasing mobility of images and information the world is increasingly inhabited 'from afar'.

'education', 'creativity, experiment, innovation' and 'sustainability' (http://fablab-karlsruhe.de/fablab, accessed 13.04.2015). As I showed above, Neil Gershenfeld, drew on many different framings to make sense of his initial observations in his course. Similarly, FabLab Karlsruhe became discursively embedded in particular cultures. 'Open source' and 'creativity, experiment, innovation' can be linked back to technology creating cultures, such as hacking, art and do-it-yourself practices. The others, however, reflect particular 'social' goals, that have a long history, particularly in 'Left' discourse and practice, they explicitly frame the FabLab as something to contribute to a more equal, democratic and sustainable society. Discursively locating the FabLab within such framings also envisioned particular norms and values and practices contributing to them. Which in turn also stabilised the FabLab within already existing cultures. There is, however, much diversity in how particular FabLabs frame their activities and the 'official' presentation of a lab can be quite different to the goals and motivations of individual members or users of FabLabs or the actual practices taking place (Hielscher & Smith, 2014, p. 6–9). Thus, through integrating FabLabs in particular contexts of meaning, adding to the rather open framing by MIT, a creativity in defining or interpreting FabLabs is included in the practices of FabLabs themselves, not only by their observers.

There were some meetings to get support for the planned and envisioned FabLab, in particular with the municipality in Karlsruhe. How the local vision was being mobilised in these meetings nicely sums up, what 'creates' a FabLab in a particular place and how this process imitates other FabLabs. For these meetings we tried to be a handful of people with various backgrounds and interests ('a diverse community'), some 3D-printed objects were brought along ('digital fabrication'), the manifesto was with us ('particular and well-known goals'), the global map of FabLabs ('network') and pictures of other FabLabs ('people work creatively in there'). There were some difficulties, such as the time it took to register the non-profit organisation ('gemeinnütziger Verein') since the FabLab by the tax authority was seen as close to a commercial endeavour by providing access to 'high-tech' machines. Yet, after about half a year of defining, discussing, debating and contesting the FabLab and the form of the group that would start it, a room in Karlsruhe's dedicated area for creative enterprises had been in sight for the FabLab to move in to.

Fab Money

'And who pays for that?' This is a question I was often asked when the discussion was about FabLabs. It is not that surprising, therefore I put it here and not further below. Technologies, their invention, production and usage are about money and particularly profit; not all technologies, but certainly most of the technologies people in capitalist societies encounter[12]. This relationship has become so tight and taken for granted, that Ulrich Beck (1997, p. 115–120), only dares a 'thought experiment' to reflect upon what if technology was autonomous from economic dictate, what if it was 'free' and not simply a means for profit, would society then be more free to choose its technologies? Not only for intellectuals, also in everyday life, thinking technology and its advancement not in the sense of an 'industrial technology', including the way how the

12 Marx (1976) gives an ontological argument for this relationship: Each commodity has 'exchange-value' and 'use-value', the latter pointing to the technical character of commodities. From this, however, does not follow that everything with use-value necessarily has exchange value. Yet, many capitalist practices are keen to commodify the things which are not yet endowed with exchange-value and circulated in markets.

unfolding of technology is being organised, is hard to do. Strangely, however, science and technology studies have largely ignored the question of how political economy is entwined with technoscience and knowledge production; this is an only recently emerging research agenda (e.g., Birch, 2013; Tyfield, 2012; Lave et al., 2010). Here, I briefly show, how questions of economy matter a great deal for the experiments of FabLabs.

First of all, FabLabs have to be vaguely differentiated in two categories concerning this question. As I showed above, there are the 'standard' FabLabs for which the Fab-foundation estimates cost for machines and materials of 40.000 to 100.000 $ - there exist, however, labs with even higher initial budgets (http://www.fabfoundation.org/fab-labs/setting-up-a-fab-lab/, accessed 13.04.2015). Many of these high-class FabLabs furthermore have employed staff for running the lab and they have other cost such as rent. As international networkers in the FabLab scene report, many of such FabLabs were set up with initial funding, e.g. by a university, but many are expected to become financially autonomous after a certain time. Others started right of as commercial FabLabs. For these labs, finding suitable business models is a big issue (Hielscher et al., 2015a, p. 32–33; see also Troxler, 2010). Other, 'grass roots' FabLabs, such as in Karlsruhe, face different economic realities. FabLab Aamersfort started with 5.000 €. In Karlsruhe we started with no money and within the first year, the equipment that accumulated in the lab, mainly through donations by individuals or companies (mostly from the IT and 3D-printing sector), to my estimations had a monetary value of about 15.000 €. The bills for rent and other things are paid by the members who each pay a monthly fee they decide themselves from 1 € onwards.

Whilst the 'economic realities' of FabLabs can be vastly different, the challenges and the opportunities they face have the same cause, which is based on a restructuring of 'moral economy' taking place in the FabLab assemblage. Besides 'purely' economic questions of offer and demand and efficient organisation and the resulting production and distribution of 'wealth', there are questions of 'moral economy' as an intrinsic part of each economy, which legitimises particular distributions of wealth for example. Investigating 'moral economy' is thus investigating 'the moral justifications of basic features of economic organisation' (Sayer, 2015, p. 19; also Tyfield, 2013). FabLabs 'invest' in a particular moral economy – which in many ways challenges the still dominant moral economy of neoliberalism, where (amongst other things) a tight intellectual property regime, the commercialisation of education and research and concentrations of technological development in large companies are justified through 'the market' as the 'best' way for social organisation (e.g., Crouch, 2011; Sayer, 2015; Harvey, 2012; Tyfield, 2013; Lave et al., 2010). With the explicit promotion of sharing of knowledge, open usage of the labs and decentralisation of technological development, FabLabs provide other justifications for the economic practices that they are entangled with. This does not mean, that FabLabs are per se anti-capitalist, rather what they promote does not neatly fit into the dominant arrangements of economic practices and justifications. And the tension this creates provides space for debating moral economy and searching for economic practices in line with the 'FabLab moral economy' in the making.

