CURRENT STATE OF PRACTICES IN OPEN SOURCE PRODUCT DEVELOPMENT

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Abstract

Open source innovation is a well-studied phenomenon of the ICT sector, but its evolution towards the field of tangible hardware product development is a newer phenomenon which remains mostly theoretical. Existing literature has identified that to push existing open source product development (OSPD) practice towards the achievement of high quality complex products, methods and tools adapted to this specific organisation of work are needed. The objective of this article is to explore the practices emerging from OSPD communities in order to support the development of appropriate process support in the future. It reports first observations made during a qualitative and comparative empirical study performed with participants of 23 OSPD projects through semi-directed interviews. Activating a formerly published framework, these observations address four themes: the organizational structure of OSPD's surrounding communities, their design process, their underlying business models and the supporting online tools they use. The preliminary results are delivered to the engineering design and management scientific community as an impulse for further research.

Keywords: Open innovation, Open source design, Organisation of product development, Collaborative design

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1 INTRODUCTION

The rise of participative web and low-cost prototyping technologies increasingly enables the general public to take an active part in manufacturing activities.

On one hand, via the “maker movement” (Voigt et al., 2016), people “reclaim the production”, that is, contest industry’s product manufacturing monopoly. Supported by open source, or inexpensive CAD software, an emerging category of “home engineers” engage in home-based production and share their designs in online CAD repositories. Organized in repair-cafés or maker spaces, they learn and teach each other how to produce and repair things on their own.

On the other hand, value creation in companies is becoming more permeable to outside input. Under the umbrella of “open innovation” (Bogers et al., 2016), companies are encouraged to increase individual customer participation in the development of their offer.

This context favours extending the open source philosophy to physical products. Indeed, the last decade has seen new practices appear in tangible product development based on online collaboration and on open source documentation. For any product creator, the ease of sharing digital content definitely facilitates online design publication as his design can be copied and further developed by spontaneously emerging online communities. Furthermore, online web technologies allow distributed product development teams to assemble from a common willingness of users to shape solutions adapted to their needs. Companies take advantage of open source publication to encourage adoption of their products and to stimulate market demand.

The objective of this paper is to deliver a qualitative description of open source product development (OSPD) practices from an engineering and management perspective. It particularly focuses on four aspects of OSPD projects: (1) the underlying business models, (2) the organisation and structure of the surrounding community, (3) the design process and (4) the online support tools used. The next section summarizes published knowledge about OSPD practices with a particular focus on development process and business models and introduces the research gap addressed in this article. The adopted methodological approach—a qualitative empirical study performed with 29 participants of OSPD projects—is introduced in section 3 and is followed by a description and discussion of preliminary findings.

2 WHAT IS OPEN SOURCE PRODUCT DEVELOPMENT?

In the context of this paper, OSPD is defined as the development of open source hardware products in a collaborative process permitting the participation of any person interested. Open source hardware is further defined as “hardware whose design is made publicly available so that anyone can study, modify, distribute, make, and sell the design or hardware based on that design” (Open Source Hardware Association, 2016). OSPD is a form of open source innovation described by Raasch et al. (2009) as: “free revealing of information on a new design with the intention of collaborative development of a single design or a limited number of related designs for market or non-market exploitation.” Although originally focused on electronic hardware, the term "open source hardware" has come to refer to any type of tangible artefacts, like mechanical, construction or textile hardware, as these technologies are increasingly impacted by the phenomenon. OSPD is aligned with crowdsourcing in that its outcome is not protected from copy and that it does not necessarily imply corporate involvement.

In reference to the "Business Model Canvas" (Osterwalder and Pigneur, 2010; Fjeldsted et al., 2012), OSPD projects are described as a combination of five factors: a platform (a meeting place for contributors), a drive (to motivate contribution), a community (the group of contributors), a development process, and a business model. OSPD projects are further defined by their degree of openness, based on three factors: transparency, accessibility and replicability (Balka et al., 2014). Transparency is the possibility for any interested person to have unrestricted access to information sufficient for understanding the product in detail. Accessibility means that any person interested is able to actively participate in developing the product by editing design information. Replicability means that any person interested can physically reproduce the product. Bonvoisin et al. (2016) analysed documentation published on seventy-six, open source, mechanical hardware products spanning categories from agricultural machinery, machine-tools and transport, to renewable energy technologies and medical equipment. Their results provide empirical evidence of the OSPD phenomenon while emphasizing its heterogeneity, suggesting there may be divergent, underlying motivations for going open source, though no explanation for the heterogeneity is given.

