This paper was presented at The XXVIII ISPIM Innovation Conference – Composing the Innovation Symphony, Austria, Vienna on 18-21 June 2017. The publication is available to ISPIM members at www.ispim.org.

The Maker Movement - Current Understanding and Effects on Production

Frank Hartmann

Technical University of Applied Sciences Wildau
Hochschulring 1, 15745 Wildau, Germany
E-mail: frank.hartmann@th-wildau.de

Dana Mietzner*

Technical University of Applied Sciences Wildau
Hochschulring 1, 15745 Wildau, Germany
E-mail dana.mietzner@th-wildau.de
* Corresponding author

Abstract:

The Maker Movement has been passing through a period of formation as a new form of production roughly since 2005. It has been increasingly taking up space in public discussions, particularly in the mass media. These discussions, however, fail to understand the maker movement systematically as a social phenomenon. In this study we investigate the Maker Movement and explore emerging diffusion paths in social and innovation practice. The object of investigation is embedded in the theoretical background of the Multilevel Perspective by Geels and Schot (2007) and, based on that, a qualitative, category-based content analysis in mass media of three different countries (DE, US, GB) has been implemented. As a result the Maker Movement is described systematically along a set of categories. Furthermore, we present indications that the Maker Movement is in the beginning of its institutionalisation and discuss interrelations to the predominant production regime.

Keywords: Maker Movement, Media Analysis, Multi-Level-Perspective, Industry 4.0

1 Introduction

Associated with societal digital transformation, the industry and service sector face new challenges. Researchers, practitioners and different groups of stakeholders are discussing the future consequences and impact of the mega trend digitalisation extensively, dynamically and also controversially in the literature and amongst practitioners and different groups of stakeholders. The corresponding challenges, issues and consequences for future developments with regard to the reorganization of value creation networks, the 'Industrial Revolution' labelled as Industry 4.0 and the flexibility in manufacturing or new forms of work are all subject to foresight processes (Government Office for Science, 2013, McKinsey & Company, 2015, Aichholzer et al., 2015, KPMG, 2016, Lorenz et al., 2015).

At the same time and embedded in the digital world, a new phenomenon that is innovating the way we work, learn, produce and consume, the Maker Movement, has emerged and has been attracting increasing attention since 2011. There are first indications that the movement is at the beginning of its institutionalisation. Whereas the first Maker Faire took place in 2006 in San Mateo with just a handful of exhibitors and visitors, it was followed nine years later by an event that attracted more than 99 makers as exhibitors and no less than 130,000 visitors. In 2013, worldwide there were nearly 100 Maker Faires, in 2014 there were approximately 150 Maker Faires (MakerMedia, 2016, 2). In the same way, the number of established FabLabs worldwide is an expression of the increasing institutionalisation of the movement. If the first FabLab was founded outside the MIT in 2003 in Boston, in 2012 there were nearly 100 FabLabs (Gershenfeld, 2012), at the beginning of 2016 there were 618 and in September of the same year already 711 FabLabs (FabFoundation, 2016). Finally, the increasing use of two of the platforms ascribed to the Maker Movement is mentioned. Thus, for example, the platform Thingiverse recorded in year 2012 "merely" 25,000 published designs, in 2013 they were 100,000 and in 2014 as high as 400,000 objects with 21 million downloads (MakerBot, 2016). On the platform 3D Hubs, which supplies 3D prints to makers as an intermediary, there were still 32,000 printers registered in 2016 in more than 150 countries. In this year alone, 5,350 printer owners printed 714,300 objects by order (3DHubs, 2016). The prevalence of the idea is also evident in the establishment of Maker Spaces in specific institutions, originally not belonging to the Community. Thus, a survey held in 2013 in 143 US American libraries indicated that 41 percent of them maintain currently a Maker Space, 36 percent planned setting up a Maker Space in near future (Price, 2013).

However, the number of scholarly articles written about the Maker Movement points to the fact that it has not yet been an established focal point of scholarly research (see e.g. Papavlasopoulou et al., 2017, Smith et al., 2013, Toombs and Bardzell, 2014, Voigt et al., 2016, Petschow et al., 2014, Deloitte, 2014, Hagel et al., 2014, Hatch, 2014, Anderson, 2012, Browder et al., 2017, Buxmann and Hinz, 2013, Howard et al., 2014). Scholarly publishing activity, if any, on the Maker Movement began in 2012 and continues until today at a relatively low level of about 25 to 35 articles per year worldwide, as an analysis in Google Scholar indicates. Probably the article titled "The Maker Movement" by Dougherty (Dougherty, 2012) might be playing an important role in initiating the publishing activity. Articles related to "Education" and "3D printing" are the focus of the contributions in terms of content found in Google Scholar and directly attributed to the Maker Movement. Even Springer Link reflects a large number of articles which deal with 3D printing but mainly only indirectly with the Maker Movement. The result is that the scholarly literature on the Maker Movement as a new social phenomenon remains within manageable limits.

Until now, we neither fully understand the Maker Movement nor are able to comprehensively explore the implications of the Maker Movement as a possible structural shift, to what extent the movement has established itself as a new social practice or what kind of impact on economic and social environment the Maker Movement will create. Therefore, the focus in our study is on answering the question, whether and in which way the Maker Movement will influence the prevailing production system, which is currently developing towards Industry 4.0. One prerequisite for this is to gain a more systematic understanding of the Maker Movement in order to identify possible fields of interaction between the Maker Movement and the existing production regime and to anticipate possible impacts on it.

This paper was presented at The XXVIII ISPIM Innovation Conference – Composing the Innovation Symphony, Austria, Vienna on 18-21 June 2017. The publication is available to ISPIM members at www.ispim.org.

In our paper, we identify a suitable theoretical background to explore the Maker Movement. Following this, we describe the methodological approach to a media content analysis, which is the empirical basis of our study. Based on the analysis we characterise the Maker Movement and develop a definition before discussing its interactions with the existing production regime and describing possible impacts. Finally, we draw conclusions regarding the future diffusion of the Maker Movement through interaction with the predominantly production regime and articulate further need for both empirical and theoretical research.

2 Theoretical Considerations

To find the right point of approach for investigating the phenomenon of the Maker Movement and its possible impacts on the prevailing production regime, we need a conceptual framework to appropriately describe the Maker Movement and elevate its development to a higher social context. For this purpose, the transition approach, which has been under discussion for many years in various facets and with different degrees of emphasis (Grin et al., 2010, Wissenschaftlicher Beirat der Bundesregierung Globale Umweltveränderungen, 2011), is ideal. According to this understanding, social transformations result from interrelated changes in technologies, social institutions and individual behavioural trends in social subsystems (Wissenschaftlicher Beirat der Bundesregierung Globale Umweltveränderungen, 2011, 342). To understand them, we must develop a system to describe their dynamics, pinpoint change drivers and unveil the associated constellation of stakeholders and levels of action (Wissenschaftlicher Beirat der Bundesregierung Globale Umweltveränderungen, 2011, 87). An appropriate method for this is the multilevel perspective as suggested by Geels and Schot (Geels and Schot, 2007) (2007) for transformation processes and used by Grin et al. (2010) to determine accessible levels of action during the transformation process. This approach aims to reflect the transformation process's complexities, multiple dimensionalities and asynchronous characteristics and, at the same time, present a model that would radically simplify matters. The authors also view this model as suitable for systematizing the Maker Movement's context and proposing the research question in which way the Maker Movement can influence the existing production system in the future, a research question strongly related to foresight. At this model's core are three different interdependent, dynamic levels of action (Geels, 2007, Geels and Schot, 2007) (Geels, 2007; Geels and Schot, 2007).

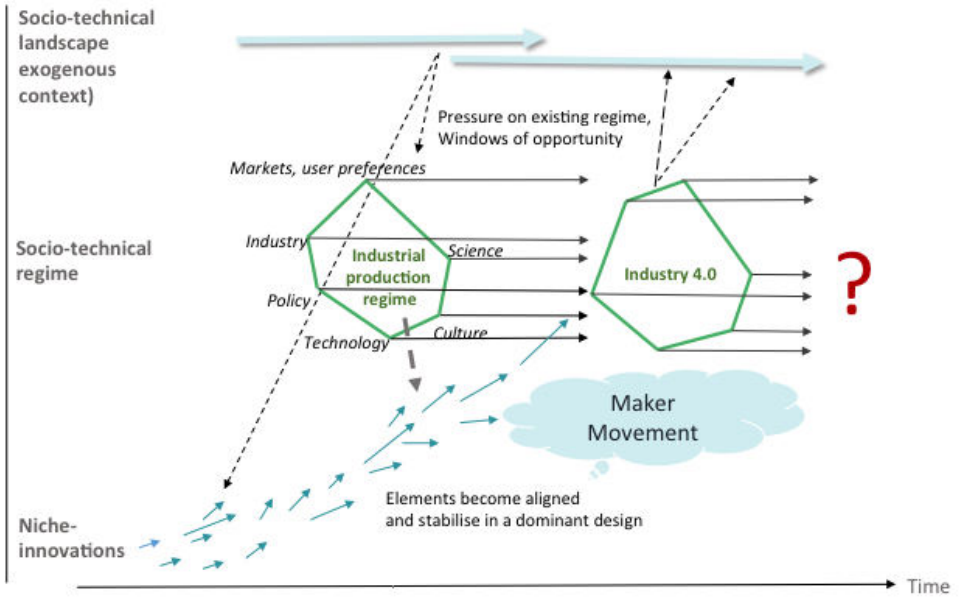

Figure 1 Multilevel perspective of the transformation approach (according to Geels and Schot, 2007, 401).

