



THE SOCIAL DIMENSION OF OPEN DESIGN

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ABSTRACT

The sustainability of the quality and rate of the design process has always posed challenges. Initial open design concepts evolved from the need for an even faster rapid product development process and the desire to have co-creative platforms. Innovative open design platforms and toolkits ensure a continuous interchanging of knowledge between many and diverse stakeholders from a community with a common vision. Companies continuously research social strategies to get volunteers' attention and keep their interest to contribute to the company's objectives. Doing this can create significant value for the company's customers and shareholders. Therefore, the objective of this research study was to understand the main reasons for contributing to these open design platforms. Both community- and company driven open design platforms were studied and; the benefits and challenges for utilising these platforms discussed. As a result boundary conditions were identified to exploit, without compromising the constraints of current design systems. Plans for further investigations are also given.

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1 INTRODUCTION

Sustainable design processes requires the reconciliation of environmental, social equity and economic demands. Numerous sustainability standards and certification systems are developed from these sustainability spheres, which are also known as the triple bottom line (TBL). Economically motivated design for manufacturing (DFM) and assembly (DFA) aligns the design process with the organization's manufacturing capabilities and assemble processes, needed to reduce operating cost and increase throughput. Environmentally, design for recycling (DFR) and disassembly stems from the pressure of recycling and refers to the product design that takes into account the ability to disassemble a used product to recover the recyclable parts. Eco design is also the incorporation of environmental considerations and is an extension of the other important economic requirements considered in the design process [1].

Social design relies on the premise that personal and social networking relationships and ties provide value to organizations in a network by allowing them to tap into the resources embedded within the network for their benefit [2]. Real economic value is created out of these new principles simply due to concurrent, mass collaboration where people are living, experiencing and expressing gradually more within digitally enabled social- and peer networks. The idea of open design systems is to change the way we construct knowledge around manufacturing itself, as the ability to generate new knowledge can play an integral role to stay competitive [3]. Throughout the 1980's Sony had an impressive track record for being innovative, but by the 1990's the company's engineers started to suffer from a damaging "not invented here syndrome". Even as competitors introduced next-generation products such as the iPod and Xbox the engineers were insular. As a result of their belief that outside ideas were not as good as inside ones, they missed opportunities in such areas as the MP3 players and flat-screen TV's. Therefore, a company's success should be increasingly based on knowledge-seeking and knowledge creation [4]. In today's highly competitive industrial environment, no individual can accomplish production tasks alone.

Collaboration is necessary at every technical and organizational level [5]. OD has its roots in the open source software movement, which is described in [6] and can be understood as a change in the value creation process [7, 8]. Open design, virtual-reality environments, digital collaboration as well as web 4.0 technologies allow customers to be more closely involved early in the product design cycle. OD means that all information, which is related to the product, is available without obstacles, as well as that the developer community is open to every interested participant [9]. It breaks up this traditional point of view and involves a community, which has free access to the knowledge of the company [10]. This level of openness can be influenced by various factors, including the level of proprietary information sensitivity, the purpose of the challenge and the decision whether the product is fit for the platform. OD is based on the principles of open source, network manufacturing and social networks in order to ensure sustainable development. This way leads to new methods for solving problems and accelerate the process of co-creation [11].

In the past the economy was not as sophisticated and organisations not as complex with the rapid changes and knowledge workers at the core. In the industrial economy, attention wasn't the scarce resource that it is in today's connected world [12]. Information was scarce, and so virtual communities pursued open hardware and software strategies that made vast amounts of information freely available. Open design also embraced these new ways of sharing information, ideas and risks, so as to create the most collaborative environment possible. It is becoming the norm in once traditional companies, where intellectual property and production capacity is shared among hundreds of specialized companies. Together, with the enormous boost from the Internet of Things (IoT) megatrend, the information generation succeeded in sharing ideas via rapid communication. At the same time it made human attention a scare commodity [12]. In the attention economy, it is critical to evaluate actions with regard to how much attention it consumes and how we can get people to contribute to



a company's needs. Still, it is critical to realize that an open design system can only become ubiquitous if a critical mass of elements is achieved. Research [12] suggests that one of the most important factors for gaining attention and keeping contributors' interest is engaging with the users' emotions. There are four linked lessons from psychobiology:

- Survival instinct are strongly present in everyone sub conscience - a contributor's attention can be gained through this natural reaction;
- Natural competitiveness is common across most people - open design platforms utilise this competitive urges that are part instinct, part cultural conditioning and eminently exploitable;
- Attention deficiencies leads to easy distraction - some platforms and toolkits exploit these distractions by offering to help users with their personal challenges; and
- Personal engagement encourages people to participate conscious - various open design platforms get people to invest something of their own, making them more committed than if they feel like observers. This co-creation dynamic also attract people to contribute.