2.1 Implications of openness for the product development process

How product development is influenced by different aspects of openness, has thus far hardly been studied. The few empirical studies providing insight into the maturity of practices in OSPD projects, first underline a generally low level of process support (Affonso and Amaral, 2015; Macul and Rozenfeld, 2015; Paulini et al., 2011). Hansen and Howard (2013) as well as Bonvoisin and Boujut (2015) highlight the role to be played by online collaboration platforms in supporting OSPD process efficiency. Both report the lack of an appropriate platform designed to help product development communities face their organizational challenges and achieve high quality design of complex products. Few theoretical and empirical contributions have been made to identify the intrinsic characteristics of OSPD processes. It has been noted that OSPD projects are not characterized by clearly defined inputs, outputs and timelines, but more by ongoing, continuous improvement processes (Geyer et al., 2012; Howard et al., 2012). Characterized by a low level of restrictions, self-motivation and self-selection of modular tasks, these projects are not embedded in formal organisations, but rather in communities of practice (Müller-Seitz and Reger, 2010). Aksulu and Wade (2010) point out that open source development processes not only aim at generating functional technology, but also personal development and process learning. While in conventional product development, the technological output is well defined from the start, in OSPD, it tends to be loosely defined at the beginning and to mature over time.

2.2 Implications of openness in terms of business models

Early views of open source software specifically excluded business ambitions (Stallman, 2009). Initially, economists were puzzled by the possibility of value creation based on a collective good (Von Hippel and Von Krogh, 2003). Then, Dahlander and Gann (2010) opened new perspectives by describing open innovation as engaging both monetary and non-monetary interactions. Teece in (2010) highlights the lack of business model study as an interdisciplinary subject in social sciences and business despite its importance in creating value for projects developing in new areas. Three different approaches to open source business models have nevertheless been identified. First, Chesbrough (2012) describes them as having an amplification effect on innovation. Open innovation lowers the cost of innovation and product development—thereby increasing the effectiveness of value capture and creation. Secondly, Osterwalder and Pigneur (2002) go beyond the inflow and selling of intellectual property to define open source business models as those in which value creation relies on systematic collaboration with outside partners. The third approach is to consider the models in the context of market entry (Bonaccorsi et al., 2004; Davey et al., 2011).
Today, several options of building a business around open source software, have been identified to be applicable to open source hardware (Gershenfeld, 2007; Troxler, 2010). Dual licensing, as in the case of freemium models, offers a version of free, open source software and a second version with added functionalities under a proprietary license with revenue. The service option is based on revenues from services such as support and system implementation or consulting. The retailer model sees profits from sales of complementary products such as books or materials. Distributors create new value by aggregating and optimizing open source material so that it becomes easier for the general public to install and use. However, as put forth by Osterloh et al. (2001), firms wishing to choose a proprietary business model face difficulties if they have relied heavily on external contributions from open source.
The growing importance of open innovation is tied to distributed contribution of which crowdfunding is a natural development (Bogers et al., 2016). Through crowdfunding "proponents not only receive money, but also collect suggestions and perform an early market test" (Colombo et al., 2015). Mollick (2014) suggests “several determinants of crowdfunding effectiveness " leading to new measures of success in open innovation projects.

2.3 Research questions

Few empirical descriptions of OSPD practices have been provided to date. For instance, the process support needed to push existing practices forward has yet to be characterized. The objective of this paper is to fill the gap by providing a qualitative description of current OSPD practices based on empirical data. Fjeldsted’s (2012) framework will be investigated with the five characteristic components of existing OSPD projects: *platform*, *drive*, *community*, *development process* and *business model*. Based on these, the remainder of the paper will address the four following research questions:

- *Q1 – What basic elements characterise OSPD business models?*
- *Q2 - How are product development communities structured?*
- *Q3 - How is the product development process organized?*
- *Q4 – What are the requirements for appropriate online supporting platforms?*

3 METHODOLOGY

The research questions above were addressed through interviews with OSPD project initiators. Interviews were semi-structured, declining the four topics in more detail through open questions in order to let unforeseen topics emerge. Interviewers were free to concentrate on one subject then spontaneously ask additional questions in order to grasp these new ideas, as long as all interview themes were treated. Interviews were conducted by two people in order to increase the potential of live analysis, and recorded so as to maximize the potential of post analyses. After each interview, both interviewers collaborated in writing the summary of findings, identifying the most salient issues.