First, there is the central question of 'openness'. Gershenfeld and MIT wanted to provide 'public access' and have later on in the Fab charter defined that FabLabs should be open to individuals, at least during regular open days. Furthermore, the

open source culture identified with by a significant share of FabLab users equally demands 'openness'. This, however, is an abstract term which needs to be actualised in concrete arrangements. Does it mean 'free' or is it OK to charge, if yes, how much, just open access or open collaboration, simply an open licence for sth. or also good documentation of a work, open to whom? These and more are questions that an ethics of openness raises and has to answer in (contested) practice[13]. When the manifesto of FabLab Karlsruhe was written, some self-employed people raised their concerns over the 'open source' paragraph. Demanding everything to be open source, would prevent small businesses from creating products in the FabLab, they argued. The paragraph now reads, that knowledge in the lab 'should' be open source but that everyone may choose what they share (http://fablab-karlsruhe.de/fablab, accessed 13.04.2015). Such discussions have been taking place ever since the FabLab was established and there are members of the lab who are pursuing their business. Besides merely discussing the relationship of openness and economic practices, such discussions partly also lead to mutual learning and for example hints at business models of open source hardware businesses.

Second, FabLabs do not operate 'beyond' business. Of course, many FabLab practices draw on markets (materials need to be bought), or even helped some markets, such as the market for open source 3D-printing emerge. And besides of some individuals using labs for their commercial activities, e.g. for prototyping (FabLab Berlin, a company, for example has many such users renting machines for a certain time) there have been links between companies and FabLabs emerging. Most prominently, the Fabfoundation launched two activities in 2014 – www.fabconnections.org and www.fablabconnect.com – which aim at bringing FabLabs and their users in exchange with companies who might want to cooperate or are looking for innovative people and ideas. These were set up to foster the further development of the FabLab 'network' and and the capabilities of FabLabs (see Hielscher et al., 2015a). MIT also positions itself as a gatekeeper for such exchanges, drawing on the usually good relationships between (technical) universities and industry (Lave et al., 2010). Gershenfeld and MIT argue, however, for business activities which benefit FabLabs instead of simply exploiting the 'free' knowledge there[14]. The Fab Charter states: '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' (http://fab.cba.mit.edu/about/charter/, accessed 13.04.2015). Such an economy of mutual benefit was already created in Karlsruhe, where the open source 3D-printer model developed by one central member has been contracted to a small shop who now sell the parts and assembled machines while the design remains open source and a fee is paid to FabLab Karlsruhe.

Third, the moral economy which is fostered by FabLabs has a particular attraction to individuals and organisations. Besides the new technology that is being experimented with in FabLabs, the ways how this is organised and the economic practices it

13 Which it has been doing for example in software development, where in 1998 'Free Software' and 'Open Source Software' split apart because of unsolved moral differences and relations to business (Kelty, 2008, 2013).

14 In very different variations, such ideas of connecting corporations and 'crowds' in producing knowledge are being debated in discourse on 'open innovation' or in projects such as the UK's Big Innovation Centre http://www.biginnovationcentre.com/, accessed 15.04.2015. See also (Chesbrough, 2003).

entails and promises appeal to many FabLab supporters. A FabLab based on volunteers as in Karlsruhe, clearly has to provide its members a particular meaning for their efforts and I know of many, who explicitly want to foster practices of knowledge sharing. It is also striking here, that within one year, the paying members of FabLab Karlsruhe rose from 27 to about 100. As mentioned above, Barcelona has a new economic vision (of becoming the world's first self-sufficient city) in which FabLabs play a central role (for the importance of imaginaries in political economy: Jessop, 2010). Yet, there are also companies such as Chevron (one of the world's largest oil corporations) who have issued a grant to MIT to launch ten new FabLabs especially dedicated to education in natural sciences and technology (http://www.fabfoundation.org/2014/09/fab-foundation-launches-fab-lab-for-innovation-and-hands-on-learning-at-ca-state-university-bakersfield/, accessed 15.04.2015). Whatever the reasons for this, this shows, how even companies, not particularly known for bringing well-being to the world, try to get a piece of the moral economy which is enacted by FabLabs; but in turn, ten new FabLabs provide opportunities to deal with it. This has led to controversial discussions during Fab10 in Barcelona between critics and pragmatic supporters of this relationship (Hielscher et al., 2015a, p. 27). FabLabs thus, can no longer be seen as a nice little subculture. Others, in larger and different context of political economy have become aware and raised their stakes in trying to influence the further trajectories of the FabLab assemblage – which from the beginning has been defined 'in between' the co-functionings that it engendered.

As Tyfield (2013) in his discussion of 'open science' (which has a kind of family resemblance to open source technology) points out, a transformation of a particular settlement of political economy is a systemic change, involving a new moral economy, successful economic practices, positions for actors and institutions providing for the reproduction of this system. Such a transformation is thus also a process entrenched with power and conflict, and without guarantee of success. If thus a 'Fab economy' (including a distinct form of moral economy and successful business practices, which go beyond some hacking and some hobby tinkering) was to emerge in the near future, without becoming simply absorbed by the existing settlements of techno-capitalism, this economy will have to engender and draw on multiple changes – also beyond FabLabs and beyond their control. Following Tyfield, this would include first, the support of 'powerful groups', providing for example funding for projects. Second, institutions and organisations would need to emerge that provide for the reproduction of FabLab practices (e.g., education) and recognise the individuals and their work in FabLabs. Third, these individuals would need to be able to have well-paid jobs within this economy. A task which is not made easier by the fact, that typically jobs 'in technology' involve high salaries and large companies intensely searching for skilled employees. This would in turn also involve, remaking the subjectivity of the 'engineer' (and other forms of technological subjectivity), which emerged precisely to connect 'science' and 'industry' (Noble, 1977).

