

A Survey of Open Source Hardware Developers - Perspectives on Digital Platform-Based Product Development

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Abstract. Shifting priorities toward sustainability, longevity, and individuality necessitates adapted value-creation concepts. One promising approach to address these needs is adopting openness in product development. In line with the *Open Design Paradigm*, the aim is to make the technical documentation accessible to everyone and modifiable, indirectly turning the resulting product into Open Source Hardware (OSH). In this way, the knowledge of many can be pooled, and new innovations can be created. However, OSH frequently suffers from inadequate documentation. To enhance the quality, a reorganisation of product development processes could be beneficial. This may involve the adoption of novel methods and collaborative processes. One promising approach is the implementation of ideation contests, which allow participants to publicly share their ideas and receive early-stage feedback and community ratings. However, the question ensues: What is the subsequent course of action when current platforms seem incapable of integrating established knowledge about product development processes and existing collaborative methods appear to fail? As part of a research project, over 40 participants of an ideation contest were surveyed on *Product Innovation*, *Product Development* and *Product Processing*. The results will be presented in this article to provide a better understanding of the requirements and needs of developers for the structure of platforms for digital collaborative development.

Keywords: Open Source Hardware, Co-Creation, Ideation, Open Innovation

1 Introduction

1.1 Background and Motivation

The way in which new products are developed and innovation processes take place is experiencing a transformation [1]. Digitalisation profoundly influences all aspects of product engineering and is transforming the framework of collaboration mechanisms [2]. Software developed for efficient and comprehensive digital collaboration enables approaches to co-create innovative and new products [3]. Whether purely out of personal conviction or as a dedicated hobby, this approach suits amateur enthusiasts and committed practitioners [4]. Open Source Hardware (OSH) is seen as a promising concept for changing the way product development is organised in the future. In this

context, the exchange of knowledge between specialised production knowledge is also being investigated to positively influence production at an early stage [5]. Consistent with the principles of *Open Design*, developing products openly and collaboratively leads to creating OSH [6,7]. Studies indicate that open and collaborative approaches to product development can provide substantial competitive benefits compared to companies operating in traditional hierarchical structures [8]. Recent advancements in OSH development, such as the collaborative creation of *Open Source Magnetic Resonance Imaging* [9], demonstrate that even highly complex systems can thrive in such an environment.

1.2 Objective of Research

Improving OSH technical documentation can be achieved through the implementation of various collaborative activities. One is the integration of ideation contests, where participants share their ideas with the public, receive feedback for improvement, and undergo a community-driven rating process. Only ideas deemed valuable by the community advance. This can benefit marketing aspects on the one hand and positively influence quality on the other. In this scenario, according to the Product Life Cycle, the ideation contest becomes the initial step in the product development process. This raises the question of how the process should ideally be structured to enhance output quality at each stage of the OSH product development process. Looking at the industrial sector, the current trend is towards highly agile development processes with lean workflows and an iterative exchange of knowledge across all phases. Moreover, it appears unrealistic to anticipate that small teams of decentralised developers can successfully implement processes designed for industrial applications. Taking a closer look at where OSH product development takes place in the digital sphere today reveals that it is commonly on platforms originally conceived to develop open source software (GitHub, Gitlab or Airtable). These platforms bundle billions of software repositories, and many very successful software applications have already been created there. This gives rise to the hope that a smart layout of platform processes will positively influence OSH development in the future. In the research project **Production Next Door**, requirements for such OSH development platforms are investigated to answer the research question: *What expectations do participants in an ideation contest have regarding the further development of their idea and its commercialisation on digital platforms?* To this end, over 103 participants in an ideation contest were invited to take part in a survey, over 40 % of whom submitted a complete evaluation on **Product Innovation**, **Product Development** and **Product Processing**.