29 people from 23 OSPD projects were interviewed, (For some projects, more than one person was interviewed). The average age of those interviewed was 33: 23 was the minimum and 64 the maximum. 86% were male, 14% were female. Five interviewers participated in the interviewing campaign. The project initiators interviewed were based in France, Germany, England, the United States, Finland, Spain, and Estonia.

Criteria used for selecting the OSPD projects were:

- The product was tangible and discretely manufactured. Food, process industry and software products were excluded. A large panel of technologies was considered from mechanical through electronic hardware to textile.
- The product was of minimal complexity containing at least several parts. Products such as business card holders or cell phone cases made of a single, 3D-printed part did not fulfil this criterion, the objective being to focus on a higher part of the complexity range.
- The product was labelled “open source” by its community, which satisfies, or aims to satisfy, the transparency criteria, i.e. publicly available blueprints and/or CAD files.

4 CURRENT FINDINGS

This section presents preliminary results structured around the four research questions formulated in Section 2.

4.1 Q1 - Business Models

Revenue models. Revenue streams of the projects observed came mainly from personal means, from external foundation grants or from crowdfunding. The later described by one person interviewed as “one of the largest innovations in finance in the last century or more”, is considered as a means of decentralizing innovation so anyone can develop his ideas. Some projects purposefully adopt a non-commercial strategy aiming merely to sustain their activity. Other projects consider a commercial strategy (e.g. based on product selling) as a way to strengthen their activity as well as the open source movement as a whole. When looking for financing, those interviewees discovered that banks shirk from the open source concept, and that the venture capitalist culture is too distant from their own as it focuses mainly on securing income through protection of intellectual property.

Legal statuses. A third of the projects discussed are non-profit; four have no legal status (hobbyists) and four are established companies. Five are “mid-goal entities”: a blend of profit and non-profit, or Community Interest Companies (CIC) aiming to use their profits and assets for public good. Some projects shifted status during their development, until they found a suitable, mid-goal solution. Open source projects are reported to challenge legal classification.

Dealing with competition. Selecting an appropriate licensing scheme is also difficult. Protecting innovation through out-licensed patenting guarantees it stays open, and that competitors do not seize-and-freeze it. But it is, it is confusing to choose the right one among all the existing licences. The choice is ultimately tied to the overall project vision. Intellectual propriety is also a concern. Although most creators would be honoured to see their innovations of use to others, they considered that common courtesy requires at least acknowledging the original inventor. When asked about competition, they generally felt stimulated in the sense that a competitor's presence justified the need they were working to fulfil. Surprisingly, many concurred that if an outside company managed to do something similar in a better and more affordable way, it would be a victory and they would even love to collaborate with that company.

Normative pressure toward openness. A general dissatisfaction with projects such as Makerbot, which closed after receiving external funding, spontaneously popped up in the interviews. This was perceived as opportunistic, against the open source philosophy and disappointing to the community. Starting closed and then opening seemed more chivalrous. True innovation was understood to be transparent, and even empowering as anyone can access the blueprint and knowledge to replicate. In this light, dual licensing may be considered a realistic option.

Lever/Power of low cost innovation. Many interviewed saw the main advantage of open innovation as that of lowering the cost of innovation and product development. The lower cost structure of OSPD projects means that "you don't need much capital; you can start with an idea and develop it and afterwards it grows and everything is much better, more efficient and more effective from the innovation part to the economical part". Some even argued that this approach will lead to a positive societal transformation, in the sense that disciplines such as medicine will be more transparent, more efficient and involve more people trying to find solutions to a given problem. Perhaps, the natural propensity of open projects to develop communities and strategic partnerships will serve as a value-catalyser. At times, what was first conceived as a product evolves into a pedagogical approach, taking on a whole other dimension when the project holders realized they were literally and positively changing the lives of others. Sometimes, input from the community serves to create novel uses for a given product. Many interviewees mentioned that this constant iteration between developers and other community members enhances the quality of an OSPD product.

