Future trends in NPD

Product Design and Development (ME30294). Lecture 11.
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Last update: August 8, 2018

Abstract

The ever-growing affrdability of manufacturing and information technologies combined with raising criticism about the consumption society led to the emergence of a "maker culture" promotingn citizens' rights to keep control on everyday technologies. Formerly pushed in the background as a passive consumer, today's citizen enjoys an increasing capacity to take action and to participate in product development. This lecture explores the consequences of this evolution and sketches the future of NPD as a collaborative process involving institutions and individual people working in communities to create shared designs.

Contents

1 Design for everyone

The vision delivered in this lecture is those of an increasing participation of individual people in product development, outside any hierarchical organisation, outside the firm, maybe even outside the market. This vision is at the confluence of three contemporary trends: the ever increasing demand for customized products, the increased accessibility of design tools for laypeople and the emergence of counter-cultures challenging the distribution of roles in the production of everyday products.

1.1 A short history of manufacturing

It is nowadays commonplace to observe that since mid 20$^{\text{th}}$ century manufacturing follows a trend towards lower production volumes per model and higher product variety. In the first half of the century, the industry strove to escape *craft production* and targeted at *mass production*—its efforts were focused on increasing volumes and lowering variety in order to harvest economies of scale. The mindset of the mass manufacturing era is well exemplified by the citation attibuted to Henry Ford: "Any customer can have a car painted any colour that he wants so long as it is black"[1]. Since the second half of the century, industries increasingly strove to take advantages from new technologies in order to come back to the starting point [Slide 1]. It strove to offer the advantages of craft production in terms of customization together with those of mass production in terms of price. This led us to the current era of *mass customization.* Nowadays, the number of possible variants offered by the automotive industry goes far beyond the number of actually produced cars. "In 2004, Daimler Chrysler produced about 1.1 million Mercedes A class at the production plant in Raststatt. Only two of these cars were completely identical." [1].

This evolution towards more customization is predicted to lead to a new paradigm of 'personal fabrication' where "customers create innovative products and realize value by collaborating with manufacturers and other consumers" [2][key reading]. In this new paradigm, the role of the customer is not only to *buy* like in the mass manufacturing paradigm or to *choose* like in the mass customization paradigm: it is also to *design* their own products [Slide 2]. The role of the industry also changes to become those of a facilitator of a 'commons-based peer-production': "a model of social production, emerging alongside contract- and market-based, managerial-firm based and state-based production. These forms of production are typified by two core characteristics. The first is decentralization. Authority to act resides with individual agents faced with opportunities for action, rather than in the hands of a central organizer, like the manager of a firm or a bureaucrat. The second is that they use social cues and motivations, rather than prices or commands, to motivate and coordinate the action of participating agents" [3].

[1] I don't know whether Henry ford *actually* said this but this is not important here. What is important is that this presumed citation is well known in industry and is symptomatic for the mindset of this era.

1.2 Democratization of design

This evolution is made conceivable by the observable radical increase in the range of design and production tools accessible to laypeople in the last decade [Slides 3-8]. It is now common for pupils or students to have access to a desktop-size machine-tools such as a 3D-printer or a CNC mill. Medium-size machines such as laser cutters are increasingly available to every interested person in a growing number of FabLabs and Makerspaces. At the same time, there is a growing offer of easy to use 3D-modelling software such as TinkerCAD as well as of open source or free-to-use parametric CAD software such as FreCAD or OnShape. It is easier than ever to share 3D-models with the use of online libraries such as Thingiverse or in-browser 3D-viewers such as Sketchfab. There is also an increasing offer of computer supported collaborative work (CSCW) platforms such as GitHub allowing to structure coordinated work and manage shared content.

Tools are more accessible, so do the possibilities to learn how to use them. Know-how is easily shared through video tutorials or wikis. It is easily exchanged between peers in community forums, in hackathons or in makerspaces. The combined accessibility of tools and know-how comes along with an increased self-confidence to tackle activities related to product design, prototyping and production. It helps 'relieve[ing] the need for formal segmentation' [4] between designers, producers and users. It challenges the traditional distinction between professional and layperson and establishes the figure of the normal citizen as a qualified and credible stakeholder of product development.

1.3 Maker culture

This evolution is contemporary to the emergence of the 'do-it-yourself', the 'hacker' and 'maker' subcultures [Slide 9]. They tend to reject consumerism and passive dependence on established social structures (such as schools, corporations, governments) [Slide 10]. Instead, they promote self-empowerment, active learning (learning-by-doing), 'do-it-yourself' and the vision of a society where people are valued for what they are able to do instead of what they are able to buy. They value the figure of a 'prosumer' taking action to influence their consumption patterns. They also tend to value voluntary and collective effort as well as unconditional knowledge sharing.