I am not saying that there are by now no visible tendencies of such changes, rather I want to point at their complexities and possible contingencies. Yet, not everything needs to be 'settled' for FabLabs to exist and it is this 'unsettledness' which is a main reason for experimentation. As Tyfield argues, 'open science' in its existing forms is far from providing the answers to different crises in the political economy of science, yet it provides particular questions for transforming the moral economy of knowledge production. Such a transformation involves the 'emergence of

new groups, powerfully enabled by knowledge technologies and socio-technical practices emerging simultaneously, who are transforming fundamental philosophical concepts' (Tyfield, 2013, p. 43). FabLabs can be seen as one such group within a far wider tendency to 'open (source)' and 'digitise' aspects of knowledge and technology. And FabLabs experiment, this text shows, with fundamental philosophical concepts such as what constitutes 'good' technology, what is ('good') innovation and in turn also touching wider questions of well-being and flourishing. This, however, is not simply taking place in abstract 'philosophical' reasoning and debate, building 'blueprints' and 'perfect' arrangements. Rather, the FabLab assemblage enables concrete experimentation with these questions in discourse and practice which can, without guarantee, be creative. And this is about much more than only money. FabLabs, the forms they have taken so far and the practices that entangle with them, are concrete and imperfect arrangements for practising and contesting such experimentation: FabLabs enable, they not necessarily always are, 'concrete' instead of 'abstract utopias' (cf. Bloch, 1986). They are performative of experimentation with moral economy and practices of the production and distribution of technology, which are entwined.

The moral aspect of experimentation is still the more important from a sociological perspective, compared to the money that has been made in FabLabs so far. The moral economy which is being assembled within the FabLab assemblage is one geared towards transformation of dominant techno-economic practices, or at least creating lasting arrangements beyond these. This is one of the main reasons for the importance of visions and imaginations of the future, which are recursively entangled with the experiments, one producing the other. And together they enact FabLabs as 'prototypes' and vehicles of a possible change – for participants in these experiments and for observers of them. And within these prototypical arrangements there is room for different meanings and their contestation – from Silicon valley-esque techno-entrepreneurialism via hobby tinkering to ideas of solidary peer-to-peer economies. And in turn it is this plurality which is a sign for and a potential driver for experimentation.

'Opening' the lab

Above I mentioned the manifesto of FabLab Karlsruhe and how it reads 'technology for everyone' and 'diversity, cooperation, equality' providing a vision of a workshop with an 'open' culture. Opening a FabLab in a literal and metaphorical way isn't only about talking and framing the lab, it is very much about what is being done with and in it. There is a lot of research about seemingly 'open' online communities that challenges the assumption that these groups are formed by 'everyone' and show that some groups are rather homogeneous and partly even hierarchical. Similar research started to point to the limited diversity of FabLabs or hackerspaces: There seems to be a dominance of middle class, well educated and techno-enthusiast white men in these spaces and even in the wider maker culture (Walter-Herrmann & Büching, 2013; Toupin, 2014)[15]. And FabLab Karlsruhe is no exception here. Most of the members are male, between 20 and 40 and within the core group most share a background or hobby in IT or electronic technologies. Yet, instead of simply lamenting the not-so-diverse culture I focus here on the construction of FabLab Karlsruhe, its as-

15 The maker culture therefore also reproduces dominant features of technological cultures and fields, which are mainly male and middle-class, and which have been critically addressed by feminist studies (e.g., Wajcman, 2007). At least discursively, however, the maker culture challenges the taken-for-grantedness of such arrangements by claiming that 'everyone' could and should be a 'maker'.

semblage. This highlights that existing structures, power relations and perceptions concerning technology influence a FabLab. But it also highlights that there are particular creative tensions, contestations and openings which can engender experiments with practically opening the lab towards other people and practices.

The interior of FabLab Karlsruhe, 2014, picture Barbara Weiß

The culture in FabLabs is strongly object-centred. 'Maker' identities are strongly linked to the objects that are being tinkered with by persons (Toombs et al., 2014) and the sociality is particularly formed around the objects of 'digital fabrication' and the desires these engender. FabLabs are clearly 'post-social' (cf. Knorr-Cetina, 1997) cultures and thus the effects of these objects for structuring the culture and sociality needs special attention. Instructive is an early episode in FabLab Karlsruhe, when, still in the planning phase, wood construction was strongly opposed by some since it would dirty the 3D-printers with dust. Now, that the lab has opened in a 60 m² room, wood construction is taking place but one has to go outside. Whilst many would welcome a proper workbench for wood there is no space in the small room although many machines for it wait in the lockers for their usage. Besides simply expressing technological problems this episode also expresses a particular valuation of technologies and in turn the practices that take place in the FabLab. Within the lab, the machines for digital fabrication get the 'best' places, not only in the room but also in the stories and explanations that are being told to visitors to the lab, curious about what a FabLab actually is (see below the chapter 'digital fabrication is the message'). Such exclusions, either explicitly or rather implicitly, with a FabLab being structured by its history and its 'resources' (objects and people with particular interests), make it more difficult for some things and some persons to actually use the lab and 'feel welcome'. This is crucial not only in terms of limiting openness but also in terms of stabilising the labs and actually providing the conditions for their successful operation and quick global distribution – as FabLabs and not simply as open workshops of any kind.

There is a further sense, how 'technologies' are a challenge for openness. Much of the inventory in FabLab Karlsruhe cannot simply be used, rather, one needs skills and knowledge to run the machines and about the procedures and routines in the lab.

And these, instead of simply existing have to be created as part of the process of organising a FabLab. Whilst there are experts for particular machines, making them available to others involves providing ways for learning to use them, e.g. in courses. But this also involves setting up rules and routines to implement security measures and to keep the machines in good condition. There already were a couple of instances when machines didn't work any more since a lot of people have been using and changing them without passing on what they exactly changed. Providing access to machines is a very demanding organisational task and a learning process, involving 'technical' and 'social' skills and their passing on. The techno-utopian talk of turning data into things and vice versa, however, tends to neglect persons who are actively involved in these processes. People who cannot simply be programmed and who often actually help the machines to success by readjusting and repairing them.