Strong focus on customization. Perpetual dialogue with the community broadens the range of products and services. Contemplating the possibility of mass customization, persons interviewed specified that the open source movement is less about mass-manufacturing what is average and works for most, and more about what is optimum and works best in each context. For instance, depending on the project and the product, there is a "full spectrum" of potential products to be developed: a product to build from scratch, a final product, or a kit including many options for personalisation. In this perspective the most pragmatic financial approach seems to be either workshops or ready-to-buy products. Because "a lot of people want to have the product but are not so knowledgeable about how to make it on [their] own", the sales revenues will serve as a lifeline to support the project development.

4.2 Q2 - Organizational structure of communities

Two project archetypes. Projects seem to range between two archetypes: isolated innovators and development communities. Isolated innovators are characterized by a low willingness to co-design. They tend to publish their design only after reaching a first stable state, to strive for transparency and eventually replicability, but not accessibility. Consequently, their surrounding community leans towards a community of followers, replicators or users rather than of developers. There is a small number of stable members on the development team, which is not much influenced by outside contributions and controls design decisions. Development communities are characterized by a high willingness to co-design with their surrounding community. They appear to adopt an early release policy, both for working documents regarding the product and for the product development process. As a result, the development community usually consists of a core group plus the dynamic, rather unstable participation of community members. The originators of the project may therefore have limited control over decisions as the design can be highly influenced by community members. The limit between these two extreme archetypes is blurred by factors such as the success in building a community. Indeed, some project developers―though open to collaboration and hence striving for accessibility―may experience difficulties in reaching their target audience and get stuck in the state of being an involuntary, isolated innovator.

Division of work. No evidence of common organization schemes has been found beyond the existence of a small core team and a larger group of unbound contributors in the case of development communities. Depending on the size of the project and its degree of collaboration, the activity of the core team may include participation in the collaborative product development process as well as management activities, such as facilitating the work of the community and ensuring the project remains on track. Beyond the scope of this core team, affiliation to a community appears fuzzy in terms of quality and quantity. First, the activities defining affiliation to a community may be understood in different ways depending on the project: who follows it, who uses/buys the product, who gives feedback, who promotes the product, and who participates in the design. Second, active participation in a development community is voluntary and therefore characterized by a high turnover: people who come and go and may not finish their tasks. In other words, participation intensity is fickle, and extremely flexible over time. Then, a portion of a community may be visible to the core team while autonomous pockets of invisible activity may exist. The core team is not always aware of the number of times a product is replicated or eventually further developed. Keeping off-track activity visible without creating centralized organization is therefore a challenge for core teams. Finally, there is no clear figure for workload distribution within development communities. There may be significant workload imbalance in the visible part of communities, with the core team doing most of the work while the rest of the community does little. A challenge for the core team and the platform may then be to stimulate collaborative activity in order to correct this natural imbalance.

Diverse Motivations. Motivations to create or contribute to a community vary and may be difficult to categorize. Nevertheless, in development communities, two contributor types seem to exist. On the one hand, there are those directly interested in using the product for their own needs (i.e. for running and eventually improving their daily work). These people tend to be more constant in their involvement and their contribution is viewed as a crucial part in the progress of projects. On the other hand, there are those who are more interested in the process of making an open source product rather than in the final product itself. Their motivations may be diverse, which might include boredom, affinity for technology, enjoyment of the social aspect of working together, enrichment of their CV, or training. The contribution of this group however tends to be more volatile, and may lack continuity, which does not allow for a sufficient basis for bringing projects forward.

Qualification. Contrary to what may be generally assumed about projects that are not part of a corporate activity, no evidence of lack of qualification or amateurism of project members has been found. In fact the opposite was found: people contributing to the projects observed tend to be highly qualified and specialized (e.g. physicians, engineers, and filmmakers). The level of formal education among those interviewed was quite high. Several of them had university degrees, including masters and PhDs.

4.3 Q3 - Design process

Community momentum. Project initiators who would like to tap into the potential of co-design are confronted with the challenge of building a development community. An absence of structuring mechanisms can prevent the emergence of a collaborative process when collaborative tools and methods are not readily available or sufficiently understood, or when resources adapted to community management and the technological knowhow required are lacking. This may result in a discrepancy between the initiators' intention to collaborate and the actual organisation of the design process. In some cases initiators may also want to involve volunteers while insisting on maintaining exclusive ownership of their projects, thus limiting the space available for action. A crucial prerequisite to the successful creation of the momentum necessary for the emergence of a development community is to accept a relative loss of control over the project. This loss of control is required for the emergence of the distributed organisation of work, based on self-selection of tasks.