According to Geels and Schot (2007), spaces for transformation opportunities result from changes and dynamics at these levels of action and interaction. In this regard, it is all about the level of 'socio-technical landscape' as an exogenous macro-context, the level of 'socio-technical regime' as an object of transformation in the narrower sense, and the level of 'niche innovations', where the innovation process acts at the micro-level as an important driver of the socio-technical regime's transformation. The established sociotechnical regime - as a system of technologies, markets, industry, scientific systems and cultures - develops under the influence of the socio-technical landscape, which exerts pressure on the regime towards change and possibly towards preservation. The socio-technical landscape is characterized by long cycles and trends that the stakeholders cannot readily influence. The level of niche innovations describes at the micro-level the emergence of radical innovations in certain constellations that will have the chance to significantly influence the socio-technical regime. In particular, destabilizing the established socio-technical regime throws open the 'windows of opportunity' for radical niche innovations. Rectifying the processes at the three levels enables breakthrough innovations that begin to dominate available markets and compete with the existing regime (Geels, 2007, 400).

Following the briefly described model, in the context of the Maker Movement, the socio-technical regime can be understood as a prevailing production regime that is currently evolving under the influence of digitalisation towards Industry 4.0. At the same time, the Maker Movement is emerging as a niche innovation, which will influence this process if it institutionalizes itself as social innovation (Howaldt et al., 2014).

This paper was presented at The XXVIII ISPIM Innovation Conference – Composing the Innovation Symphony, Austria, Vienna on 18-21 June 2017. The publication is available to ISPIM members at www.ispim.org.

2 Methodological Approach

To answer our research question it is necessary to better understand and systematically describe the nature of the Maker Movement and to identify its interactions with the existing production regime (areas of possible impact). For this purpose, we conducted a media content analysis on the Maker Movement in US-American, British and German media in 2015/2016. 'Media Content Analysis is a specialized sub-set of content analysis, a well-established research methodology' (Macnamara, 2005, 1). Macnamara (2005) provided an overview of media content analysis approaches and definitions, for example, regarding uses, benefits and best practices methodology of media content analysis. Our study identifies media content analysis as a technique for gathering and analysing the content of text. The 'content' refers to words, meanings, pictures, symbols, ideas and themes (Neuman, 1997, 272-273). Because media has the power to affect and reflect certain developments and events, we can explore how certain events and phenomena occur and disappear in the media, in what context they are discussed and placed or how their importance may change over time.

In implementing a qualitative, category-guided content analysis (Kuckartz, 2012, Mayring, 2010) we followed a defined process with guidelines adjusted to the object of investigation and research questions. This approach centres on a category system for systematically classifying content. The category system considers feedback loops within the process of the content analysis and quality criteria (Mayring, 2010, 603 et seq.). According to Kohlbacher (Kohlbacher, 2006, 6) the strength of this approach is its potential for dealing with complexity, theory-based guidance, integration of different kinds of material and its quantitative aspects.

According to Kuckartz (Kuckartz, 2012, 49 et seq.), we followed a defined process in this study containing (a) a planning phase, (b) a developing phase, (c) a code phase and (d) an examination phase.

(a) Planning Phase

Since information spreads today via blogs with a wide reach, bloggers filter and select information and blogs are gaining importance as a channel for creating public opinion, we have selected also the domain of online forums and blogs as an area of investigation in addition to the traditional mass media (especially print media) as a field of published opinion. Thus, we have intended to take into account also various forms of group-specific public communication and interpersonal public communication for the analysis (Albrecht, 2013).

The choice of the print media (with online edition) was based on the country of origin (USA, Germany, UK), the affiliation to publishers of different orientation and according to media types, such as the high circulation supra-regional newspapers, weekly newspapers and magazines (Almeyda et al., 2015). Media from the USA were chosen because the Maker Movement had its origin there. As expected, particularly the American blogs provided abundant relevant information. The German media drew attention because the discussion about Industry 4.0 plays an important role here and there is a conceptual relationship with the Maker Movement. Print media from Great Britain were used as a com-

parison with that of the USA in English. The database Nexis[1] was used, supplemented by a search in the archives of the Süddeutsche Zeitung and the Huffington Post, which were not included in Nexis. The forums and blogs have been searched using Google News Germany and Google News America.

(b) Development Phase

The development phase started with an open sampling, based on a pre-selection of the print media and blogs/forums. During the sampling process, it was assumed that, with the identification of keywords comprising suitable introductory texts on the Maker Movement (quality, width, contrast), a first text block can be selected which maps the entire breadth of the understanding of the Maker Movement and the corresponding context. In addition to the introductory texts, the last used 45 keywords were selected against the background of the underlying theoretical concept and the research questions. The search with the 45 keywords resulted in a digitized text block, which was archived and transferred to the analysis tool atlas.ti.

For the following content analysis, we developed a suitable system of categories (see fig. 2). In this context, it was possible to rely on the underlying theoretical concept, selected publications on the Maker Movement (see e. g. Gershenfeld, 2005; Anderson, 2012; Hagel et al. 2014) and on several years of personal experience gained from the operations of a Maker Space in the form of a FabLab. The system of categories has been specified later in the process of content analysis with the material. It applies to summarizing and differentiating categories/subcategories.

[1] Nexis is a database that provides, among other things, content from thousands of daily and weekly newspapers and journals in full text.

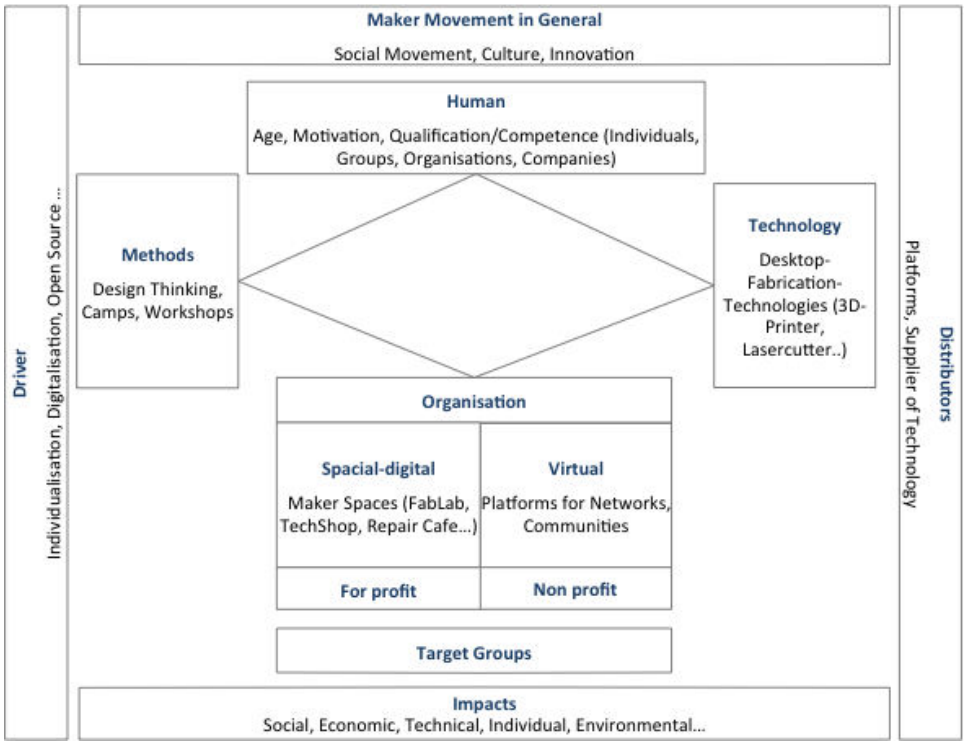

Figure 2 System of categories for the content analysis Maker Movement.

(c) Coding Phase

The system of categories was used as the basis for generating codes, to which text blocks from the media contributions were assigned, based on content, while coding using the tool atlas.ti[1]. The codes used largely matched with the categories described above. Coded content based text blocks were mostly chosen in such a manner that they are also comprehensible outside the context. They include phrases as well as entire text paragraphs.

(d) Examination Phase

We carried out a quantitative, software-based examination of the coded material (e.g., number of quotes per code or quotes per country and type of media) and a qualitative examination based on the main categories (Kuckartz, 2012, 94).

5 Findings

In the following, we give a brief overview of quantitative aspects of the media content analysis followed by a short characterisation of the Maker Movement and a more detailed discussion of qualitative results along the dimensions “innovation”, “organisation”, “hu-

[1] Atlas.ti is a software application for qualitative data analysis. Using this tool, text, graphic or audio related data are sorted, managed and interpreted.

man resources", which we identified as main fields of interaction between the Maker Movement an the prevailing production system.

5.1 Quantitative findings

We searched for 45 key words regarding the Maker Movement in the defined period from 1 January 2002 until 29 January 2016. The search identified 297,115 articles in the selected media as relevant. The high number of keywords and the corresponding matches indicate the broad search approach for the object of investigation at this stage of the study.

In a further comprehensive selection process (see figure 3), 902 articles were considered relevant for the Maker Movement, which means that we can directly link only a relatively small number of articles (902 out of 297,115) to the Maker Movement as a social phenomenon. The selection process first referred to analysis of headlines. We excluded conference announcements, event coverage, purely technical articles and articles with no direct reference to the Maker Movement. The majority of remaining articles (588; 65%) came from newspapers, whereas 314 articles (35%) came from blogs. With the total number of 902 contributions, a meaningful and evaluable number of media contributions was available for analysis.