Besides the 'routine' days of the FabLab where members are tinkering or socialising and often visitors want to have a look at the lab, there are many special events in which FabLab Karlsruhe is putting a lot of effort – and many other FabLabs do similar things. In Karlsruhe, education and learning are central aims of a significant share of the core members. Courses for building particular things are designed and held, at larger events there is a spot provided by the FabLab (e.g., at the repair café or at faires) and together with others, such as the municipality or the local adult education centre, particular workshops or projects are being conducted. Many of these events show a larger diversity of people than the 'normal' evenings in the FabLab. Yet, they have to be seen as a normal element in FabLab culture – which is also about reaching out and sharing knowledge in wider contexts. These events also create internal learning, fostering skills for cooperation and communication amongst the FabLabbers.

I want to point out such an event which involved myself, as it also shows, how such events modify what is being done in a FabLab. In summer and autumn 2014 Julia, a colleague of mine, and I lead a project trying to combine technology assessment, the FabLab and citizen participation in investigating changes to knowledge due to digitisation (see www.manifest-digital.de, accessed 20.04.2015). The project came up as an application to a science communication challenge which we won and which provided us with 10.000 € to conduct the project. Several public workshops that we co-organised with members of the FabLab were held to discuss about the digitisation of knowledge and to practically experience it in engaging in projects and the machines in the FabLab. We also included some aspects of the building process of the Lasersaur in these workshops (see case study Lasersaur). Instead of making things, these workshops turned the FabLab into some kind of 'science shop' a place for explicit reflection: Different aspects of digital technologies and their entanglement with knowledges were discussed and knowledge co-produced. The event attracted many people, who otherwise wouldn't use a FabLab. The project, led to different ways of engaging in 'research' and to a different enactment of the FabLab, a co-becoming (Schneider & Hahn, forthcoming).

Networking FabLabs

Within the FabLab assemblage there are partly huge aspirations for 'networking' amongst the labs to fully harness the technosocial potential in a synergy of the labs. Networking is even inscribed in the design of FabLabs, which asks for a similar inventory in each lab, such that the reproduction of things is facilitated amongst labs. Such networking, however, is far from taking place everywhere equally. Although, many

share the impression that the 'network' emerged by chance, particularly Gershenfeld and MIT have become key players in creating organisations within the FabLab assemblage that foster and channel networking amongst labs and individuals. Gershenfeld, himself, however sees this network as rather chaotic (Hielscher et al., 2015a, p. 14) – which emphasises once more that the FabLab landscape resulted from an emergent assemblage and not particularly from a central plan.

> ‘At Fab1 we were ten people at MIT and thought we would never meet again ... Hakan a crazy guy started his lab above the arctic circle ... and we had a meeting there ... the meeting in Chicago, called it Fab4 only as a joke because there was a film out called Fab4 ... we thought we were done but they [the 'network' of FabLabs] kept on growing bigger' (Gershenfeld at fab10 documentary youtube 2014 quoted in Hielscher et al. 2014 p. 14)

For this network, several activities initiated at MIT became important. Yearly Fab conferences – 2014 the tenth conference in Barcelona –, Fab academies for teaching courses in digital fabrication and the Fab Foundation, established in 2009, which recently launched two further activities (fabeconomy and fab connections – see chapter Fab money) to foster networking among the labs and with business. Besides these, Neil Gershenfeld himself is by many addressed as something like a symbolic centre of the assemblage.

> ‘So Neil still pulls the strings but he is the founder, it is his vision and frankly where he sits intellectually is 5-10 years ahead of what he is doing ... this is why I still call this an experiment. He is the only one sitting outside the petri dish’ (Chris Wilkinson quoted in Hielscher et al., 2015a)

This is a person of Fab Foundation, closely working with Gershenfeld, who narrates the hero narrative that I am challenging here. Whilst Gershenfeld has an important position in the assemblage, he is certainly not the experimenter overlooking everything. And whilst MIT tries to regulate and form the network, the actual networking and governance of the process is far more complex and challenges the idea of a particular centre.

Besides this there are regional efforts for networking, e.g. FabLabs in areas or nations setting up mailing lists and holding their own conferences, events or meetings. Such visits of other FabLabs can be hugely important to see their solutions to common problems in labs. In Karlsruhe the safety concept was strongly inspired by a FabLab in Bavaria that some people visited. Yet, although such networking which involves co-presence in other FabLabs takes place it is limited due to several constraints (time being particularly important in Karlsruhe) and the demands of locally running a lab. Besides this, however, internet platforms have been connecting or at least informing about FabLabs. Noteworthy is the social media inspired site www.fablabs.io where FabLabs create profiles. Such digitised 'networking' has to be considered beyond simply connecting labs as well. FabLabs are often intensely networked arrangements which are insufficiently grasped if one only imagines a network 'of' FabLabs. In Karlsruhe, there is a whole digital sphere of the FabLab of mailing lists, wikis, social media where people interact or inform themselves about the FabLab without being in the actual lab. Much of the organisation of the volunteers engaging in different tasks and projects is done via email. This further extends concerning all kinds of information online – notably open source projects – which is almost routinely investigated by many FabLab members when there is a question and partly

also contributed to. These forms of digitally mediated exchanges and connections are heavily dependent on the sociotechnical practices available 'online' and their further evolution.

A third important field for 'networking' is with other organisations. In Karlsruhe there are links to the municipality, to some companies and to the adult education centre and to KIT. Again, there seems to be a particular willingness to network – which might be hugely different depending on actual labs. On the one hand, however, there is a precarious financial situation for many labs (see chapter on Fab money). On the other hand, discursively there is an emphasis on cooperation and 'openness'. Thus, whilst a global 'network' of FabLabs is missing, there are many and diverse aspirations for 'networking', an activity in different formats and intensities. One can describe the experimental character of such networking in two dimesions. On the one hand, sociotechnical practices for networking have to be found which succeed in mutual connections and on the other hand, such connections might foster synergies and shared projects which in turn can open up new ground for 'FabLab practices'.