2 Thematic Framework and Method

2.1 From Open Design to the Principles of Ideation

Open Source Hardware (OSH) is currently available to the public, offering extensive applications and opportunities. The founding dates back to the *Open Source Hard-*

ware Certification Programme [7] in 1997 and the advantages (wisdom of the many, avoidance of redundancies) of open source designs were already recognised two years after the *Open Design Foundation* was founded. With the *OSH Definition 1.0* from 2011, a first attempt was made to describe the concept of OSH in general terms [7]. This definition is still the basis for today's understanding and for the DIN SPEC 3105, an attempt to provide a guideline for OSH [11]. According to that norm, certain information must be defined. The authors of technical documentation must be clearly identifiable, and it is necessary to specify valid licence conditions for the use and reproduction of a design. Most publishing platforms for object-based artefacts were founded in the late 2000s, when the integration of digital technologies drove the digitisation and accessibility of software and computers. Since then, many platforms on which OSH is published today have followed, as SAUBKE et al. (in print) showed in a more extensive study [10]. The study shows that around 82% of object-based artefacts that are published on the web with the aim of reproduction have open source certification or open source concepts are officially advertised on the respective digital platforms [10]. From this, we can deduce that some developers release their models and documentation without using a valid open-source licence. In order not to "lose" this 18 %, the term Open Hardware (OH) will be used throughout instead of OSH.

In the innovation cycle, idea generation is the first step towards product development. It refers to the creative process of developing and formulating ideas [12]. At this critical point, the risk assessment, benefits and potential market success must be precisely evaluated. These tasks can be delegated to the community through ideation contests. Ideation contests offer an opportunity in a new value creation scenario for individuals (e.g. inventors, innovators) who are not embedded in the protective structures of a larger system (e.g. an innovative company) to become part of new product creations. Voting procedures quantify the actual need for a new solution, minimising the risks associated with the further development of a potentially unsuccessful idea. Ideation contests also facilitate networking and enable potential collaborations, which is perfectly in line with the goal of developing OH. Through transparent selection and evaluation, these competitions provide a fair platform for all and are crucial for future innovation in the field of OH.

2.2 Methodical Approach – Introducing the Survey Structure

This research is based on an online survey of OH developers, conducted by soliciting opinions from participants of an ideation contest. The objectivity of the survey should be maximised by asking neutral questions; to this end, the items were asked precisely and without the use of highly suggestive formulations. Completing the survey was not mandatory and was optional for all those submitting ideas. The survey is thus orientated towards the standards of scientific surveys and considers aspects of research ethics and quality. Therefore, the participants' autonomy should be ensured. The voluntary nature enables participants to exercise their freedom of choice without pressure or coercion. Voluntary participants are likely to be more motivated to give honest and thoughtful answers, which improves data quality. Furthermore, this approach is intended to increase the results' validity and ensure that a more natural se-

lection of responses and behaviours is incorporated into the knowledge creation process. Additionally, the survey uses a five stage likert system consisting of multi-level items (item batteries) where respondents can agree or disagree on a graduated scale. The responses to these items can be added together to produce an overall score. In the present survey structure, a symmetrical system was selected in which the intervals have equal weighting. The number of possible answers is five and therefore odd, so no decision is forced. The survey itself is divided into four parts.

In the initial part of the survey, called **Participant profile**, the questionnaire design aims to characterise the idea providers. It focuses on the participants' demographic information, their professional experience and background. This part is followed by a scale survey using a five stage likert system, it includes three aspects of the brighter topic of value creation. Each Aspect is specified by three characteristics. The characteristics are further subdivided into three to six likert items (e.g. sub-questions).

With **Aspect I. – Product-Innovation** the aim is to find out more about how the idea providers position themselves in the topic area of innovation. The characteristics of **Product Innovation** are aligned with the following key questions: Do goals such as profitability or the degree of innovation play a role in the development of an idea? What is the respondents' understanding of the topic of innovation? The three characteristics of **Product Innovation** surveyed are as follows: *Product Innovation – Mindset*, the *Product Innovation - Community* and the *Product Innovation – Steadiness*. Each of the three characteristics is assigned by three to six different likert items.

With **Aspect II. – Product Development**, a deeper understanding of the attitude of the idea providers with focus on **Product Development** shall be gained. The analysis focuses on specific characteristics to determine how the participant understands the product and its development process. It also examines whether objectives such as design and potential user value influence the development of an idea. These questions aim to provide a deeper understanding of the perspectives and priorities of the idea contributors. The characteristics surveyed in this aspect are: *Product Development – Mindset*, *Product Development - Finalisation* and *Development – Alignment*.