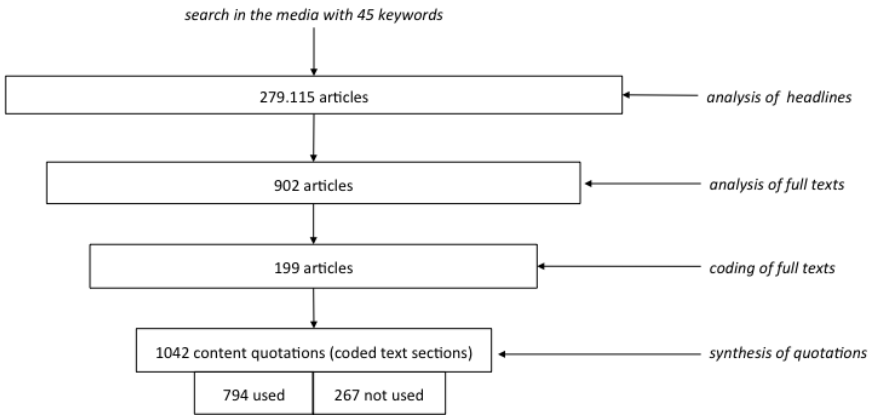

Figure 3 Quantitative overview of the sampling and coding process.

With the exception of German blogs and British newspapers the shares of coded articles of all the 902 selected articles is more than 20 percent. Thus, we have coded with 22,6 percent a total of 199 items. From the selected US-American and German newspapers 25,7 or 26,5 percent were coded. This shows, that here again a strong selection process was carried out. The selection is based on the content analysis of all 902 selected articles.

The assessment of the relevance was based on the current status of knowledge of the Maker Movement (see system of pre-defined categories). Only those contributions were coded which could be simultaneously associated either with the category "Maker Movement in general" or with several "subcategories" of the Maker Movement. That is to say, even in this step, for example, purely technical contributions, for example, on 3D

printing, were sorted out. As the subject matter of the analysis becomes gradually understood, the selection perspective for the media being considered also narrows down. Another drastic reduction of the media contributions also indicates that initially many search terms can be associated with the Maker Movement. A deeper analysis showed, however, that the search terms are not directly related to the Maker Movement. Since the search was carried out with a very wide lead angle, the reduction effort was very high, but the risk of not taking into account important aspects of the Maker Movement was extremely low.

Considering the number of coded articles according to their release clearly indicates that the reflection on the Maker Movement started in 2011 and has steadily grown since then (see figure 4). Unlike previously thought, in the time frame from 2002 till 2010 only very few contributions regarding selected aspects could be identified.

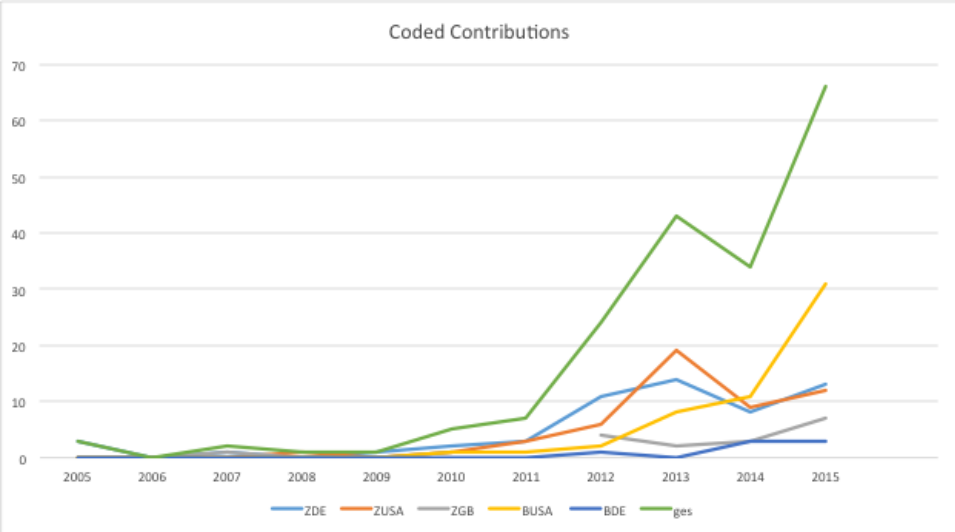

Figure 4 Coded contributions by years.

All in all, 1420 quotations in 199 articles are coded. The quotations are spread relatively equal (with exception of German blogs) in German, American and British newspapers as well as in American blogs. Most of the quotations (202) can be related to the code "Maker Movement in General", followed by "Human" (140), "Impact" (127) and "Organisation space" (116). The codes "Regulations" (12) and "Non profit" (11) are less defined (see table 1).

Codes	Blogs DE	Blogs USA	Newspaper DE	Newspaper GB	Newspaper USA	Sum (total)
Distributors	0	18	22	6	4	**50**
For-profit	0	9	13	10	4	**36**
Content	0	29	24	12	13	**78**
Maker Movement in General	8	67	61	18	48	**202**

Human	2	41	40	22	35	**140**
Methods	3	14	7	11	6	**41**
Nonprofit	0	2	8	0	1	**11**
Organisation space	1	44	37	14	20	**116**
Organisation virtual	0	13	9	14	6	**42**
Regulations	1	0	11	0	0	**12**
Technology	3	22	30	17	23	**95**
Drivers	4	4	8	11	7	**34**
Impact	3	38	29	28	29	**127**
Target group	1	13	11	8	25	**58**
Sum:	**26**	**314**	**310**	**171**	**221**	**1042**

Table 1 Distribution of quotes.

5.2 Qualitative findings

5.2.1 Understanding of the Maker Movement

The predominant general opinions expressed in the media regarding the Maker Movement are initially summarized in the concept of a modern, democratic culture of innovation that builds on the open availability of a number of digital production technologies, including specially developed software that empowers the general public to create new products and further develop and manufacture existing designs. In particular, these digital technologies include 3D printers, laser cutters, CNC routers, software tools and, more recently, affordable scanners. These tools are accessible (i.e., most people can easily learn to operate them) and available in workshops (labs or maker spaces).

Furthermore, an important role plays the question of who the makers are? To facilitate better understanding of the Maker Movement, views found in the media are classified in into certain groups of actors of the movement. A first group of makers is described as hobbyists who create and produce things at home and make use of new technologies such as the 3D printing. These are private individuals who just produce new things within confines of their households. In this, they follow quite different intentions. For example, often producing spares for household devices, toys or similar objects plays an important role in the media. The condition for this is a corresponding low threshold technology that can be operated easily, so that millions of hobbyists the world over can conquer the digital production terrain for themselves. With that, the makers differ from fitters and craftsmen of the old school, who characterize the traditional DIY movement. Whereas many tinkers are fascinated about the challenges of making, for others what is more important is the compulsion to develop and implement something better, that is functionally and/or in terms of design custom-made, at acceptable conditions, for example, something relevant to sustainability or social compatibility, that is the driving force of making.

All the same, even making for others happens often from home and by hobbyists. For example, one's own designs are shared in forums and those of others are improved.

At the boundary between hobbyists, i.e. individuals, and organisations, there exists a new generation of industrial designers, engineers and even doctors in the context of makers, who prepare themselves for the future professional life by utilizing the new maker technologies. However, there is also the assumption that the technical threshold continues to abate so that in principle anyone can become a designer. The digital production probably changes also the relationship between designers and users of the design. In such a scenario, designs will be less dependent on finding producers for implementing their ideas. In view of the available production technologies, they are in the position to produce prototypes themselves and to sell their work directly. To that end, they are likely to change themselves more into entrepreneurs.

It is often not so easy to draw a boundary line from the so-called hobbyists to professionals and organisations, and individuals with a variety of motivations and objectives are clubbed into a single group. Coders, knitters, mechanics engineers, tinkers of electronics, 3D printer masters, trainees for digital production and anyone who likes to use his hands to create something, all of them belong to makers (Clark, 2014). In the context of digital makers, also the term prosumer props up, where prosumers are understood to be people who produce something digital based at home, in future often using 3D printers. Among makers, children and youth as a group play a significant role. They are believed to possess a high degree of not yet tamed creativity, demonstrating a great affinity for new technologies, such as the 3D printing based on their own designs.

A second group of actors in the Maker Movement are organisations of various types. This includes networks, which play an important role as a form of organisation of actors in the Maker Movement, which is often known as a kind of peer networks or commons based peer production. Their special ability of innovation is seen in its open architecture that enables other non-traditional actors to participate in top-grade development projects and continue to develop them further. Non-commercial recognition but participation is here the main driving force for the dynamism of innovation, combined with less bureaucracy due to decentralized structure and flat hierarchies (Bauwens, 2005, Al-Ani, 2013). But even companies of the classical bearing are actors of the Maker Movement. Thus, for example, 3D printing is regarded as a driver for the emergence of a so-called cottage industry of entrepreneurs, for whom business opportunities come forth, since they have the access to small scale manufacturing. Enterprises of the Maker Movement can be distinguished from these “core enterprises” of the Maker Movement that are often start-ups by individual makers based on their new ideas and products. They either develop and market the technology for makers or operate platforms to support the development and marketing of the products of makers. In the US American media, in particular, schools and universities are regarded as important actors of the Maker Movement. It is based on the discussion according to which making, in the sense of producing physical objects, should be pushed into the focus of comprehension and construction of the world and, thus, also into the centre of learning processes in training especially young people.