Alternative technologies

In 1973, Ivan Illich wrote the book 'convivial tools' which became hugely influential in counter-cultural movements, early computer hacking where a 'personal computer' was imagined, the environmental movement and the short-lived 'appropriate technology movement' (Turner, 2006; Leadbeater, 2010; Smith et al., 2014). Illich writes that the crisis of industrial society

> 'can be solved only if we learn to invert the present deep structure of tools; if we give people tools that guarantee their right to work with high, independent efficiency, thus simultaneously eliminating the need for either slaves or masters and enhancing each person's range of freedom. [...] They need technology to make the most of the energy and imagination each has, rather than more well-programmed energy slaves. I believe that society must be reconstructed to enlarge the contribution of autonomous individuals and primary groups to the total effectiveness of a new system of production designed to satisfy the human needs which it also determines. In fact, the institutions of industrial society do just the opposite. As the power of machines increases, the role of persons more and more decreases to that of mere consumers [...] I choose the term "conviviality" to designate the opposite of industrial productivity. I intend it to mean autonomous and creative intercourse among persons, and the intercourse of persons with their environment' (Illich, 1973, p. 23–24).

I do not want to claim, as some others do (e.g., Rifkin, 2014), that in FabLabs such conviviality is completely being realised and that it is directly influenced by Illich - although there has been a diffuse influence of his thought in particular cultures that also resonate with FabLabs. And his thought is having a comeback: Recently, an international collective of renowned intellectuals has published 'the convivialist manifesto' (http://www.lesconvivialistes.org/abridged-version-of-the-convivialist-manifesto, accessed 17.04.2015). What I want to argue is that within FabLabs there are experiments of 'making technologies alternative' to industrial technologies. As one can learn from Illich, however, alternative technology does not simply mean different artefacts. Rather, this is about different relationships between artefacts, individuals and collectives, involving each of them to become different to industrial techno-*lo*-

gies. Neither a solar panel, nor a 3D-printer is in itself an alternative technology. Although, FabLabs do not provide a whole system of alternative technology, I show in two examples how such a potential othering, the making of different relations is taking place in FabLabs.

When FabLab Karlsruhe was still in planning stage, with much discussion and little tinkering, many welcomed the first 'repair café' in Karlsruhe. Initiated by the ITAS project 'Quartier Zukunft', together with citizens a place and time were arranged to help people repair broken stuff during this particular event. The contemporary form of repair café was initiated in the Netherlands in 2009. By now, a small organisation is spreading knowledge of this concept worldwide, with hundreds of local initiatives holding their repair cafés. Similarly to FabLabs, this organisation makes use of the Internet, a loose basic model of what a repair café should be and voluntary structures. Repair cafés imagine themselves as events for changing consumer's perceptions and usages of their technologies and therefore critically engaging with the issues of waste and obsolescence inherent in the industrial system (http://repaircafe.org/about-repair-cafe/, accessed 17.04.2015)[16].

Many welcomed that FabLab was part of organising the café and was to conduct the electronics repair. The actual event was seen as the first 'materialisation' of genuine FabLab practice: tinkering with stuff and showing the possibilities of 3D-printing. Already before the repair café was planned, there had been an email discussion in the FabLab group about 'planned obsolescence' and FabLabs being places for repair and anti-consumerism. During the repair café many things were repaired by the FabLabers, although the 3D-printer of one of them was rarely used beyond showing its capabilities. The actual reasons for repairing electronic stuff lay in the skills of the group, used to tinker with things. The 3D-printer, however, embodied the usage scenario of a FabLab possibly providing all kinds of parts for repair by simply producing them. Thus, what mainly happened was a 'creative intercourse among persons' (Illich), transgressing service centers and professional repair (often more expensive than buying new things), mediated by broken objects and an ethics of joining forces in the flows of their transformation. At the time of writing, the repair cafés still continue every couple of months and still find large resonance amongst FabLabbers and people who want to repair their stuff. Whilst this is not a completely new arrangement of an alternative technology, it definitely is literally about the 'repair' of wasteful tendencies within industrial circuits of technology.

I now turn to one of the most 'visionary' projects that emerged within FabLab Karlsruhe. Chris, a self-employed consultant, specialised in 'open innovation' joined the FabLab early on and participating in its making, an idea and question of him became rejuvenated and creatively entangled with the lab. He once lived in South America and didn't like the cheap concrete and metal huts the government was building to provide affordable housing. Why not make a house completely different, mixing traditional crafts and local materials with high-tech and contemporary expertise, he has been asking himself since then. With the FabLab unfolding, Chris told me, the idea came to life again. And Chris has been working on a project called 'House5k' with the aim to create an open source house for 5000 € made of clay with the help of 3D-printing and a networked organisational model. The house should at the same time

16 The issues of waste and obsolescence are already addressed in Illich (1973) and Urry (Urry, 2014, chap. 7) shows how tremendous amounts of waste are moved out of sight of consumers to create their problems elsewhere.

be customisable, practical, beautiful, ecologically friendly and provided by a company with a business plan similar to open source software companies, selling service instead of products. Although, as of yet, such a house does not exist, Chris has been building a network of partners with this vision, including the FabLab and the department of architecture at KIT (http://fablab-karlsruhe.de/images/pdf/House5K_EN.pdf, accessed 17.04.2015). Currently, however, the project is on halt since from this network developed the plan to at first start a business dealing with 3D-printing and construction in general – House5k, however, is not abandoned and might split off from this project, as Chris put it.