Process continuity. As mentioned earlier, product development communities are characterized by a high turnover of members, which considerably impedes process efficiency. Indeed, short involvement periods imply a higher ratio between time spent getting started and time spent on productive work, as well as a higher rate of unfinished tasks. In order to offset poor process efficiency related to the lack of stable staff, development communities tend to promote continuity and team awareness. They strive to ensure that new members who join become quickly accustomed to the current status of the project, and that information is not lost when people leave. The following strategies are implemented by core teams in order to offset these difficulties:

- Decrease process-learning time by defining clear, quickly understood processes, publishing process-related information and providing newcomers with training.
- Increase team awareness by promoting documentation of day-to-day activities (e.g. journals, work-logs) and facilitating project-related as well as social communication in order to bridge geographical distance and strengthen social ties.

- Reward individual contributions to encourage further involvement of the volunteers and therefore lower turnover, and create interfaces beyond product design issues (e.g. interfaces with other development communities).

Evolutionary design process. In a collaborative environment based on intrinsically motivated contributions and without effective operational structures, the essential instruments employed in heavyweight processes that ensure convergence, fall short of accountability. Indeed, design briefs, milestones or roadmaps have been observed to play a marginal role in the design activity. On the contrary, OSPD projects embedded in development communities tend to implement an evolutionary design process. This process is driven by the formulation of requirements, which are broken down into modular tasks, eventually embedded in a Kanban board, an issue tracking system or another project management tool. The objective is to reach the right level of "granularity" allowing a self-selection of tasks by community members. This self-selection of tasks replaces conventional assignment mechanisms in the absence of operative, hierarchical structures. How the contributions of community members are then gathered and combined depends on the collaborative development platform used and its versioning logic. For example, platforms based on the versioning software Git embed workflows that allow a central quality assessment of members' contributions which is performed by skilled members or within the core team based on formally or informally stated criteria. Platforms such as wikis tend, on the contrary, to support what could be called a "do-ocracy", i.e. a governance model allowing for anyone to initiate ad-hoc solutions as long as they are willing to provide them. In this case, the decision process tends to be implicit or even nonexistent. The member who performs the changes also decides on their integration. Unless another contribution comes up in the future and overrides it. From a time perspective, external events such as maker fairs set a scene for presenting project results and therefore tend to replace project milestones as a motivation driver to get tasks done.

Differentiation and convergence. Although the evolutionary design process described above seems to be lacking in structure, it has been reported to result in sufficient process convergence. What enables coordination and integration of contributions towards convergence, and eventually stable products, is the provision of general project standards setting minimum requirements. Different levels of detail are structured in the form of vision statements, design guidelines, manuals or simply templates for task setting or contributions. In case of a design conflict, a new avenue of development can branch off from the main project, leading to variations being simply pursued in parallel and ultimately to product differentiation. The emergence of spin-offs from a given project happens to be seen as a sign of proliferation, not dissent. From this results the possibility for every community member to work towards project convergence or differentiation.

4.4 Q4 - Supporting IT tools

Lack of integrated solution. In order to reach process efficiency and convergence in a context of voluntary work, defining product development processes striking the right balance between stability and flexibility is not enough. These processes also need to be supported by appropriate, collaborative, software tools. Different CSCW (computer-supported collaborative work) software products have reportedly been used. However, a number of practitioners interviewed underscored the limits of existing software. There seems to be a tension between an overabundance of specialized IT-tools on the one hand, and the absence of an integrated solution for supporting the OSPD process on the other. The high diversity of tools used generates conflicting functionalities, creates double work, and can lead to communication channels cannibalizing each other. The abundance of tools is also reported responsible for a work overload, as tools must be tested in order to find those appropriate. Furthermore, they have to be maintained along the course of the project. There is a noticeable improvement potential in terms of tool selection for appropriate functionalities and technical solutions, and their integration. The most frequent comment regarding the existing supporting tools is the lack of a "Github for hardware", Github being a portal based on the open source versioning software Git and widely used in the open source software community. General-purpose platforms such as wikis are considered as good candidates to integrate the necessary supporting functionalities. The advantage of these platforms is that they can embed additional modules extending needed functionalities on demand. They can also integrate documentation templates, which lowers the entry level for novices and generally reduces workload as they offer a predefined structure of data to be stored. Wikis, however, were reported to be messy, lacking structure and therefore requiring constant attention.