Getting design communities to contribute to designs on open platforms and to keep contributors interest (stickiness) is crucial to stay competitive in the current corporate innovation field. Idea challenges adapt an idea suggestion system to be more competitive by rewarding successful value (from inside or outside) financially, or in other forms related to the organisation. Innovation networks also incorporate the input from a network of contributors in the form of solutions to identified problems, with the difference relating to the proposed problems. Whereas challenges are orientated to gain new ideas for innovations, networks are used to find solutions for more specific problems within a product design process [13].

Customer immersion platforms harness customers' inputs as to product requirements in a customer-product interaction process with the assistance of new technologies [13]. To succeed, companies must respond to changing customer needs and the move of their competitors [11]. The ability to identify opportunities co-creatively and bring innovative products to market effectively in an efficient way will enhance a manufacturer's competitiveness. Therefore, as shown in figure 1, desired products should be brought to market on the right time at the desired quality level. Managers naturally look first inside their own functional groups or business units for creative sparks as it is easier to understand what is available. The bigger sparks, they discover, are ignited when fragments of ideas come together - specifically, when individuals across units brainstorm or when companies tap external partners for ideas [13].

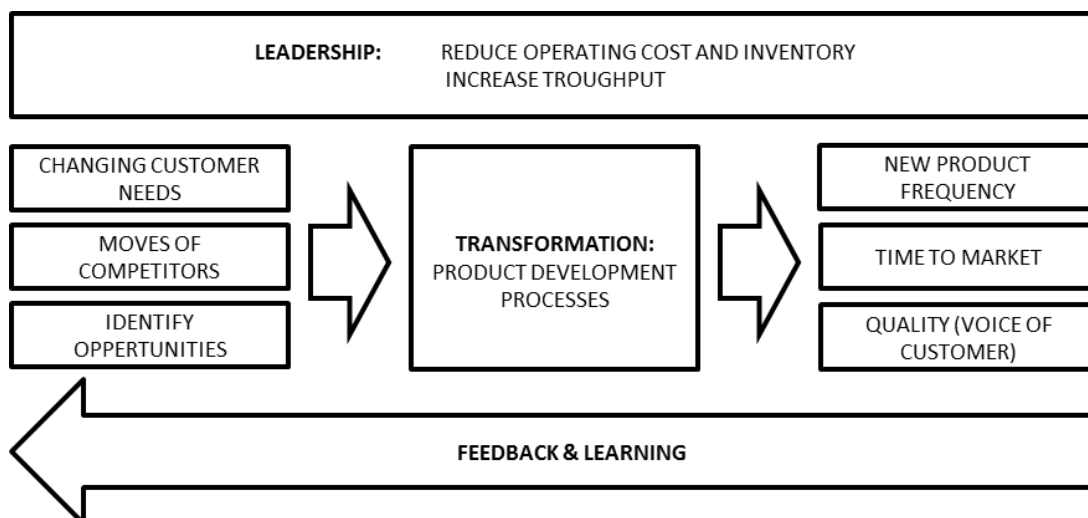


Figure 1: Measures of product development success (Adapted from [1])



Measures of product development success can be categorized into those that relate to the speed and frequency of bringing new products to market, to the productivity of the equal development process, and to the quality of the actual products introduced [1]. The time, quality and productivity define the performance of development. In combination with other activities like sales, manufacturing, advertising, and customer service the transformation process determine the market impact and its profitability [14]. When organisations decide to collaborate in open innovation, the level of governance and level of participation should be decided [15]. Platforming uses co-creation tools for developing and introducing a base product with the purpose of providing a basis for contributors to access and co-create more value as the creative exploitation part of the product is left to the imagination. Collaborative product design and development is the technique of increasing the importance and responsibility of suppliers' and customers' role in the product design process. Thereby, increasing productivity to the benefit firstly the organisation, and eventually the customer [13].