In parallel to this context of actors, the foundations of the Maker Movement build on the desire for self-fulfilment by ‘doing’ as expressed in the Do-It-Yourself movement and reveals that movement’s democratic aspirations. Considered as a whole, Maker Movement does not simply represent a new technical or process-based form of production. Note that the process of ‘making’ integrates contemplation, deliberate learning, the development of a value system and knowledge — the scope of which is not restricted to individual products, but touches upon production, application and usage contexts. The

Maker Movement's aspirations therefore far exceed the simple desire to revolutionize industry and society through 3D-printing individual products and in fact include a philosophy associated with the production process's applications, roles and values.

This revolutionary potential is often seen as a socio-critical attitude that wishes to break up the existing economic structures and seek an alternative to mass production. In this regard, the objective of the holistically understood Maker Movement is seen not only in terms of technology or processes by a new form of creation, but the process of "creating" includes reflection, conscious learning and establishing values and knowledge. It is not only about the knowledge about individual products, but knowledge about culture, society or even history.

A general understanding of the Maker Movement must therefore acknowledge the contradictory relationship between individualization and collaboration. On the one hand, making is connected with a rather individualistic Do-It-Yourself attitude, but, on the other, the Do-It-With-Others approach frequently resurfaces in the discussion. Makers are clearly not just interested in creating and manufacturing things for themselves but also wish to collectively develop and exchange knowledge. Thus, describing the maker scene as a community is justified, and the principle of sharing can be considered another defining characteristic of the Maker Movement.

Under a social point of view, the Maker Movement is often associated with sustainability. It is often assumed to be not just as creative but also empowered and inclusive, following a paradigm of participative design. According to this understanding, the movement does not pursue an elitist approach to design but instead focuses on altering, modifying and improving available resources in terms of both designs and products.

Considered on a somewhat theoretical level, the Maker Movement is neither merely part of a protest movement based on mass collaboration nor the expression of a shift in attitudes, for example, toward the democratization of the production processes; it is a new form for the organization of production.

Summarising that, the Maker Movement can be understood as a new social phenomenon based on the fact that modern digital manufacturing technologies and the development software meant for them as well as virtual cooperation and distribution platforms are accessible to people at a low-threshold and enable them to create new products themselves, to further develop existing designs, to produce and distribute related products. It is an expression of a democratic culture of innovation, it develops with its new forms of cooperation and organisation beyond existing industrial economic structures and forms a counterbalance to mass production.

At this point we do not make a distinction between social movement and community. We assume that both are coordination forms which stabilise the action of collective actors. They are marked by common aims, rules, identities and organisational structures below that of formal organisations (Dolata and Schrape, 2014, 12).

5.2.2 Interactions of the Maker Movement with the prevailing production regime and possible impacts

Based on the media content analysis, we identified three main areas of interaction between the Maker Movement and the prevailing production regime (Fig. 5). First of all, three is the area of innovation, with new products, new fields of applications and new firms that challenges the traditional production regime with its innovation culture. The interaction can have either substitutive or complementary effects. Mentioned second, it is the area of organisation, with different spatial, virtual and economic organisational forms, which can serve as a model for the modernisation of the existing production regime under the pressure of digitisation. However, the organisational forms are more directed tower an internal structuring of the Maker Movement than of interacting with external organisations. Thirdly, human resources are an important area of interaction, because the Maker Movement is permanently generating a suitable workforce reservoir for the running production system. The mentioned organisation forms are linking the other two areas of the Maker Movement - innovation and human resources. On the other side, the prevailing production system is supporting the Maker Movement by supply of digital fabrication technologies as well as by offering service platforms for organising and distribution.

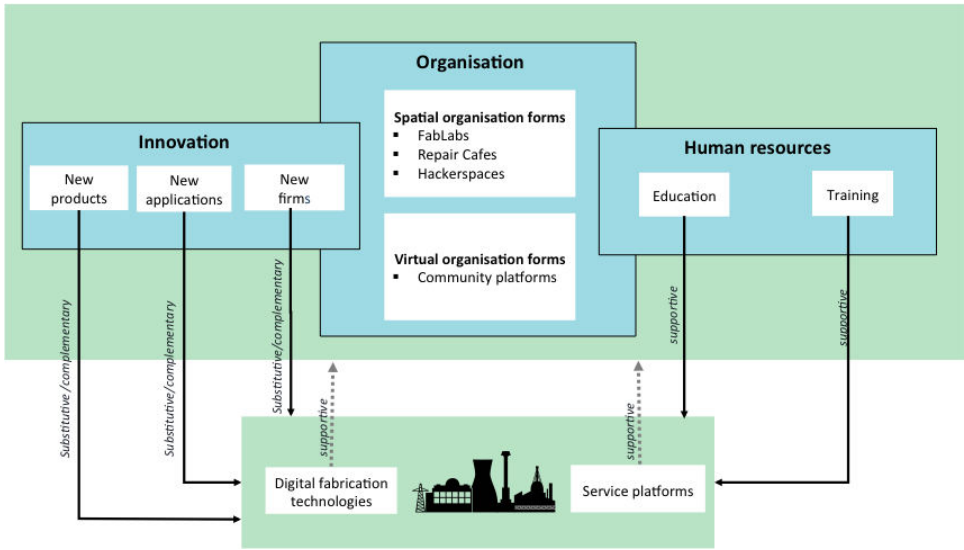

Figure 5. Areas of interaction between the Maker Movement and the prevailing production system

5.2.2.1 Innovation

At the same time, companies are continuing their path to open up innovation processes and sometimes to implement in-house creative spaces in order to enhance collaboration (Lo, 2016), maker demonstrate their ability to design, prototype, produce and sale new products by collaborating within new settings and sharing ideas. Doing so, they combine physical and digital capabilities not by following an elite design but by pushing change, modification and improvement of things already present into the centre stage, regardless of whether it is a design or a product. What is quite conspicuous here is its proximity to the hacker culture. "Tinkering" with the Computer Software is in a way carried over to the so-called physical world, by which new forms of art, manufacturing and industrial designing are made possible.

Often self-rewarding is the mechanism behind such collaborative innovation processes. Maker do not firstly develop new products for existing markets but for their own use and sharing with others. Within these processes they are very highly motivated: usefulness, participation, fun, learning and creativity play an important role (von Hippel, 2017, 2).

Time and again, makers and their movement are known to be endowed with a high degree of creativity. It is described as a contemporary culture of creativity, in which makers produce new products and, in doing so, rely on engineering oriented approaches as well as on experience gained from trades dealing with wood and metal processing, art and handicraft. The unfolding of creativity of makers is connected with new social relationships in the process of making and with new spatial settings in so-called maker spaces.

For understanding the innovation culture of the Maker Movement it is important to recognise, that the new ways and means of producing are closely associated with the opportunity of following not only instruction manuals for manufacturing processes, but of developing physical products in an independent and individualized style by improving one's own or others' designs. "*With the addition of feedback loops and forums, participants can then communicate improvements to design ideas, enabling these projects to evolve and to be perfected."* (Uyeda, 2013)

Improving something always plays a role, whether in the Open Source movement in general or in the Maker Movement. An open manufacturing culture is obviously closely associated with new learning processes that go hand in hand with changing and improving of things constantly. Smith (1996) already in 1956 introduced for decision methods that look for good or satisfactory solutions instead of optimal ones the term "satisficing" (Simon, 1996, 119), which is also appropriated for characterising innovation processes of the Maker Movement (Browder et al., 2017).

Impact by improved products and new applications

The Maker Movement is closely associated with high expectations of quality in new products. This applies, on the one hand, to highly individualized products of a fine product design that is appealing and useful to all; on the other hand, the makers are often concerned about extending the lifecycle of products and also about environmentally conscious consumer behaviour. It also takes the fact into consideration that the Rapid Prototyping, typical for the Maker Movement, can have radical impact on the work of design-

ers until now, just like the Desktop Publishing had on book publishing or the Video Sharing on entertainment industry (Petersen, 2013). The fact that makers are in a position to create better products probably also owes to the circumstance that they organize the designing process differently. In this, the iterative, repetitive character of the process in projects plays a role, but also the environment and the culture, in which hands-on-learning and making result in a situation where the significance of repetitive product change and improvement is no longer in a negative light. While in relation to new products of the home production still predominantly critical positions dominate, new applications allow us to perceive unusual possibilities in the future. This applies, for example, to the healthcare sector taking into consideration the support for people with visually disability. Thus, for example, objects of fine arts are made apparent through 3D printing for blind people by tactile sense and 3D printed notation helps musicians read music.
Svensson and Hartmann give a clear example of numerous product innovations and their economic effects which were developed in maker spaces of hospitals(Svensson and Hartmann, 2015).

Completely new applications are enabled by spatially separating the designing and manufacturing processes, where also this impact associated with it is traced back not directly to the Maker Movement, but to technologies that are associated with it, which, in turn, are primarily driven forward by the Maker Movement. The diversity of makers also points to the fact that they operate in nearly all areas of applications, so a broad spectrum of effects is opened.

Impact on the economy as a whole

The Maker Movement is ascribed a highly disruptive character in relation to the economy as a whole. Because makers draft, share and manufacture their own designs and control their own property rights, they break away from previous modes of production, distribution and sales structures. Possession of and access to necessary resources plays an important role in this regard. In a certain sense, the Maker Movement has developed in deliberate opposition to existing economic structures and cultures of innovation. This is enhanced by the aspect of spatially decentralized production, which, in many cases, is considered a fully realistic alternative. Decentralization and localization of manufacturing processes are expected to gain in significance, and there is mention of a new type of artisanal manufacturing.