The capacity of these subcultures to exceed the field of spare-time activities and to become mainstream, that is, to disrupt production patterns outside some niche markets, is disputable [Slide 11]. Nonetheless, they tend to challenge the traditional distinction between professional and layperson and to establish the figure of the normal citizen as a qualified and credible stakeholder of product development.

Take-aways of this section:

- *The 50 last years of history of manufacturing shows a strong trend towards increasing product customization and customer participation.*

- *Laypeople have increased capacity to act as product designers, hence blurring the border between professional and hobbyist.*
- *There is a cultural change from the citizen as a passive consumer to the new figure of the 'prosumer'*

2 Participation in firm-led product development

Today's best practices of innovation management encourage permeability of the firm's boundaries for inbound and outbound information flows. In line with this, companies show an increased interest in sourcing innovative product ideas from the 'crowd'.

2.1 Open Innovation

"Today, the common understanding of the innovation process builds on the observation that firms rarely innovate alone and that innovation is a result of interactive relationships among producers, users, and many other different institutions [...]. The early Schumpeterian (1942) model of the lone entrepreneur bringing innovations to markets has been superseded by a richer picture of different actors in networks and communities" [5]. This contemporary understanding replaces the formerly dominant "funnel model" of innovation based on a stage-gate product development process [Slide 12] where "the initial phase is a wide screening of the raw ideas in order to find the most successful one; then, the approved ideas are turned into projects and developed; of these, just few are actually launched on the market" [6]. The new dominant model of innovation is those of an '*open innovation*'*, defined as "the use of purposive inflows and outflows of knowledge to accelerate internal innovation, and expand the markets for external use of innovation, respectively" [7][Slide 13]. "While in purely closed innovation discarded ideas or projects do not generate value, in the open innovation paradigm, they can be licensed to external companies as intellectual property, or generate spin-offs and enter new markets. [... External] sources of knowledge can be leveraged in to order to foster novel ideas at the beginning of the NPD process or during the process as technology insource" [6]. In other words, while the closed innovation model "involves keeping all of a company's information private and protected, open innovation encourages making varying amounts of proprietary information public to allow a larger sampling of people to participate in solving the problem." [8].

2.2 Crowdsourcing and related concepts

In line with this, there is nowadays an increased interest in opening the product development process to the participation of external people, regardless of their affiliation to any institution. This increased interest is revealed by the large variety of partly overlapping names given to this phenomenon: co-creation, crowdsourcing, mass collaboration, user innovation, lead-user methods, mass collaboration, cloud-based design, social product development, etc. [Slide 14]. Co-creation is for example defined as an "active, creative and social collaboration process between producers and customers in the context of new product development" [5]. It is about involving a specific type of people: the users, customers, people who already know the product or have interest in using it. As for *crowdsourcing**, it is defined as "the act of a company or institution taking a function once performed by employees and outsourcing it to an undefined (and generally large) network of people in the form of an open call" [9]. The concept of crowdsourcing is not specific to product development but can apply to this type of corporate activies. And here, in contrary to co-creation, the people involved are neither necessarily users nor they need to have any interest in the using the product.

2.3 Examples of crowdsourcing

The French sportswear company **Raidlight** provides a good example of co-creation [Slide 15]. They maintain a constant link with their community of users, organize design challenges, let users vote for the best ideas, and invite users to come to the R&D department to explain their innovation ideas. Doing so, they establish the image of a participative company, they build a feeling of belonging and therewith customer fidelity, and they get innovative ideas their R&D departments can turn into new products. They have been successful in bringing user ideas to the market and rewarding the contributors for these ideas. A trail show they issued in 2014 has the name of all contributors written on the sole [Slide 16].

Not only SMEs can take advantage of the creativity of the crowd, but also big players of 'serious' markets such as aerospace. In 2014, **GE** launched in cooperation with the online 3D model sharing platform GrabCAD a challenge to redesign an airplane engine bracket [Slide 17]. "The original bracket GE asked the GrabCAD Community to redesign via 3D Printing methods weighed 2.033 grams (4.48 pounds). The winner, M Arie Kurniawan, was able to slash its weight by nearly 84% to just 327 grams (0.72 pounds)"[Slide 18][2]. 637 designs were submitted and the winner has been granted with a 7,000 USD award. The story does not tell whether GE actually integrated the bracket into any jet engine. Nonetheless, "$7,000 for that lighter bracket seems like a pittance compared to its economic impact, or even what GE would have paid a high-caliber engineer to solve the problem."[3]. Contrarily to Raidlight who pays back contributors with symbolic rewards (e.g. public acknowledgments), rewards are here pecuniary and based on the "winner takes it all" principle.