3D model integration. Among functionalities identified as supportive for the OSPD process and that could be embedded advantageously in an integrated platform, the in-browser integration of 3D models is the one most frequently cited. This encompasses: 3D model viewing with interaction features (rotation, zoom, annotation, section, exploded view, version comparison), interoperability (compatibility with all types of 3D file formats), and online and concurrent editing.

Predominance of open source software. Open source tools tend to be preferred to proprietary tools. One reason for this is the normative pressure towards the ideal of a complete, open source tool chain. For example that not only the results of the work are made open source, but also that the work is done with open source tools. Another reason is the increased control over one’s own data and the independence from software vendors or online portal providers. Keeping one's own data on one’s own server(s) prevents other stakeholders from suppressing access to it, as in cases reported during the interviews.

5 DISCUSSION AND OUTLOOK

This work is a first attempt to provide a detailed, qualitative description of the emerging phenomenon of open source product development (OSPD) based on empirical data. The knowledge gained in OSPD practices provides the necessary basis for the future development of methods and tools supporting OSPD communities in the efficient development of high quality and complex products. It also allows formulating more precise questions for further research. Observations related to the four research questions are summarized in Table 1 below. Corresponding practical challenges are identified.

Some of the observations reported confirm, extend or clarify earlier academic contributions.

In terms of business models, the uncertainty in choosing the appropriate revenue model and intellectual property licensing strategy to launch or sustain activity fits with the lack of clarity mentioned by Teece (2010). Concerning OSPD community structure, identifying two archetypes (development community and isolated innovator) delivers an interpretation for the heterogeneous behaviour of OSPD projects in terms of product-related data sharing first observed by Bonvoisin et al. (2016).

Regarding design process organisation, the phenomenon of self-selecting modular tasks described by Müller-Seitz and Reger (2010) (as well as Howison and Crowston (2014) in the case of open source software) has been identified as a feature of an evolutionary product development process implemented by development communities.

In the case of supporting IT tools, this study clearly confirms the lack of integrated software support identified by Hansen and Howard (2012) as well as by Bonvoisin and Boujut (2015). Furthermore, it suggests that distributed IT-architecture and open source software are two elements, which if adopted, could positively influence OSPD communities, an aspect that tends to be overlooked by the existing offer and by previous academic contributions such as those of Hansen and Howard (2012).

The methodology chosen has permitted covering a broad panel of topics and obtaining an overview of practices, believed by the authors to be of upcoming relevance. A drawback is that it does not allow definitive and generally applicable conclusions. It is worth noting, however, that, due to its emergent nature, the phenomena studied may be subject to rapid evolution. Nevertheless, the quantity of interviews conducted ensures results representative of the current state of OSPD development while highlighting critical aspects from the perspective of various actors in the field.

The material presented in here is to be considered a preliminary hypothesis for further research, for example in further qualitative studies on a precise topic or for quantitative data acquisition. It is therefore hoped that it will open new research perspectives in the engineering and management research communities.

Table 1. OSPD practices observed and corresponding challenges

	Observed practice	Challenges
Q1 Business models	– Strong focus on customization – Need of funding – Normative pressure towards openness – OSPD seen as a lever for low cost innovation	– Lack of clarity about which license to use – Find an appropriate legal status – Understanding of staged openness which would help articulate both incoming revenues and patents
Q2 Organizational structure of communities	– Two types of projects: isolated innovators and development communities – Core team surrounded by a community of contributors with diverse roles and working paces – Workload imbalance between core team and community – Two types of contributors: contribute for fun or contribute to fulfil a day-to-day need – High qualification level of contributors	– Create momentum so a community of developers emerge, if wanted – Facilitate the work of the community – Ensure the visibility and the convergence of activities – Mitigate the work imbalance – Settle the fickle contribution of hobby contributors
Q3 Design process	– Discrepancy between level of whished and actual collaboration – High turnover decreasing the process efficiency – Diversity of strategies for ensuring continuity – Evolutionary design process – Coexistence of project convergence and differentiation	– Accept losing ubiquitous control on the project – Get access to sufficient supporting methods and tools – Ensure continuity – Ensure both pace and convergence of the design process
Q4 Supporting IT-tools	– Concurrent use of specialized IT tools creating double work and competing communication channels – Normative pressure and practical incentives to use open source tools	– Finding the appropriate tools for supporting the project – Need for an integrated solution, a "GitHub for hardware" – In-browser integration of 3D-Models required – Open source tools that can be deployed on the project's own server

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