But the Maker Movement is also seen as an integrative component of the economy when considered in connection with entrepreneurship. This reflects the assumption that individual makers might later found companies to market their ideas, prototypes and products. Additionally, large, established companies have more recently shown interest in the Maker Movement, and their participation will be necessary for attaining larger scales. This view contains a more integrative perspective of the Maker Movement.

The discussion of the impact on methods of production is directly associated with the impact of the Maker Movement on the economy, elevating the discussion of the problem to a higher level. Accounts of this impact are based on the perception that new digital desktop production technologies will be capable of transforming full-scale production infrastructure and traditional factories, even rendering obsolete the organizational structures on which they are based. It can be noted that although these kinds of consequences

regularly figure in the discussion, in most cases little is said regarding transitions or corresponding timeframes, and these topics are usually addressed with sceptical undertones. Makers are still primarily associated with the creation and production of accessories. Until the movement develops past this stage, consequences such as the transformation of production infrastructure continue to represent a distant prospect.

The disruptive influence of the Maker Movement and its technologies on future production has also been linked to its integration with two other technologies: 'intelligent robotics' and 'open source electronics'. Together, they are perceived as having the potential to end the age of large and complex global value chains by developing flexible, local value chains based on modern software.

Another aspect of the effect on methods of production has been derived by drawing an analogy with the destruction of traditional business models in the fields of communication, publishing and entertainment and other fields such as energy supply and, of course, 3D printing. These ideas contain (1) the relocation of production away from large companies towards the level of individual 'prosumers' and (2) the increasing propagation of business models from the sharing economy model and a trend of 'disownership'.

Individualization and prosumers occupy a large proportion of the discussion of the Maker Movement's possible effects. Individualization is clearly viewed not just as a driving factor of the Maker Movement but also as one of its consequences. After the ages of the social market economy, globalization and the sharing economy, an age of individuality is perceived to be on the horizon.

Another thread in the discussion of the impact on methods of production is the idea that in an Maker Movement-engineered future, people will purchase fewer things. Purchased products will be more expensive than before but will be more robust and will support local business. In parallel to this, the middle class will be reinforced by the Maker Movement's revitalization of 'manufacturing'.

The role of technology for makers

Looking at the other side of the interaction model, the prevailing production system is offering continually improved digital fabrication tools at affordable prices to the Maker Movement. These tools and technologies are the prerequisite for the movement and also drive it forward (Rayna and Striukova, 2016, Jiang et al., 2016, Fuenfschilling and Truffer, 2016). First and foremost, the additive manufacturing technologies must be mentioned here, which have 3D printing at the focal point (Petrikowski, 2015, Ford et al., 2016). 3D printing gives digitalisation a new direction. Consequently, not "only" physical objects and processes are replaced by digitalized, virtual objects and processes, but digitalized objects are transformed into physical objects. According to Gershenfeld, bits turn into atoms. In the discussion around 3D printing, two concepts play a crucial role. On the one hand, the concept of a disruptive production, based on 3D files published in the internet and, on the other hand, the notion that additive methods have the potential to generate precise complex High Performance Structures, which goes beyond the potential of existing production methods. In this, the 3D printing technology is not only an ideal prototyping technology that is beginning to penetrate the production processes as a whole,

but it enables nonprofessional people, more or less anyone, access to manufacturing processes, with simplified forms.

Progress in the field of designing and engineering software supplements the 3D printing technology remarkably. To create CAD drawings, there are meanwhile programs such as Autodesk, Blender, Rhino 3D and Google SketchUp or Tinkercat. Also traditional product manufacturers are offering software solutions for designing like Lego with its cost-free Digital Designer. In the field of easily and intuitively to learn software applications, the media often envisions also the major challenges of the future to further democratize creativity and to promote the Maker Movement.

In the media analysed, there are many contributions that describe the status of the 3D printing technology. While some authors assumed in 2015 that the 3D printers work only slowly, cumbersomely and messily, others foretold already in 2014 that the 3D printing technology would grow. From a component for the aircraft to replacement ear for surgery, everything can be spatially duplicated. The advancing status of technology is also being reflected by the fall in prices for 3D printers, which has led to the fact that in 2016 they had become affordable at less than 2,000 Euros even for private individuals.

More recent trends refer to supplementing methods for duplicating printed designs, for example, with REVO rotational casting machines (Alec, 2016), to integration of 3D scanning functions into the printer or combining printing process with milling operation.

The availability of a number of print materials suitable for special applications plays an important role in further development of the 3D printing technology. While some 3D printers print a variety of molten plastics, others use lasers to harden layers of powdered resin or liquid resin. And some other printers are capable of manufacturing products made of glass, steel, bronze, gold, titanium or even icing. It is also possible to print human organs made of tissue grown from human cells. Moreover, such materials like chocolate, amber resin and wax appear in the media.

Various filaments have different specifications and functionalities. For example, conductive or magnetic filaments, including “smart materials” capable of changing their colour if touched or respond to current, are available in the market.

Besides 3D printing as the “core technology” of the Maker Movement, there are other technologies that will be brought in line with it. Laser cutter, computer numerical control machine, and 3-D scanner have been added to 3D printing technologies. In some cases, for example, in the FabLabs, the new digital fabrication technologies are combined with traditional machines and tools. That includes lathes, drilling machines, sewing machines and welding equipment. At the moment we are seeing virtual reality technologies entering FabLabs.

Other rather non-traditional technologies, which play a role in the Maker Movement, are microcontrollers. One of the well-known examples is Arduino, an Open Source microcontroller, i.e. a small circuit board, that can be customized to any project and application. Whether robots or quadcopters or a washing machine – using computers which can be freely interconnected nearly everything can be automated and controlled. There are people who sometimes insist that Arduino is the core of the maker scenario (Albrecht, 2015). Another representative of the microcontrollers is the Raspberri Pi. (2006) In the

case of Raspberry Pi-Top, the Raspberry Pi is the core of an entire Notebook. In addition, the assembly kit contains a display with a screen diagonal of 13.3 inches, a casing, a keyboard with trackpad and cable and a WiFi controller. Whoever wants it can make the casing on the 3D printer himself, the relevant file is anyway included in the assembly kit. Assembling the Pi-Top is just the first step. Using the on-screen lessons, users can learn how they can produce other hardware items. The basis for it is the Pi-Top. It becomes apparent if we take the concept of the HATs: that is what the developers call the Hardware Attached on Top modules, which users can buy additionally. The modules come in the form of a circuit board and are mounted in the Pi-Top on the Raspberry Pi. There, they can be programmed and modified in such a way that they can be used for automating home devices or as control units for small robots.

Focused on the future, the maker technologies could be significantly more effective by bringing out housings, circuit broads and moving parts in the same work cycle. A robot out of the printer could have sensors, conducting paths and mechanical musculature, all integrated in its artificial body – similar to a human being.

5.2.2.2 Organisation

The Maker Movement is organising itself in specific analogous und virtual spaces with different business models. Maker spaces include a variety of different spaces and locations in which makers meet to communicate with one another, develop ideas and exchange, design, produce, teach and learn. The flagships of the Maker Movement, known as Fabrication Laboratories (FabLabs), are the leading examples of maker spaces. The creation and opening of an increasing number of FabLabs and maker workshops is often even conflated with the Maker Movement itself in the media, and the dynamic development of the movement is explained by its access to new technologies provided by all kinds of maker spaces. The first FabLab was founded in 2002 at MIT in Boston by Neil Gershenfeld as an open workshop and provided access to 3D printers, laser cutters and CNC routers. The underlying philosophy was to forge a closer connection between the processes of idea creation and implementation in the context of specific locations that could provide space for collaboration. By 2006 there were eight other locations in the USA in which practically anybody could gain access to the latest fabrication technologies and transform ideas into prototypes, and by 2015 there were already 450 FabLabs worldwide according to information provided by the Lab Foundation, which illustrates the strongly dynamic character of the movement. FabLabs are generally not profit-oriented companies. They are intended as open workshops and incubators for products, business models or start-up companies. The economic exploitation of the generated ideas and products occurs outside of the FabLabs. FabLabs use a wide variety of financing models, from sponsorship to member subscription fees or revenue from lab activity or organizational connections (Smith et al., 2015).
Another type of space is given by the example of so-called TechShops. TechShops are equipped with a very broad range of production technologies that are made available to users in exchange for a subscription fee. TechShops are companies that are far better equipped than the average FabLab, offering full metal and wood workstations, plastics and electronics labs, CNC machines and countless software tools.

There also exist maker spaces that are not economically oriented, fully non-profit and open to the public. These spaces are often not institutionalized. Examples include repair cafés and hackerspaces. Another form of publicly available space is given by dedicated maker spaces in schools and universities. These began to develop around 2009 in the USA. Today, the utilization of maker spaces as places of learning and training has reached a relatively advanced stage, especially in the USA. More than 200 universities and colleges in the USA integrate 3D printing coursework into their curricula, not simply restricted to printing but also including 3D scanning and design.

More recently, libraries and museums offering spaces and technology have acquired a significance as locations of the Maker Movement. Some libraries have undertaken a transformation in which they increasingly view themselves as "hands-on creative hubs" – spaces in which people can experiment with new digital manufacturing technologies (Benton et al., 2013).

Maker spaces are not only organized in the form of single central locations, but can also develop along other spatial dimensions. City districts or even maker cities are currently the topic of discussion. These large-scale maker spaces would supplement the core functionality proposed by FabLabs with other features such as training, incubation, co-working space, living space and leisure activities (Research Group Collaborative Spaces, 2016).