In this research the main reasons for contributing to these open design platforms were studied. Factors that contributed to keeping interest and capturing designers' attention were also investigated. Understanding the social dynamics of these platforms can help to increase the steady stream of new products to market in order to enhance the competitiveness of companies.

2 OPEN DESIGN PLATFORMS AND ENTERPRISES

Similar to the open source information revolution, open design platforms could eventually put the means to produce physical objects in the hands of every individual and community. Local Motors is the first disruptive entrant in the US automotive industry in decades, also applying OD principles. Co-creation and collaborative (peer) production of hardware is coming of age, and advanced production corporations are getting with the program as shown in Table 1. Open design creates opportunities for internal related work or with corporate partners to have seamless access to relevant information, transfer and share documents and to automate manual tasks that can accelerate processes and decision making. OD is also evident in China's growing motorcycle manufacturing industry. The approach has been so successful that motorcycle production has quadrupled from 5 million to more than 20 million vehicles a year since the mid-1990s, giving China about 50% of the global share [16].

Highly collaborative design and manufacturing ecosystems isn't unique to the motorcycle industry. Although the success is questionable, Boeing replaced its traditional manufacturing systems for the Boeing 787 Dreamliner, with innovative international collaborations. This modern aircraft consist of many specialized parts, sourced from hundreds of suppliers. For companies managing these cross-pollinating ecosystems of value creation, innovation is less about inventing and building physical things and more about cultivating and matching good ideas [17].

Value creation of Open Design cannot be described as a traditional process, where the consumer and the producer are separated from each other. Instead the consumer changes his role into a consumer with development competence (prosumer) [18]. The Open Design principle for value creation follows a bottom-up approach [19]. It is characterized by collaboration as a form of interaction between the actors. Due to the collaborative possibilities of amateurs, they are superior to single professional designers [7]. For the implementation of an open design project in particular open source web-based collaboration platforms are suitable. They are a subset of so-called computer supported cooperative work systems, which are typically used in the cross-company collaborations [20].

Web-based collaboration platform refers to computer-based work environments that facilitate collaborative work, especially in the unstructured and non-recurring tasks [21]. Furthermore, the product can be built in so-called open-access factories which are contacted via platforms (e.g. Alibaba). Open source software programs (e.g. Linux) give any

interested party access to the source code, leading to a distributed innovation platform in which users actively participate in the product's development thus enabling co-creation of value [11].

LinuxCNC has many features and brings a lot of new functionality (a flexible and powerful hardware abstraction layer that allows you to adapt it to many kinds of machinery, a software PLC controller and a new trajectory planner. LinuxCNC is precompiled with Ubuntu LTS (long term support) versions for ease of installation and longevity and is a descendent of the original NIST enhanced machine controller software, which is also in the public domain. Often free, OSS products are distributed under many public licenses, are more reliable, and provide greater flexibility and choice. The system also leads to fascinating competitive and cooperative relationships among companies and communities [17].

Table 1: Examples of open design platforms and networks

	Logo	Platforms	Website
1.		3DVIA.com	http://www.3dvia.com
2.		Sketchchair	http://diatom.cc/sketchchair
3.		SketchUp	http://www.sketchup.com
4.		Autodesk 123D	http://www.123dapp.com/
5.		Open Cascade	http://www.opencascade.org/
6.		Tinkercad	https://tinkercad.com/
7.		Blender	http://www.blender.org/
8.		eMachineShop	http://www.emachineshop.com
9.		Open Source Ecology	http://opensourceecology.org
10.	OpenStructures	OpenStructures	http://www.openstructures.net/

Recently, there are open design initiatives to provide open source hardware (e.g. Open Source Ecology). The idea of this platform is to provide license free product documentation to be downloaded for a do-it-yourself realization.

Open project management tools help people organise their work using cards on a virtual task board that the interface is easy to understand also exist (e.g. Kerika). Despite these success stories of open design platforms and toolkits, some platforms like the Design byMe experience form LEGO® struggled to live up to the quality standards for a LEGO service. As a result, the Design byME service was closed in January 2012 [22].

In order to define the various OD platforms better it were divided into design toolkits, projects, education and learning initiatives and enterprises.



2.1 Open Design Toolkits

3DVIA.com, also known as the 3DVIA Cloud, hosted online to provide a specialised 3D service, a suite of SaaS (Software as a Service) applications for interactive viewing specifically designed to help 3D professionals communicate, market and sell more effectively. SketchUp also helps people to model anything they can imagine, like to redecorate their living room, designing a new piece of furniture or to Re-model a city for Google Earth.