Quirky [Slide 19] is one of the most cited examples of successful crowdsourcing because its entire business is based on bringing ideas from the crowd to the market. They help individual creators bringing products to the market

[2]GE jet engine bracket challenge on GrabCAD

[3]Elisabeth Stinson, How GE plans to act like a startup and crowdsource breakthrough ideas, wired magazine, 04.11.2014

through a 4-step online process: 1) the creator submits an idea 2) the idea is reviewed by the community of other registered creators, 3) Quirky takes over the detailed design and industrialization to bring the product to the market and 4) pays royalties to the creator. The company claims to have a community of more than 1m users and to have paid back more than 10m USD royalties to the creators. Contrarily to the GE's challenge, contributors do not compete but collaborate and reward is conditional to the extent and the success of ones contributions.

Companies like **OPENIdeo** [Slide 20] or Innocentive implement the same kind of process but as a service for other companies. They involve individual people in challenges initiated by client companies and are focused on more general issues than on product design (for example: Seeking an Alternative to Raw Wood for Packaging and Fastening of Cargoes in Sea Transportation or How might we create a waste-free, circular future by designing everyday products using Nike Grind materials?)

Take-aways of this section:

- *The business world shows an increasing interest to exchange product-related information outside the boundaries of the firm.*
- *There is a wide variety of practices involving individual people as active stakeolders of product development.*
- *Among these, crowdsourcing even acknowledges the competence of individual players as designers*
- *There are numerous success stories of fruitful collaborations between companies and individual contributors.*

3 Community-based product development

Not only can individual people and communities participate in online to product development processes set up by companies, but product development processes can also happen outside the field of influence of the firm. There are rising numbers of high complexity and quality products designed in decentral process with limited involvement of institutional stakeholders. *Open source hardware* is a concept playing an large role in this phenomenon.

3.1 Open Source Hardware

Open Source Hardware (OSH) products are those products "whose design has been released to the public in such a way that anyone can make, modify, distribute, and use" them [10] [Slide 21]. In other words, an OSH product is a physical artefact whose documentation is released under a license granting anyone with production and distribution rights, and is detailed enough to enable anyone to study and develop it further. The concept of OSH is based on an adaptation of the four freedoms of open source (first stated in the context of software development by the free software fundation [11]) to the field of physical products [12]:

- **Hardware freedom 0**. The freedom to use the device for any purpose.
- **Hardware freedom 1**. The freedom to study how the device works and change it to make it to do what you wish—access to the complete design is precondition to this.
- **Hardware freedom 2**. The freedom to redistribute the device and/or design (remanufacture).
- **Hardware freedom 3**. The freedom to improve the device and/or design, and release your improvements (and modified versions in general) to the public, so that the whole community benefits.

The four freedoms of OSH require the publication of the 'source' of a 'design'. In contrast with software, there is no clear definition of what the 'source' of a hardware product is [13]. Instead, it may take different forms depending on the intention of the product originator to engage into OSH [Slide 22]:

- The originator intends to build transparency for their customers. In this case, relevant documentation may be computer aided design (CAD) files and drawings.
- The originator wants the product to be widely produced and adopted beyond their own sphere of influence. In this case, relevant documentation may be bills of materials and assembly instructions.
- The originator intends to create a community-based product development process allowing the participation of any interested developer. In this case, it is not only relevant to share the CAD files, but also information about the development process: what are the expected requirements for the product, what has been already achieved and what are the pending tasks, how can a contributor join in the project, etc.

3.2 History and contemporary relevance

From software to hardware. OSH results from a recent extension of the open source movement outside the domain of software and into the realms of physical products [Slide 23]. In software engineering, open source products have been developed for around 30 years and generate nowadays billion-dollar businesses. The first domain to which the principles of open source have been extended is electronic hardware. The flagship of this new era and one of today's most successful companies building on open source hardware is Arduino. More recently, the extension of the open source principles has also reached other types of physical products such as mechanical products, mechatronic products, construction, and textile products. Two frontrunner projects which raised large attention from the public are Local Motors[4] and Open Source Ecology.

OSH as a grassroots movement. Open source principles have first and mainly be applied to hardware within grassroots communities, in non-commercial sectors or freelance businesses. A typical example of open source hardware product born in academia is RepRap [Slide 24] which has been adopted by a vivid community of enthusiasts, scholars and enterprises, who generated an impressive number of remixes. A famous example of grassroots community built upon OSH principles is Open Source Ecology [Slide 25], a project aiming at developing and building a 'Global Village Construction Set', i.e. a set of 50 open source industrial machines allowing to 'build a small civilization with modern comfort'. Some of their machines—for example the brick press—have been replicated several times outside the initial community. An example of product resulting from a freelance business is Hovalin [Slide 26], "a functional acoustic violin that can be produced using most standard consumer 3d printers". The 3D-models of the product are freely available and are provided with detailed assembly instructions. For those who don't want to build their violin by themselves, the authors offer to sell either the fully assembled products or the parts to be assembled.