In addition to physical spaces, virtual spaces play a key role within the Maker Movement and have a strong impact. In particular, these spaces can host platforms for ideas, sales and financing, thus fulfilling the important function of enabler within the Maker Movement. Here it is worth to mention the so-called Community Platforms that provide and share designing tools and designing solutions. A prominent representative in the field of 3D printing is the platform Thingiverse.com, which has meanwhile over 900,000 members who regularly download 3D designs, share and process them. This platform is being operated by the 3D printer manufacturer Makerbot. Other platforms open up digital access to designing tools such as eMachineshop or Formulor and provide the necessary implementation services. Other platforms are meant for implementing designs through 3D printing, such as Shapeways or Sculpteo.

The platform 3D Hubs has established itself with far-reaching influence ("Uber of 3D printers"). It enables designers to identify matching 3D printers in the neighbourhood or worldwide using which their designs can be printed against payment. According to information by 3D Hub, in 2015 nearly 20,000, mostly personal, printers have been registered on this website, which means that one billion people on the earth already have a 3D printer within a radius of 10 miles from their home (Dunn, 2015).

Two more virtual organisational forms have evolved. These are academically oriented online communities where MakerSchools particularly in the USA have merged together (Henseler, 2014) and community labs, funded by crowdfunding, grants and membership contributions, would be able to develop into scientific Hotspots of the 21st century.

At the interface with the Maker Movement there are distributors, which include primarily sales platforms (online marketplaces), a few examples of these are the platforms Etsy, Dawanda and The Grommet. From the viewpoint of time, founding of many such platforms belong to an early phase of emergence of the Maker Movement. In some media,

these platforms are also interrelated with democratisation of sales. In addition to purely distribution platforms, there are a number of mixed forms between design and distribution platforms.

In the media, different aspects of the economic organisation of the Maker Movement are discussed. According to the scholarly literature, a differentiation can be made between For Profit Organisations and Non-Profit Organisations, or Not For Profit Organisations, (Glaeser and Shleifer, 2001). However, the boundaries between these organisational forms is often vague and it is not always easy to determine their position accordingly.

A number of distributors/enablers are For Profit Organisations and offer their services to makers. They include technology producers as well as distribution and service platforms. A known example that took off from the Maker Movement is the 3D printer manufacturer MakerBot, who simultaneously runs the maker platform Thingiverse. Initially, the intention was to manufacture the 3D printed in a Non-Profit Organisational form and to distributed it. This approach had its roots in the idea of sharing software and knowledge. But things turned out to be different and, at the end, a profit-oriented enterprise was founded.

Further economic activities in the form of the Profit Organisation are the professionally operated 3D print shops, which implement individual designs and, therefore, put the principle of Mass Customisation into practice.

Partially, even FabLabs have become profit-oriented For Profit organisations. A renowned example of this is the TechShop enterprise with eight operating units in the USA alone. Another For Profit organisational form are the professionally operated FabLabs based on membership contributions such as NextFab with 300 members who pay 1,300 $ per head membership fee or TechShop with similar organisational form.

The Maker Movement enables even individuals to work gainfully, even if not in the form of a traditional profit enterprise. A prerequisite for that are the distribution platforms for makers, the Crowd Financing platforms for makers and the manufacturers of 3D designing software.

Even the predominant section of the FabLabs, Repair Cafés and hackerspaces does not pursue a profit-oriented strategy, although FabLabs, for example, finance themselves by renting out their devices and space through contract work, training and advanced education. The objectives of the actors, who constitute the Not for Profit organisations, are mainly in solving socially relevant problems, and in imparting new skills and ways of tackling.

However, a large section of the actors of the Maker Movement can be attributed neither to the Profit, nor to the Not for Profit organisations, because they are not sufficiently organized. That is to say, there are no clear objectives and activities, rules and conditions for the membership in an organisation. But still, these people are bound by a common idea of a new way of creating and producing.

To what extent and in what kind of forms the makers organize themselves in future, might play an important role as to whether and how the Maker Movement will move forward as a social innovation.

5.2.2.3 Human Resources

At present, the topic of Maker Movement and the new ways of working still seem to be hardly of any importance in the media, although important aspects of this field have been taken up sporadically. First, what needs to be mentioned is the endeavour to strike a balance between work and life. Since makers often "work from home", they can divide their work relatively flexibly. By offering their products over the internet, they control themselves as to how much time they invest in the production of their goods. This could imply a more flexible working and vanishing of boundaries between work and leisure, which would not only have positive impact. Critical approaches are also expressed here, based on negative experiences with processes of decentralisation and flexibility in the field of knowledge production.

A second aspect of the connection between the Maker Movement and work is taken up over and over, and it refers to the special abilities of makers which could meet the future requirements of work or, which could be acquired by using various forms of making (Martinez and Stager, 2013, Sheridan et al., 2014, Halverson and Sheridan, 2014, Hamidi and Baljko, 2015). This would be a contribution to training and recruitment of skilled workers of the future.

"The Maker Movement also reflects the technological, political, and economic zeitgeist: the need for a technologically skilled work force, hope for a revival of American manufacturing, concern about STEM education all the while cutting many of the programs in schools that foster these skills - arts, wood shop, metal shop, computer science - to make more room for more standardized testing." (Savage, December 13, 2012)

Learning is in a close relationship with working and this, too, is discussed in the context of makers, predominantly in the US American media. The opportunities associated with it are seen not only in the fact that one procures people as one would produce and print 3D models, but in the fact as to how one inspires them to take part in a decentralized production and then teaches them how one does it (Uyeda, 2013). Therefore, it is about much more than special technical abilities that can be acquired. It is about the ability to produce things in new ways and means. These new ways and means of producing are closely associated with the opportunity of following not only instruction manuals for manufacturing processes, but of developing physical products in an independent and individualized style by improving one's own or others' designs.

"*With the addition of feedback loops and forums, participants can then communicate improvements to design ideas, enabling these projects to evolve and to be perfected."* (Uyeda, 2013)

Improving something always plays a role, whether in the Open Source movement in general or in the Maker Movement. An open manufacturing culture is obviously closely associated with new learning processes that go hand in hand with changing and improving of things constantly.

In addition to this, various contributions highlight the fact that making has a profoundly integrating function for learning processes not just in the academic but also in the occupational training. *"We observed, investigated, played, and analysed how the aspects of making, inventing, and creating combine and fit in innovative ways into science, technol-*

ogy, engineering, and mathematics (STEM), career and technical education (CTE), and the arts." (Washor, 2010) An interesting aspect in this context is the assertion of makers that "learning through doing" takes place in informal and interactive Communities where knowledge is shared in the process of making.

In the USA, the Maker Movement appears to have arrived in the schools as well. This new form of teaching has many facets, of which some seem to be in focus. It is about teaching and learning by "*[…] doing, sharing and mentoring, playing, exploring, and risk-taking […]"* (Henseler, 2014) In this regard, one should imagine a place of learning, as said in a US American blog, where teachers and students work together when producing things, document their "tinkering" and feed the relevant knowledge into a Community of other makers (Reed, 2011). Teachers have in such processes an altered function. They are no longer those who simply give instructions, but they rather act as facilitators who motivate others for collaboration and make sure that everyone is heard.

What needs to be highlighted is the opinion that the maker culture in the academic training should remain restricted not only to natural science and technical subjects and application-oriented fields such as economics and entrepreneurship. The focus on natural science and technical fields and linking of maker spaces to the related specialized areas underestimated the possibilities of social science and liberal arts to render valuable contribution. What is absent here is *"[…] toward the self-reflection and articulation needed to learn not only how things are made, but also how they are embedded and can transform society and culture over time. We believe the ethos of the Maker Movement and that of the Liberal Arts go hand in hand."* (Costanza, 2013)

Another aspect related to work and the Maker Movement concerns the requirements placed on people in work processes in future and which even today many makers largely seem to meet with their skills. Thus, the representative of a US American student FabLab is of the opinion that the students can acquire all these new sets of skills and abilities in a FabLab, which are expected of them in the future. Elsewhere particularly the ability of collaboration and creative problem solving is regarded as a "style of thinking" which instructors try to cultivate. Therefore, in the Labs, it is not primarily about technical skills, if teachers and students and pupils want to prepare for a job in a "*Changing workforce*." (Plummer, 2015)

This paper was presented at The XXVIII ISPIM Innovation Conference – Composing the Innovation Symphony, Austria, Vienna on 18-21 June 2017. The publication is available to ISPIM members at www.ispim.org.

6 Conclusions and Prospective on Future Research

Following the adapted and heuristic model by Geels and Schot (Fig. 1), on which this qualitative content analysis based, the Maker Movement can be understood as a niche innovation, in the sense of a social innovation which is in its initial phase of propagation.

What is meant here by a social innovation is an […] *"intensional and targeted reconfiguration of social practices on certain areas of action or social contexts originating from actors"* […] *"that has the aim to solve problems or needs to satisfy them in a better way than it is possible on the basis of established practices"* (Howaldt and Schwarz, 2010, 89). According to Howaldt and Schwarz, this reconfiguration must be socially accepted and diffuse into the society and into the social subsections, transform them and in this way become institutionalized as a new social practice (Howaldt and Schwarz, 2010, 90). In the backdrop of the model by Geels and Schot, the existing industrial production regime, which is currently evolving towards Industry 4.0, will diffuse the social subsection into the Maker Movement. To understand this process, we may once again refer to Geels and Schot, who describe different paths of the transition of existing socio-technical regimes that ought to be explained in the context of the Maker Movement. They outline, in addition to others, (1) a path without any pressure from the socio-technical landscape, in which the socio-technical regime merely reproduces (reproduction path), where niche innovations hardly play a role, because they are not adequately developed. This differs from (2) a transformation path that is characterized by a moderate pressure from the socio-technical landscape on the socio-technical regime if the niche innovations are not fully developed. In this path, the actors of the predominant socio-technical regimes modify this, the niche innovations are of symbiotic nature and supplement the regime to enhance its performance. (3) In the substitution path, there is strong pressure on the socio-technical system and the niche innovations are developed. In this constellation, the niche innovations accomplish a breakthrough and the existing socio-technical regime is replaced. (4) In the reconfiguration path, at moderate pressure itself the symbiotic niche innovations are adapted early by the socio-technical regime and cause substantial changes in its basic structure (Geels and Schot, 2007, 406 et seq.).