Autodesk 123D helps turn ordinary photos into extraordinary 3D models or to convert 3D models into cut patterns for creating build-your-own projects. Open CASCADE Technology is a software development platform freely available in open source and includes C++ components to model in data exchange, 3D surfaces, visualisation, and rapid application development.

Open CASCADE Technology can also be applied in development of specialized CAD/CAM/CAE applications. Blender utilises OpenGL for drawing all interfaces but is available across platforms.

2.2 Open Design Projects

SketchChair is an open-source software tool that allows anyone to easily design and build their own digitally fabricated furniture. The program allows users design chairs, structures is automatically generated and the stability can be tested, by using a simple 2d drawing interface. Open Source Ecology is an open source, cost effective technological platform with high performance and consisting of a network of farmers, engineers, and supporters that has been creating the Global Village Construction Set for the last two years. The 50 different Industrial Machines that it takes to build a sustainable civilisation which includes modern comforts allows for the easy DIY manufacturing in this Construction Set.

The OpenStructures (OS) project initiates a construction system where everyone designs for everyone. Exchange of experiences, parts, components and ideas serves as motivation to build things together is stimulated by utilising a shared modular grid and common open design principles in this on-going. Riversimple is a UK based Car Company, with a single goal of producing efficient vehicles for personal transport and Oscar's goal is to develop a car according to OD principles. WIKISPEED is a volunteer based, green automotive-prototyping company, working in a virtual, collaborative team of skilled individuals who volunteer time to creating cost effective, safe, road-legal efficient vehicles. WIKISPEED invests all money earned back into the company as a donation to assure movement forward with WIKISPEED's vision.

2.3 Open Design Education and Learning

Tinkercad enables people to enjoy learning about design and 3D printing, as one can work collaboratively either with close friends or as part of the community. eMachineShop's open CAD software is also developed specifically to ease learning. The software commands are included for the automation of quotation, ordering, the creation evaluation of designs. Time and money can be saved because expensive engineering support is minimised due to the fact that feedback and advice is instantly provided via a built-in automated analysis tools. Adafruit was created for online learning of electronics and making the best designed products for makers of all ages and skill levels.

2.4 Open Design Enterprises

Local Motors is a crowd-powered automotive design, distributed manufacturing and technology to enable the creation of potential game-changing vehicles. Local Motors helps solve local problems, locally through open-source principles, by making transportation more

sustainable globally; and utilises innovative distributed manufacturing to co-create vehicles and components with its virtual community of role-players around the world.

Arduino is an open-source electronics prototyping platform based on user friendly, flexible, software and hardware. Arduino programming language (based on Wiring) and the Arduino development environment (based on processing) uses the microcontroller on the board for programming. SparkFun is an online retail store that sells the bits and pieces to make your electronics projects possible.

Innovation of organisations in the rapidly-growing *Internet of Things* (IoT) market is aspired by Bug Labs, a cloud-based platform. It abstracts the raw functionalities (e.g., sensors, actuators, transceivers) of any hardware device and exposes them as web services. No matter how heterogeneous hardware is the simple drag-and-drop design of the application helps to overcome this challenge.

3 EXPERIMENTAL APPROACH

The objective of this research study was to understand the main reasons for contributing to these open design platforms. This research was divided into different phases as illustrated in Figure 2. The first step constituted of a thorough literature study on sustainable manufacturing and open design.

Several case studies were studied in order to understand the various tools found on these platforms and; also their respective social integration. This evaluation helped to understand which platforms and toolkits to use during the different phases of the product development process.