OSH in businesses. OSH has also found its way to marketplaces [Slide 27]. Some emerging businesses such as start-ups and medium-size enterprises have built their operations on OSH, especially in the supply market for makers. Two examples of them are the companies Ultimaker and Aleph Objects, both developing, manufacturing and distributing 3D-printers. Another example is the company OpenBeam, producing extruded aluminum framing systems for rapid prototyping of machinery building. OSH also raised interest of larger industrial players as exemplified by the automotive industry. Tesla, one of the newcomers and challengers in this field, engaged in this way by declaring they would "not initiate patent lawsuits against anyone who, in good faith, wants to use our technology." The more established French automobile company Renault announced in 2016 a partnership with Open Motors to open up the electric car Twizy. Although the realization of these strategies has not issued concrete open source content so far, they indicate that OSH gained attention out of the sphere of grassroots initiatives and individual making.

There is today a blooming and diverse activity building on open source hardware. A curated directory of >200 complex OSH products can be seen here.

3.3 OSH development practices

How product development happens in OSH first depends on the complexity of the product.

[4] Local Motors's business model however moved over time from open-source to crowdsourcing.

Simple products. On one side of the spectrum, there is the publication of simple products designs performed by individual "home engineers". This is supported by the increased affordability of 3D-printers as well as the availability of online sharing places for CAD models such as Thingiverse, which counts more than 1.1m uploaded objects. Although these objects are generally designed as one-person-projects, they are part of collaborative development practices in the form of sequential series of remakes: one maker develops one version which is taken over and developed further by someone else, and so on [14][Slide 28].

Complex products. On the other side of the spectrum, there are more complex OSH products combining different technologies, made of several parts, designed to satisfy demanding needs. These products are the result of NPD processes as described in this module, eventually happening in collaborative, distant and decentral settings. There are basically two approaches to the development of complex OSH products depicted by the OSH life cycle [Slide 29]. The first approach is to reveal the result of a product development project performed in a private setting. The the end of this process is marked by the publication/revelation of the product documentation which has been kept private so far. The second approach is to develop the product in a community-based setting. The end of this process is marked by the release of already public documents in a stable version. In both cases, the resulting OSH product can be redesigned either in a private or in a community-based setting. Also, a product can be simultaneously in different states of the life cycle, that is, be a stable OSH product which is produced, be the object of a community-based improvement process and be further developed by other actors in a private setting.

characteristics of open processes

3.4 Advantages of open source

The relevance of open source and especially of OSH is supported by sustainability, business and macroeconomic arguments.

Product quality. The most cited argument in favor of open source is that "given enough eyeballs all bugs are shallow". In other words, the more people can have a look, the more issues they will be able to raise and solve. Individuals can check whatever they value as quality and eventually take action to improve the product. This can for example lead to safer products, as discussed in the software branch, where open source has been advocated to lead to better digital security. This can also lead to more durable products: potential breaking points can be more easily identified and product obsolescence openly discussed.

Citizen capability. Open source goes along with a lower user dependence in case of product fault. Having access to technical information allows users to find solutions by themselves in case the product originator cannot provide those, whatever the reason. This supports users to extend product lifetime for economical or environmental reasons, if they wish so. A side effect is to support technological literacy. Open source provides people wanting to develop their technical skills with more cases to quench their thirst for learning or doing things on their own.

R&D efficiency. Opening the product development process to the participation of volunteers is a promise of either decreased R&D costs or increase of fresh and innovative ideas coming in. Letting other people participate enables the emergence of an original ecosystem of stakeholders the company may not have thought working with in the first place. It may also allow identifying key talents to be hired. In summary information disclosure may contribute to the prosperity of the firm throuhg better, cheaper products.

Speed of innovation. Openness supports reusability of intellectual assets. It helps avoiding "reinventing the wheel" and accelerating product development. By having access to the technical documentation of other products you can pick up the things you need in them. This is what massively happens in software development and why it is so fast nowadays. Because you just find on the internet the bits of code you need in 99% of the cases. Moreover, the replicability of hardware may support faster adoption of best available technologies. Inventions are not locked-in but made available, which increases the chances they will actually be provided where they are needed.

4 Outlook: the designer of tomorrow

- designer as a community manager senior desinger, "'have you thought about this"', pointing good design practice, google engineering stack overflow, librairies community thinking

Credits

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