One cannot know whether House5k will be further realised or even be successful, yet, it is a prime example of how FabLab Karlsruhe provided the ground for an imagination of alternative technology. As the French philosopher of technology emphasised, the nature of technology is becoming, thus technological reality involves processes of imagination, design, development, production, use, transformation and dispersal (2010). For the House5k the FabLab provided the proper milieu to actually get imagined in concrete terms. The FabLab can be seen as expressing an evident potential of and for novel technologies (3D-printing), ways of organising them (networked, open) and of entangling them with ethical considerations (affordable, ecological, individual). As Ingold emphasises, imagination is part of perceiving and acting in a world of becoming with which one entangles (2012). True and creative imagination is an important, yet difficult to attain result of human effort, necessary in conscious transformations or trials to do so; the possible grows in imagination (Bloch, 1986). That a FabLab helps, maybe even engenders imagining technosocial arrangements of a new kind and also contributes to believing in their feasibility is from this perspective a valuable and important effect of them. And this is not confined to Karlsruhe, other FabLabs engendered such projects as well. For example, a project for low-cost open source prostheses partly made of bamboo was launched in FabLab Amsterdam with unconventional ways of organising the project (see Dickel et al., 2014).

I doubt, that FabLabs by now are a full form of a convivial technology, too much of what is happening there is still dependent on industrial technologies. Yet, in FabLabs there is space for a culture of conviviality taking place and being further developed and this as I showed here, also entails weaving the flows of technologies and imaginations differently, creating experiences of a possible 'alternativity' that emerges in such assemblages. The experiment, however, is how these can actually be woven.

'Digital fabrication is the message'

When the FabLab had opened, it rather quickly filled with rather old computer controlled machines that members brought into the lab: printers and plotters to print on paper, small laser plotters to create electric circuitry with an optical process, there were plans to build a cutter from one of the print plotters to actually cut paper instead of having the machine draw on it. Of course, there were 3D-printers as well, and half a year later a large open source laser cutter (see Lasersaur case study) was built as well in the Lab and now presents the largest CNC (computer numerically controlled) machine in the lab, able to cut almost anything from paper to thin wood, after being fed with 2D graphics from a PC. Initially, I thought it strange, that 20 year old machines were put in the lab, since it aspired to be on the cutting edge of digital culture. Then I realised, however, that this made complete sense: In principle, a printer for paper and a 3D-printer are the same. It is about having the machine realise forms

in a material that were created on your personal computer – or downloaded. A FabLab is equally – if not mainly – about the process of 'digital fabrication' as it is about the products created in that process.

Marshall McLuhan, one of the founders of media theory, succinctly put this thought in his famous slogan 'the medium is the message' (McLuhan, 1964). Instead of the content, for example of television, from soap operas to war documentaries, what has the major influence on how society entangles with this technology and changes, is the way how this content is being produced, circulated, controlled and formed by the medium television and the social structures that enable and entangle with it. For McLuhan, media are form giving milieus *within* which particular messages, interactions and communications take place and which thus configure how the world is perceived, construed and acted in (cf. Grampp, 2011, chap. 2.3). They create whole environments that channel action and thought and they do so in an ecology of milieus that have to be seen in relation to each other. The object-oriented philosopher Graham Harman points out that McLuhans argument is based on a distinction of figure and background, or content and form. Whilst the figure is realised in a given situation, the background that enabled it, recedes from view, it withdraws, it is never fully manifest. Yet, there are times and actions when the taken-for-grantedness, the invisibility of the background is challenged and cultural innovation takes place through 'bringing visible experience into vibrant relation with its background conditions' (Harman, 2012, p. 92). From a McLuhan-ish perspective I argue, that two important processes take place in FabLabs in relation to digital fabrication. On the one hand, digital fabrication is the form giving milieu, the background that structures FabLabs and what is done within them. On the other hand, what is being done actually unfolds this form giving milieu and creates 'vibrant relations' with background conditions in-the-making.

Whilst Gershenfeld initially spoke about 'personal fabrication', by now 'digital fabrication' can be read during many large FabLab events such as the Fab10 conference in Barcelona in 2014. With 'digital fabrication' a broad agenda is being named and pushed by Gershenfeld and others:

> 'Digital fabrication consists of much more than 3-d printing. It is an evolving suite of capabilities to turn data into things and things into data. Many years of research remain to complete this vision, but the revolution is already well under way. The collective challenge is to answer the central question it poses: How will we live, learn, work, and play when anyone can make anything, anywhere?' (Gershenfeld, 2012, p. 57).

Gershenfeld positions 'research' at the centre of this change, unsurprisingly, with his 'Center for Bits and Atoms' actually investigating and trying to change the relations of digital technologies and materials. Besides his nanotechnology-inspired vision of assembling atoms into things that I discussed above, Gershenfeld in Barcelona advocated a synthetic biology-inspired vision of 'growing' things with the help of data, that he would also like to see realised in FabLabs in the future (Hielscher et al., 2015a, p. 20). Yet, the more-than-technical capabilities of turning data into things and vice versa, the experiments with structuring and practising digital fabrication take place largely beyond institutionalised research and FabLabs are important in this.

In FabLabs, however, such brightly described digital fabrication that can 'make almost anything' is more arduous, far from a 'one click wonderland'. With the technologies currently available from design software to the machines and the online sharing

of designs, much learning is necessary to be able to skilfully make use of digital fabrication. Many FabLabs thus have an explicit education agenda, providing courses in digital fabrication and fostering a culture of learning from peers. Often, the machines don't provide expected results and there is a lot of tinkering to do to achieve them, which can lead to new knowledge. The deskilling through 3D-printing warned of by some commentators (e.g. Söderberg, 2013) in FabLabs is rather a remediation of skill, a skilling in another medium. Once, people have gotten used to digital fabrication, however, I saw many instances when things were 3D-printed or laser cut even if there were other maybe easier ways to do it. Furthermore, there has been a vast rise of designs made especially for the technical capabilities of most FabLabs, many of which are documented on sharing platforms such as www.thingiverse.com. 'FabLabbers designing for FabLabbers', one might say. This, however, doesn't end with things that the machines might produce, rather there are increasingly often open source designs for digital fabrication machines that can be used in FabLabs – such as the Lasersaur. There seems to be a pull of the medium to construe creation in its terms and to link other technologies to it – from traditional crafts to art.