With **Aspect III. – Product Processing**, the aim of the study is to find out more about the attitudes of idea provider towards product development. The study focuses on specific characteristics of **Product Processing** and is based on several key questions: How does the community understand the product and the associated development process? Goals like design or potential added value for the user are considered during the ideation process. The three characteristics surveyed are as follows: *Product Processing – Mindset*, *Product Processing – Access* and *Product Processing – Awareness*. ([Complete survey via Mendeley, DOI: 10.17632/5xrj4ppvw3.2](#))

3 Presentation of the Use Case and Survey Results

3.1 Ideation Contest 'For Future Furniture' by Production Next Door

PRODUCTION NEXT DOOR is a platform for the demand-orientated local production of goods. The platform's start is planned for late 2024 and the initial focus is on produc-

ing furniture. For this reason, a production network has been set up in the furniture industry in the greater Hamburg area. The value chain is reorganised with every order and thus reacts dynamically on demand, prioritising producers in close proximity to the customer. Prior to this, global developer communities are involved in the product development phase on the platform. In line with the trend towards community-driven product development, co-creation application mechanisms such as crowd sourcing for idea generation are implemented in the platform's internal product development process. An initial ideation contest named *FOR FUTURE FURNITURE* has therefore already been successfully held and product development is underway. The developers (designers, engineers, inventors, etc.) join forces in temporary digital development teams. The full process is shown in *Figure 1*. During the process of furniture production, local production capacities are combined in dynamic networks, with a platform-based system creating intelligent, demand-orientated value chains. The ideation contest FOR FUTURE FURNITURE inherently incorporates market analysis by engaging a large crowd of potentially interested individuals (potential customers) to vote for the best ideas using a digital tool called VOODLE [14]. Firstly, there is a submission phase followed by a community evaluation phase, and finally, an expert jury selection. Most of the ideation contest took place in 2023; the submission deadline was reached in February. The contest structure meant that anyone could participate in the competition. A total of 103 ideas were submitted; all have been published under an OSH license, and the participants have already been confronted with the OH concept. All participants had the opportunity to complete the questionnaire upon submission [15].

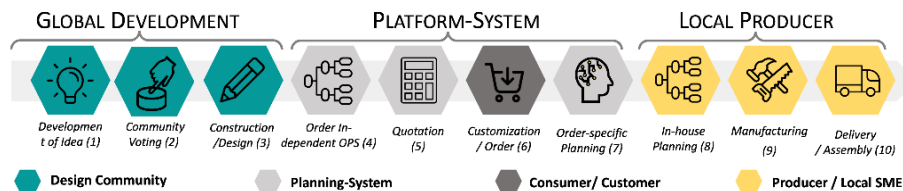
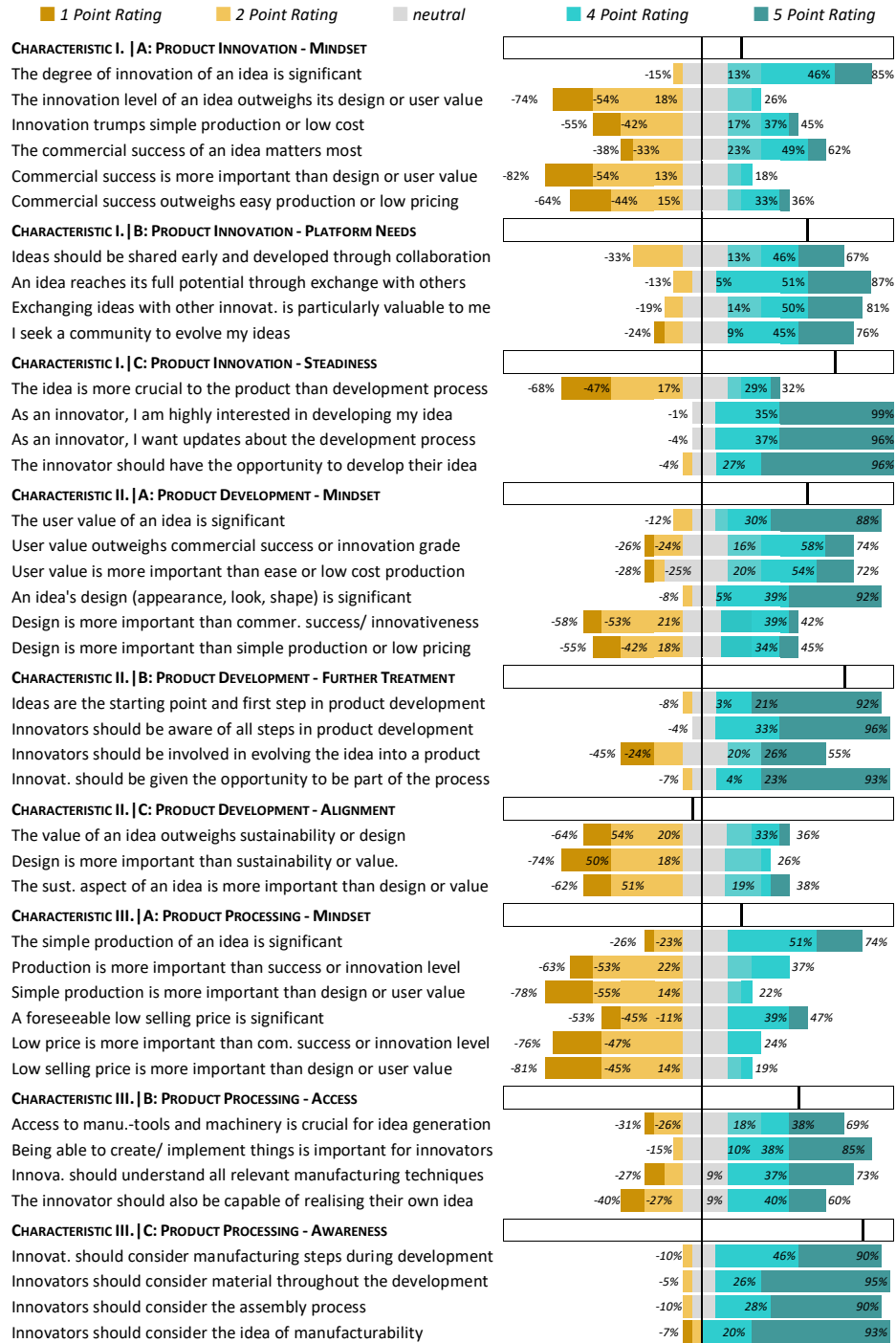