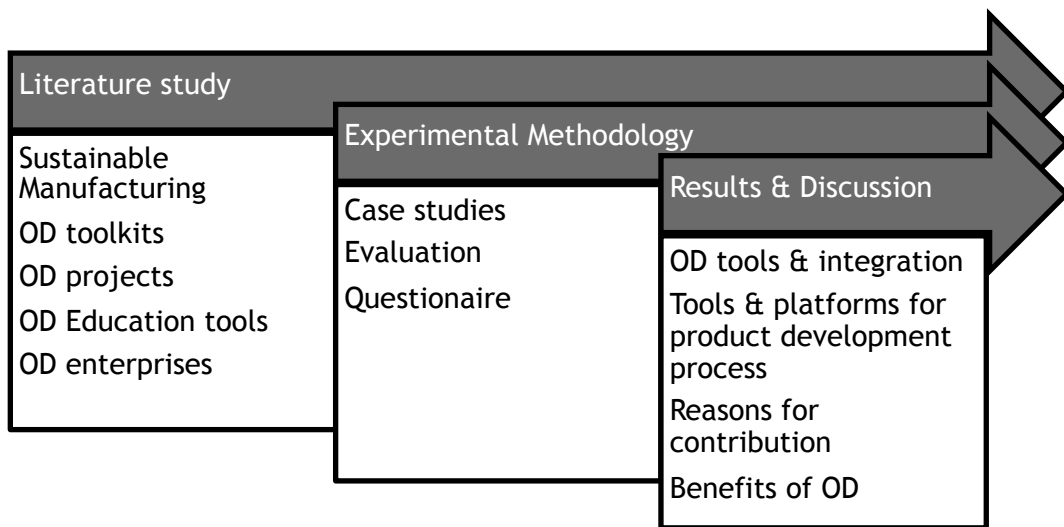


Figure 2: Experimental approach followed to better understand the dynamics of open design

Thereafter, a questionnaire was conducted with a group of fifty net generation (contributors born after 1981) open design users to understand the benefits of using open design. The main reasons behind contribution to these open design platforms, together with the benefits that open design poses were studied. Both community- and company driven open design platforms were studied and; the challenges for utilising these platforms discussed.

4 EXPERIMENTAL RESULTS AND DISCUSSION

In order to gain the competitive advantage, companies optimise research strategies to get volunteers' attention and keep their interest to contribute to the company's objectives. The main reasons for contributing to these platforms are illustrated in Figure 3. Most of these open design platforms offer no financial compensation to the contributors. Rather, most of

the contributors rely on practical solutions which are freely available; or intrinsic motivated social rewards.

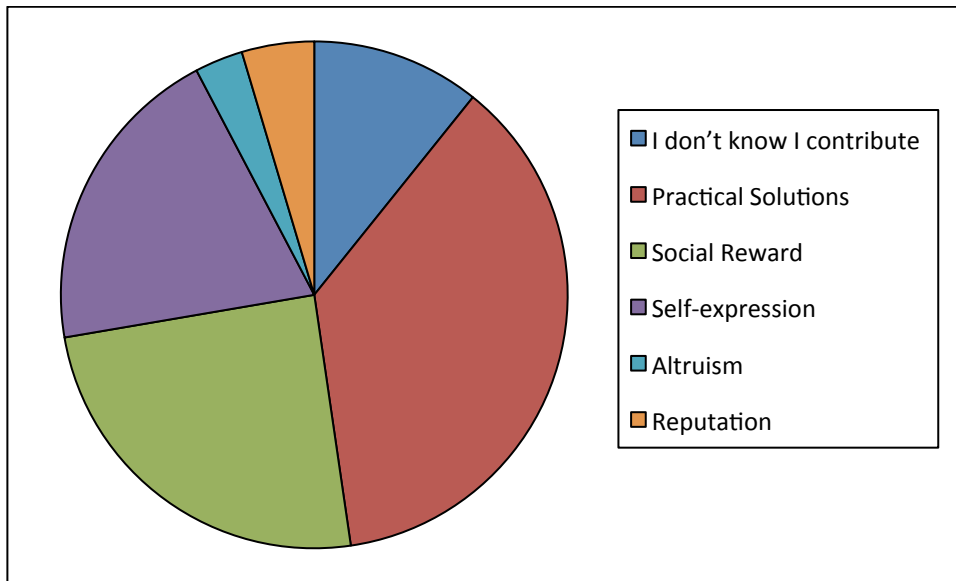


Figure 3: Reasons for contribution to open design platforms

Some contributors enjoyed participation to express themselves and exhibit skills, while few were unaware that they contribute; or simply want the truth to be heard. Most contributors use open design platforms due to the rapid product development process as shown in Figure 4. Overwhelming of the understanding that the net generation have a collaborative approach to design solutions, contributors find it beneficial to capitalise on the knowledge of others rather than redesigning the wheel.