Regarding the methodological approach, it has been shown that a qualitative media analysis is a suitable method to systematically explore a new social phenomenon, which has not yet been explored intensively. This requires a suitable theoretical framework. The MLP has proved to be an appropriate approach. Furthermore, the Maker Movement could be described systematically along a category system, and, finally, a definition derived. The analysis has shown that the Maker Movement is at the beginning of its institutionalisation process. It can be understood as a bottom up movement that has developed beyond the existing production regime and challenges it.

To understand the possible effects of the Maker Movement it is important to identify the interrelations with the existing production regime. These are "fields of interactions" in which the Maker Movement challenges and influences existing institutions. For Al-Ani the integration of the peer-to-peer production model by market hierarchies forms such a linkage and he assumes that this will form the focal point of the development of capitalism in the coming years (Al-Ani, 2013, 130). In the view of von Hippel, these interrelations are the result of the interaction of two paradigms of innovation, the producer innovation paradigm and the free innovation paradigm, which influence each other (von Hippel, 2017, 4). The question in which direction the Maker Movement may route, can

not be answered so far. However, this typology sets out a suitable framework for anticipating possible ways of its future development (Vohrer et al., Januar 2013). In terms of the existing production regimes, the further development forward to "Industry 4.0" in Germany or the „Industrial Internet Consortium Initiative" in the USA is observable. In Germany large-scale industries mainly drive this evolution, such that until now the Maker Movement has not been recognised as complementary or even competitive. Nevertheless, numerous indications in the media suggest that large corporations integrate technologies related to the Maker Movement, like additive manufacturing. In the public media, there are practically no contributions that systematically discuss the relationship between industrial production and Maker Movement. Even in the course of discussions about Industry 4.0, which is quite a "hot topic" in Germany, possible relationships with the Maker Movement are so far not or only rarely discussed, neither at scholarly, public nor at political levels.

The linkages between the Maker Movement and the existing production system is formed by the crossed over interaction areas of **innovation, organisation and human resources**.

In the area of **innovation**, there are new products, applications and business start-ups of the Maker Movement, which must prove themselves in the context of the prevailing regime and influence it. They can develop substitutive or complementary effects at different levels, from immediate product substitution to modified economic structures. What is obvious with regard to the relationships with the economy is the fact that the movement is becoming institutionalised through start-ups. As small enterprises, craftsmen and freelancers tend to become strong due to the connection they have with the Maker Movement, it also appears to be a realistic option of their diffusion.

The forms of **organisation** of the Maker Movement enable the development of specific, flexible communities, where maker can unfold their potentials. They are an important prerequisite for the institutionalisation of the movement and have regional (maker spaces) as well as trans-regional (virtual platforms) impacts. They are suitable models for future innovation processes in opening company and network structures.

The interaction between the Maker Movement and the exisitng production regime does not apply to the organisation of the Maker Movement, which has an internal structuring function for the Maker Movement and therefore can not be evaluated by external effects. Here, questions arise concerning the degree of organisation required in the process of the institutionalisation of the Maker Movement.

Which degree of autonomy will be required, so that the movement will not be directly and permanently assimilated by the dominant regime, but can contribute to renew it on the basis of relative autonomy and adequate effectiveness (Haxeltine et al., 2015, Christiansen, 2009) forms a further research question.

In this context, the distinction between the concepts of social movement and community is taken up again. Communities are characterised by deliberately shared views and objectives focused on a specific topic. They have institutional elements such as conventions, values, norms and knowledge structures, which influence the behavior of the members. These mark the limits in the self-perception and the external perception and act as identity-creating. We assume that, over time, not only specific coordination patterns within

communities will emerge), but also between content-related communities. In this way social movements can arise.

The Maker Movement would therefore be understood as an association of collective actors, formed by numerous, spatially and virtually organising maker communities. The differentiation of the relation between Maker Movement and maker communities would open up new perspectives for the understanding of the institutionalisation of the Maker Movement as a whole, as their capability to strategy building will determine the extent to which it can challenge the existing production regime.

With regard to **human resources** the Maker Movement is constantly creating people with competencies which are demanded by the changing production system (Pfeiffer et al., 2016, Apt et al., 2016). In this way it is supporting the prevailing production regime and achieving impact. This is mediated by new forms of education and training. From the perspective of the prevailing production regime the Maker Movement is especially supported by digital fabrication technologies as well as platforms for organisation and distribution. There are for example indications that the competencies acquired by makers in handling the new digital fabrication technologies and their ability for open collaboration even in "traditional" production enterprises are of interest and that the absorption of human resources by the existing production regime the Maker Movement will continue to gain significance. The digital fabrication technologies used by the makers, 3D printing in particular, are being used by the industry as such since long and will continue to be developed further.

References

3DHUBS. 2016. *Where 3D prints are made* [Online]. Available: https://www.3dhubs.com/ [Accessed 26.9.2016].

AICHHOLZER, G., GUDOWSKY, N., SAURWEIN, F., RHOMBERG, W., WEBER, M. & WEPNER, B. 2015. Industrie 4.0 Foresight & Technikfolgenabschätzung zur gesellschaftlichen Dimension der nächsten industriellen Revolution. *In:* ITA (ed.). Institut für Technikfolgen-Abschätzung (ITA) der Österreichischen Akademie der Wissenschaften.

AL-ANI, A. 2013. *Freie Produzenten: Die neuen Organisationsformen der Wirtschaft,* Wiesbaden.

ALBRECHT, H. 2015. *Das ist meine neue Gießkanne* [Online]. Available: http://www.zeit.de/2015/27/elektronik-basteln-arduino-maker [Accessed].

ALBRECHT, S. 2013. Der emergente Diskurs im Internet Wahrnehmung der Nanotechnologie im Spiegel der Online-Diskursanalyse *In:* FRAAS, C., MEIER, S. & PENTZOLD, C. (eds.) *Online Diskurse. Theorien, und Methoden Transmedialer Diskursforschung* Köln: Herbert von Halem Verlag.

ALEC. 2016. The REVO rotational 3D print duplicator for mass production coming to Kickstarter later this week. Available from: http://www.3ders.org/articles/20160128-the-revo-rotational-3d-print-duplicator-coming-to-kickstarter-later-this-week.html.

ALMEYDA, T., ANDERSSON, L. & EPPINGER, E. 2015. Nutzen und Risiken der Personalisierten Medizin - Analyse der Berichterstattung in den deutschen, britischen und US-amerikanischen Medien *In:* EPPINGER, E., HALECKER, B., HÖLZLE, K. & KAMPRATH, M. (eds.) *Dienstleistungspotenziale und*

Geschäftsmodelle in der Personalisierten Medizin. Wiesbaden: Springer Fachmedien.

ANDERSON, C. 2012. *Makers. The New Industrial Revolution,* New York, Crown Business.

APT, W., BOVENSCHULTE, M., HARTMANN, E. & WISCHMANN, S. 2016. Foresight-Studie „Digitale Arbeitswelt". Institut für Innovation und Technik.

BAUWENS, M. 2005. *The political economy of peer production* [Online]. Available: http://www.ctheory.net/articles.aspx?id=499 [Accessed 16.3. 2017].

BENTON, C., MULLINS, L., SHELLEY, K. & DEMPSEY, T. 2013. Makerspaces. Supporting an Entrepreneurial System. City of East Lansing & East Lansing Public Library. *MSU EDA Center for Regional Economic Innovation (REI).* Lansing.

BROWDER, R. E., ALDRICH, H. E. & BRADLEY, S. W. 2017. Entrepreneurship Research, Makers, and the Maker Movement. Working Paper. ResearchGate.

BUXMANN, P. & HINZ, O. 2013. Makers. *Wirtschaftsinformatik,* 5**,** 361-364.

CHRISTIANSEN, J. 2009. Four stages of social movements. *In:* EBSCO (ed.). EBSCO Publishing Inc.

CLARK, A. 2014. The Joy of DIY. *Huffington Post*.

COSTANZA, K. 2013. The Maker Movement Finds Its Way Into Urban Classrooms. Available from: https://ww2.kqed.org/mindshift/2013/09/17/the-maker-movement-finds-its-way-into-urban-classrooms/.

DELOITTE 2014. Impact of the Maker Movement.

DOLATA, U. & SCHRAPE, J.-F. 2014. Kollektives Handeln im Internet. Eine akteurtheoretische Fundierung. *Berliner Journal für Soziologie,* 24**,** 5-30.

DOUGHERTY, D. 2012. The Maker Movement. *innovations,* 7**,** 1-14.

DUNN, J. August 20 2015. Will 3D printing in space allow us to build new worlds?

FABFOUNDATION. 2016. *fablabs* [Online]. Available: http://www.fablabs.io/labs [Accessed 28.9.2016].

FORD, S., MORTARA, L. & MINSHALL, T. 2016. The emergence of additive manufactoring: Introduction to the special issue. *Technological Forecasting & Social Change,* 102**,** 156-159.