And part of the form giving milieu are also FabLabs and the social practices they promote. They contributed a large part to fostering digital fabrication as 'shared fabrication' and not as 'personal fabrication'. Such socialised tinkering with digital fabrication takes place in individual labs, and, equally important, FabLabs envision themselves as a global infrastructure for this. The Internet, software, data and technical creativity shall help to enable exchanges in a global network fostered by an ethics of global sharing and decentralised innovation. And this is partly realised in arrangements in which FabLabs take an active part. Part of this emerging background to digital fabrication are many other tendencies, of course, from research via industry to politics and law all concerned with the vastly changing relationships of data and (material) things. Yet, my point is this is a background, a form giving milieu in-the-making and FabLabs and many practices that they entangle with have an important part in this. What forms many activities in FabLabs, is at the same time formed by them: FabLabs themselves are media.

This form giving by the medium digital fabrication is that strong, that many contemporary utopian[17] visions are to a certain extent being shaped by it, although the contents differ: Former Wired editor in chief, Chris Anderson (2012), sees a future of increased capitalistic innovation, yet by small businesses, thanks to digital fabrication and the 'maker movement'. André Gorz (2010) envisions the end of capitalism through 3D-printing bringing the economy of information abundance of the Internet to the material world. And Jeremy Rifkin (2014) takes the middle position by arguing for an emerging hybrid economy in which increasingly 'collaborative commons' are being used and 3D-printers provide material abundance, yet markets are still important. In 2014, driven by Gershenfeld and others, the website www.fabeconomy.com (accessed 10.04.2015) was launched with the aim of advancing through FabLabs a 'novel economic paradigm for everyone, where local fulfilment and customization take the place of mass production and global distribution'. More radically and speculatively put: If, at least in technoscience, visionary discourses are an intrinsic part of the 'technologies' (cf. Lösch, 2014), then aren't these discourses part of the background that forms the experience of digital fabrication?

17 This is not at all meant in a denunciatory way, as if I wanted to indicate that these are mere illusions. In my thinking such visions can be part of concrete utopias! It's not about whether they are 'true' or 'false', it's about what they help create.

Down to the dirty ground of the workshop of FabLab Karlsruhe, such envisioning takes place differently. The most proficient 3D-printer builder in the lab told me that he encountered an open source project for a knitting machine able to produce clothes. And this made him imagine that a completely different paradigm of producing things for everyday life might be possible – after he had already printed many things. In a public discussion about 3D-printing another of Karlsruhe's 3D-printing experts was asked, what actual usages of 3D-printed items in everyday life he sees. He had to admit, that by now he could only think of little applications. Indeed, in relation to 'consumer technologies' much of the digital fabrication in FabLabs cannot really 'compete' in terms of quality, price, time invested and function. But these are experimental technologies, encouraging creative use, doing things classical consumer stuff wouldn't allow, for example building parts for a little machine you invented. 'Digital fabrication is the message' and it is an unfolding form giving milieu participating in it now is also to participate in the potentials that are building up with it – there are 'vibrant relations' of background and experience. And it does so in an ecology of existing and stable form giving milieus, such as 'consumer technologies'. Accordingly, the potentials that are created are experimental. They are about pulling objects, people, imaginations and routines out of the other milieus, the media that have formed them and thus making them different, rearranging them and their perceptions – without a clearly formed picture of what this difference exactly is.

Conclusion

FabLabs are real-life experiments. As such, they are processes which create surprise and novelty, at least they are geared towards enabling these. Processes, however, that need particular milieus, substrates which enable experimentation in the first place. I traced some of them back to antiquity but showed, how each of the different cultural formations is being assembled in particular ways in a global FabLab assemblage. In his ground breaking study of experimentation, Rheinberger (1997) showed, how 'epistemic things' enable experimentation, which basically is about unfolding these things. Such epistemic things have particular strength if they move between different 'experimental settings', if they bifurcate and get turned into different things. I argued that FabLabs are similar to epistemic things, they are that which enables experimentation and which gets manipulated in experimental processes. This understanding breaks, however, with typical understandings of 'things'. I don't have a material artefact in mind when thinking about FabLabs, although materials and artefacts have a large role to play in defining FabLabs. Rather, the old meaning of 'thing' as a 'gathering' seems to be fruitful here; the anthropologist Ingold, drawing on Heidegger, writes: 'The thing [...] draws us in, along the very paths of its formation. Each, if you will, is a “going on” – or better, a place where several goings on become entwined' (Ingold, 2011, p. 214). Such entwining of goings on I argued from different angles in FabLabs involves persons, objects, organisations in processes of formation and re-formation – one involves the other. For the contemporary FabLab assemblage three bifurcations of the epistemic thing FabLab have particular relevance: First, at MIT a research course turned into a fascination with personal fabrication due to the experimental practices of the many students that arrived (~2000). Second, inspired by the course a first wave of FabLabs spread to different places in the world, involving, however, larger institutions to host FabLabs and MIT as the 'distributor' of the model (~2002). Third, driven from community initiatives and inspired by 'maker' cultures a large number of 'grass roots' FabLabs have mushroomed (~2010). These bi-

furcations are not definitive cuts with beginnings and ends, rather, they enlarged the experimental fields for FabLabs which now are forming and possibly transforming the global assemblage.