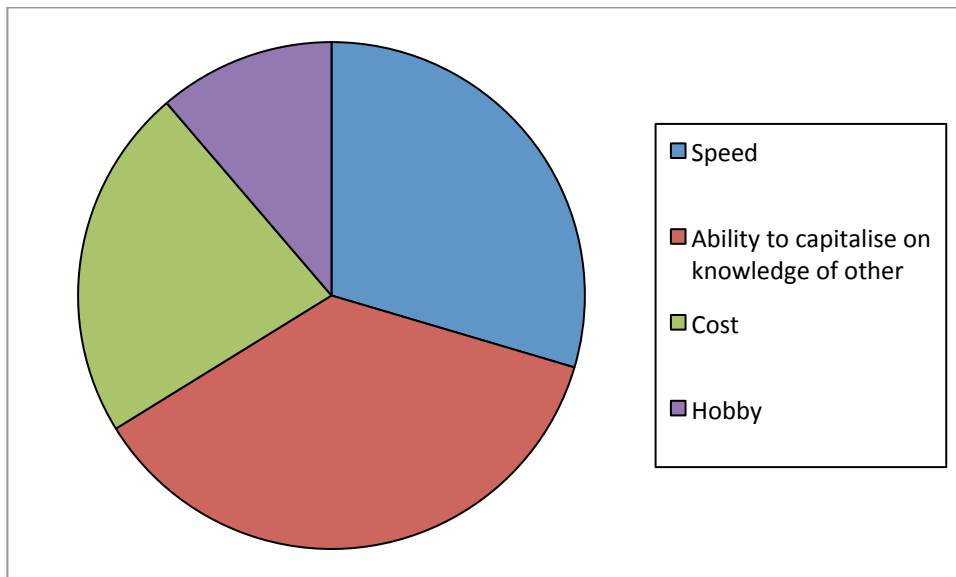


Figure 4: Benefits of open design

The most popular open design platforms and toolkits according to the selected group of users are illustrated in Table 2. These open design platforms and toolkits were evaluated to understand the tools and social integration used to get attention and ensure contribution. The free computer-aided systems (e.g. CAD/CAM) help users to modify existing designs or create new ones. The bill of materials signifies a freely available list of materials required for the specific product.



Table 2: Tools and integration of open design platforms and networks

Platforms	Free CAD/CAM software	Product bill of Materials	Videos & Education	Social Network integrated
3DVIA.com	x		x	x
Sketchchair	x		x	x
SketchUp	x		x	
Autodesk 123D	x		x	x
Linux CNC	x			
Open Cascade	x		x	
Tinkercad	x		x	x
eMachineShop	x		x	
Open Source Ecology	x	x	x	x
Local Motors	x	x	x	x
Wikispeed	x	x	x	x
Riversimple		x		
Oscar	x	x	x	x
OpenStructures	x	x	x	x

Some platforms offer educational videos and training on their respective websites in order for users to familiarise themselves with the features of the specific platform. In most instances the design platforms is attractively integrated with social networks for increased visibility.

Most of these platforms use a concurrent engineering approach to unite design- and manufacturing contributors early in the design phase. Thereby, these platforms collaboratively drive the product development process shown in Table 3. After studying these platforms it was possible to group them into specific phases of the product development process.

Table 3: Examples of platforms along the Product Development Process [23]

Idea generation & challenges	Concept development	System Level Design	Detail Design	Testing and refinement	Production ramp-up
IdeaCONNECTION InnoCentive MycroBurst	Autodesk 123D 3DVIA.com Tinkercad SketchUp	Linux CNC Open Cascade	Sketchchair Oscar Riversimple OpenStructures	Arduino Adafruit Buglabs DIY DRONES	eMachineShop FabLab MakerBot Industries Alibaba

In the idea generation and challenges phase, platforms like IdeaCONNECTION and InnoCentive can be used. MycroBurst is also a community of graphic and logo designers from around the globe who can compete on new design challenges as competition drives results. Autodesk 123D, 3DVIA.com, Tinkercad and SketchUp are typical platforms for use during the concept development phase, while the eMachineShop and FabLabs can be used to ramp-up production.



5 CONCLUSION

Both community- and company driven open design platforms were studied and; the opportunities and challenges for utilising these platforms discussed. Most open design contributors rely on practical solutions or social rewards. The benefits of open design platforms include the speed and co-creation benefits. The biggest challenge still remains the quality standards set by the voice of the customer. Future open design investigations will include the economic dimension behind these platforms.

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