FUENFSCHILLING, L. & TRUFFER, B. 2016. The interplay of institutions, actors and technologies in socio-technical systems — An analysis of transformations in the Australian urban water sector. *Technological Forecasting and Social Change,* 103**,** 298-312.

GEELS, F. W. 2007. Transformation of Large Technical Systems. A Multilevel Analysis of the Dutch Highway System (1950-2000). *Science, Technology, & Human Values,* 32**,** 123-149.

GEELS, F. W. & SCHOT, J. 2007. Typology of sociotechnical transition pathways. *Research Policy,* 36**,** 399-417.

GERSHENFELD, N. 2012. How To Make Almost Anything. *Foreign Affairs,* 91**,** 43-36.

GLAESER, E. L. & SHLEIFER, A. 2001. Not-for-profit-entrepreneurs. *Public Economics,* 81**,** 99-115.

GOVERNMENT OFFICE FOR SCIENCE 2013. The Future Of Manufactoring. A new era of oppartunity and challenge for the UK. *Foresight.*

GRIN, J., ROTMANS, J. & SCHOT, J. W. 2010. *Transitions to sustainable development: new directions in the study of long term transformative change,* New York, Routledge.

HAGEL, J., BROWN, J. S. & KULASOORIYA, D. 2014. A Movement in the Making.

HALVERSON, E. R. & SHERIDAN, K. M. 2014. Role of making in education. *Harvard Educational Review,* 84.

HAMIDI, F. & BALJKO, M. 2015. Makers with a Cause. Fabrication, Reflection and Community Collaboration. *In:* STREITZ, N. & MARKOPOULUS, P. (eds.) *Distributed, Ambient and Pervasive Interactions,*. Cham, Heidelberg u.a.: Springer.

HATCH, M. 2014. *The Maker Movement Manifesto: Rules for Innovation in the new World of Crafters, Hackers, and Tinkerers* New York, McGraw-Hill Education.

HAXELTINE, A., KEMP, R., DUMITRU, A., AVELINO, T., PEL, B. & WITTMAYER, J. 2015. Transformative Social Innovation Theory.

HENSELER, C. 2014. The Maker Movement and the Humanities: Giving Students A Larger Toolbox. *Huffington Post*.

HOWALDT, J. & SCHWARZ, M. 2010. Soziale Innovationen. Konzepte, Forschungsfelder und -perspektiven. *In:* HOWALDT, J. & JACOBSEN, H. (eds.) *Soziale Innovation. Auf dem Weg zu einem postindustriellen Innovationsparadigma.* VS Verlag.

HOWARD, C., GEROSA, A., MEJUTO, M. C. & GIANNELLA, G. 2014. The Maker Movement: a new avenue for competition in the EU. *European View,* 13**,** 333-340.

JIANG, R., KLEER, R. & PILLER, F. T. 2016. Predicting the future of additive manufacturing: A Delphi study on economic and societal implications of 3D printing for 2030. *Technological Forecasting and Social Change*.

KOHLBACHER, F. 2006. Qualitative Content Analysis in Case Study Research. *Forum Qualitative Sozialforschung,* 7**,** 1-30.

KPMG 2016. Survival of the Smartest 2016. Studie zur digitalen Transformation. *In:* KPMG (ed.).

KUCKARTZ, U. 2012. *Qualitative Inhaltsanalyse: Methoden, Praxis, Computerunterstützung,* Weinheim und Basel, Beltz Juventa.

LO, A. 2016. The development of contextual ambidexterity through a quasi-structure: exploratory case study of Renault's corporate Fab Lab. *European Group for Organizational Studies (EGOS) 32nd Colloquium.* Naples-Italy.

LORENZ, M., RÜSSMAN, M., STRACK, R., LUETH, K. L. & BOLLE, M. 2015. Man and Machine in Industry 4.0 How Will Technology Transform the Industrial Workforce Through 2025? *In:* MARKUS LORENZ, M. R., RAINER STRACK, KNUD LASSE LUETH, AND & BOLLE, M. (eds.). The Boston Consulting Group.

MACNAMARA, J. 2005. Media content analysis: Its uses; benefits and best practice methodologies. *Asia Pacific Public Relations Journal,* 6**,** 1-34.

MAKERBOT. 2016. *Thingiverse* [Online]. Available: https://www.thingiverse.com/ [Accessed 26.9.2016].

MAKERMEDIA. 2016. *makerfaire* [Online]. Available: http://makerfaire.com/gobal/ [Accessed 28.9.2016].

MARTINEZ, S. L. & STAGER, G. 2013. *Invent to learn: Making, tinkering, and engineering in the classroom,* Barbara St., Constructing Modern Knowledge Press.

MAYRING, P. 2010. Qualitative Inhaltsanalyse. *In:* MEY, G. & MRUCK, K. (eds.) *Handbuch Qualitative Forschung in der Psychologie.* Wiesbaden: Springer VS.

MCKINSEY & COMPANY 2015. Industry 4.0 How to navigate digitization of the manufacturing sector. München.

NEUMAN, W. 1997. *Social research methods. Qualitative and quantitative approaches,* Needham Heights, MA, Allyn & Bacon.

PAPAVLASOPOULOU, S., GIANNAKOS, M. N. & JACCHERI, L. 2017. Empirical studies on the Maker Movement, a promising approach to learning: A literature review. *Entertainment Computing,* 18**,** 57-78.

PETERSEN, S. 2013. The Future of Rapid Prototyping. *Huffington Post*.

PETRIKOWSKI, N. P. 2015. *Getting the most out of makerspaces to create with 3-D printers,* New York, The Rosen Publishing Group, Inc.

PETSCHOW, U., FERDINAND, J. P., DICKEL, S., FLÄMIG, H., STEINFELDT, M. & WOROBEI, A. 2014. *Dezentrale Produktion, 3D-Druck und Nachhaltigkeit: Trajektorien und Potenziale innovativer Wertschöpfungsmuster zwischen Maker-Bewegung und Industrie 4.0*, Institut für ökologische Wirtschaftsforschung Berlin.

PFEIFFER, S., LEE, H., ZIRNIG, C. & SUPHAN, A. 2016. Industrie 4.0 – Qualifizierung 2025. VDMA.

PLUMMER, M. January 19, 2015 2015. 3D printers changing the way some Pasadena students learn.

PRICE, G. 2013. *Makerspaces in Libraries* [Online]. Available: http://www.infodocket.com/2013/12/16/results-of-makerspaces-in-libraries-study-released/ [Accessed 12.03.2017 2017].

RAYNA, T. & STRIUKOVA, L. 2016. From rapid prototyping to home fabrication: How 3D printing is changing business model innovation. *Technological Forecasting and Social Change,* 102**,** 214-224.

REED, S. 2011. DIY movement: Teachers and students as makers.

RESEARCH GROUP COLLABORATIVE SPACES 2016. Whitepaper: Coworkers, makers and hackers in the city. Reinventing policies, corporate strategies and citizenship?

SAVAGE, A. December 13, 2012. Top Ed-Tech Trends of 2012: The Maker Movement.

SHERIDAN, K. M., HALVERSON, E. R., LITTS, B. K., BRAHMS, L., JACOBS-PRIEBE, L. & OWENS, T. 2014. Learning in the Making: A Comparative Case Study of Three Makerspaces. *Harvard Educational Review,* 84**,** 505-531.

SIMON, H. A. 1996. *The sciences of the artificial (3rd ed.),* Cambridge, MA, The MIT Press.

SMITH, A., HIELSCHER, S., DICKEL, S., SÖDERBERG, J. & VAN OOST, E. 2013. Grassroots Digital Fabrication and Makerspaces: Reconfiguring, Relocating and Recalibrating Innovation? *SWPS Working Paper Series 2013-02.*

SMITH, A., HIELSCHER, S. & FRESSOLI, M. 2015. Transformative Social Innovation Narrative: FabLabs. *TRANSIT:EU SSH.2013.3.2-1 Grant agreement no: 613169.*

SVENSSON, P. O. & HARTMANN, R. K. 2015. Policies to promote user innovation: Evidence from Swedish hospitals on the effects of access to makerspaces on innovation by clinicians. *MIT Sloan School Working Papers,* 5151-15**,** 1-33.

TOOMBS, A. & BARDZELL, S. 2014. Becoming Makers: Hackerspace Member Habits, Values, and Identities. *Journal of Peer Production,* 5**,** 1-8.

UYEDA, B. 2013. The Ultimate 3D Printer. *Huffington Post*.

VOHRER, P., MÜHLENHOFF, J., MÜLLER, A. & NOWROTH, C. Januar 2013. Hintergrundinformationen der Agentur für Erneuerbare Energie: Erneuerbare Wärme Klimafreundlich, wirtschaftlich, technisch ausgereift *Renews Spezial.* Berlin: Agentur für Erneuerbare Energien e.V.

VOIGT, C., MONTERO, C. S. & MENICHINELLI, M. 2016. An empirically informed taxonomy for the Maker Movement. *3rd International Conference on Internet Science (NSCI).* Florence: Springer.

VON HIPPEL, E. 2017. *Free Innovation,* Cambridge, London, MIT Press.

WASHOR, E. 2010. Making Their Way: Creating a Generation of "Thinkerers". *Huffington Post*.

WISSENSCHAFTLICHER BEIRAT DER BUNDESREGIERUNG GLOBALE UMWELTVERÄNDERUNGEN 2011. Welt im Wandel - Gesellschaftsvertrag für eine große Transformation. Berlin.