Before ending with tendencies the FabLab real-life experiment shows, I turn to non-experimentation. Through my emphasising, that there is experimentation in and with FabLabs, one might object, it seems as if FabLabs would be full of activities striving for perpetual novelty, these places would reinvent themselves over and over again. Actually, this isn't the case: non-experimentation, routine can be found all over the assemblage. And if I would have taken the typical sort of sociological gaze which looks for stability, order and reproduction of the social world. My FabLab description would have looked a bit like this: Many techno-enthusiasts around the world are following a technological utopia of creating things with industrial machines that they put in workshops where they meet to socialise and tinker. This is a typically modern technological vision of transforming the world through technology. They are a rather homogeneous group and they simply extend the existing sphere and culture of 'hacking' to some more technologies. But this is far away from technoscientific research or industrial processes, which technologically, economically and organisationally operate at far more complex and powerful levels. Thus, whilst these people claim to practice novel economic practices, they only make themselves more 'fit' as creative entrepreneurs on a labour market in today's knowledge-based capitalism. And actually, there might be some truth to such a description. But it misses the point. By emphasising continuity such a perspective is blind for the jumps, the cracks, the fluxes, the openings, the creative moments and surprises, tiny as they may be, in what has been happening in assembling FabLabs during the last 15 years. And blind it would remain for questions of possibility and process, so important not only in observing this assemblage but also inherent in many practices within it.

Experiments, however, need routine and stability, precisely to enable conscious manipulations of arrangements to move them in yet unknown directions. The question of when there is actually experimentation and when not, is thus also the question of agency. When do people engage in actively manipulating the arrangements that have been formed and stabilised so far in FabLabs? This, however, is not only a question of individual people but also a question of collective agency. In my choice of perspective, collective agency is a distributed effect of the FabLab assemblage ('agencement' in its original French usage by Deleuze and Guattari). I particularly emphasised visioneering as an activity within this assemblage which fosters experimentation when discursive strategies are used to convince others to see and mobilise the possible in the present. This is not simply done by 'heroes' such as Gershenfeld, but also on a mundane level in FabLabs when visitors are introduced to the place. Furthermore, I emphasised how within the assemblage, the coming together of different practices is productive of experimentation. In these practices, as bundles of meaning, skills and objects (e.g. Reckwitz, 2002) I emphasised the role of often 'unfinished' objects which stabilise what is being done and invite for experimentation due to their unfinished character and their clash with new 'contexts'.

In FabLabs, there is no separation of experiments with 'technologies' and with 'socialities' both are fused together into technosocial experiments. Thus, whilst many FabLab practices are inspired by technoscientific visions and cultures and partly might emphasise the new technological capabilities in digital fabrication, actually the capabilites brought about are technosocial capabilites. This is not just new 'technolo-

gies' but new technologies together with new 'social' arrangements. In this, FabLabs also open up the often constrained and narrow imaginations and practices of 'typical' technoscience, so often criticised. If such technoscience aims to 'create and realize technical potential and thus to construct the world we live in' (Nordmann, 2011, p. 28), FabLabs aim to realise technosocial potential and thus to create much more than simply technology. This is not 'technoscientists' experimenting with society, rather, parts of TechnoScienceSociety experimenting with themselves. And these experiments are also beyond the confines of 'industrial technology' with its equally settled social arrangements and powers. Instead of 'designing' and 'controlling', the technosocial sphere of FabLabs 'reveals' its own possibilities due to cybernetically engaging with its own arranging (cf. Pickering, 2009). Instead of engineering this is a culture of experimentation, a culture which embraces the possibilities of the present to reveal novelty which might improve social life with technology, a culture of enabling concrete utopias.

To end, I want to explore the 'near future' (cf. Rabinow & Bennett, 2012) of FabLabs, not by predicting it but by highlighting again tendencies that my description revealed within the assemblage. The first tendency concerns the relation of 'fab' and 'lab' or of 'production' and 'knowledge'. Vilém Flusser seemed to be right when he claimed that in 'the factories of the future manufacturing means the same thing as learning – i.e. acquiring, producing and passing on information' (Flusser, 1999, p. 50). FabLabs started at a university and from the beginning emphasised learning greatly. Many labs organise efforts for education and foster learning and knowledge sharing and they seem to be rather good at it. When it comes to producing things, however, much of what is done in FabLabs seems not (yet) to be actually able to 'compete' with much of the stuff people in everyday life use. The question for FabLabs in the near future is thus, how will this relationship be formed. Will there be more focus on education or will there be increased efforts for production and the enlargement of the capabilities here, and how might the two be aligned. This, however, doesn't solely depend on FabLabs but on the relations to other spheres and transformations. Will FabLabs build stronger relationships to industry, traditional crafts or small companies? And will they succeed in establishing and maintaining values besides 'profit' to acknowledge success in producing technology? What will the relationships to education institutions look like, will FabLabs be an add-on to universities or 'democratise' the acquisition of expertise in technology? What will the further evolution of 'digital fabrication' technologies look like and what affordances for creating things and producing and sharing knowledge do they entail? Will they remain difficult to use and rather expensive?

Then there are complex tendencies concerning the relationship of 'digital' and 'analogue' spheres and their further transformation, or of of 'data' and material settings. How will local labs be able to participate more and further create a network of FabLabs? Will there be a tiny highly mobile group doing all the networking or will novel digitised systems enable significantly larger exchanges between people from different places and cultures? This equally concerns the further development of 'open source technologies'; will there be further growth from which FabLabs can benefit? What are the constraints of digitisation, which knowledges cannot pass through the wires of the Internet and which spheres resist the pull to network and digitally connect so internal to the digital cultures relevant for FabLabs? What is with knowledge, skills and practices of those who aren't 'digital natives' or excluded from deep participation in digitised networks? How will politics react? Will intellectual property rights

be made even tighter and constraining to 'protect' the interests of industry? Or will there be funding programmes for FabLabs, already seen in some countries?

It might even be, that experimentation comes to an end, that many FabLabs consolidate a particular status quo and routine takes over. This, however, also depends on the dynamics of the assemblage that has been forming FabLabs. FabLabs have been co-defined from their beginning and thus routines might as well continue to be challenged by the elements that link in to this assemblage and together engender its emergent effects. Thus in an era of technoscientific promise, massive digitisation and an increasing pressure on industrial capitalism FabLabs seem to occupy a place which is unlikely to become quiet in the near future.

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