Fig. 1. Visualisation of the simplified platform-based value creation process of Production Next Door.

3.2 Results of the For Future Furniture Participant Survey

The individual responses on a Likert scale are added up to determine an overall value or Likert score for a particular characteristic. Those results are metric (interval-scaled) and can be statistically analysed. A rating of 5 means high, and a rating of 1 means low agreement. A total of 40 complete surveys from the participants were registered. A complete survey is characterised by the fact that more than 90% of the questions were answered, in this case more than 36 of the 41 Likert items had to be completed. First, the results are presented, and the lessons learned for the context are derived from it. The survey covers several sub-areas. This analysis does not delve into the participants' profiles. A more detailed examination will be conducted once the survey results from future competitions are consolidated, enabling more robust conclusions to be drawn from a larger dataset. The items in the table have been shortened.

Table 1. Characteristics, items and survey results.



4 Discussion

Starting with the **Aspect of Product Innovation** and the characteristics of *Product Innovation - Mindset* the participants value the degree of innovation in an idea, but they do not believe it is more important than design, which is expected in a competitive environment like furniture design. Additionally, topics related to commercialisation show a divided result and lead to controversy among respondents. While commercial success is generally considered the most important factor in evaluating an idea, design remains critically important. In the area of *Product Innovation - Community*, it is evident that many innovators appreciate early idea exchange and believe discussing ideas within the community should be encouraged. In *Product Innovation-Steadiness*, a majority of innovators feel that the product development process is crucial, even more so than the initial idea. Detailed responses reveal a strong desire within the community to be involved in the entire development process of an idea beyond just the ideation stage.

Regarding the **Aspect of Product Development**, there is a strong emphasis on user value and design in the *Product Development - Mindset*. It also becomes apparent that respondents consider commercial orientation less relevant. In *Product Development - Finalization*, participants expressed a desire for more involvement in the idea development, which is consistent with findings in *Product Innovation-Steadiness*. In *Product Development - Alignment*, participants were asked about their willingness to prioritise sustainability criteria in the value creation system, to which they agreed.

The third **Aspect of Product Processing**, concerning characteristics in the later stages of product creation, reveals that while simple production is valued, it must defer to other characterising factors like design. A higher price is tolerated for superior design. In *Product Processing - Access*, most respondents show a tendency to develop personal know-how in production or to be supported through the production process. Many recognise that access to production capabilities is crucial for developing ideas. In the *Product Processing - Awareness* characteristic, there is strong support for the general importance of knowledge about manufacturing technologies and processes.

The survey results of the **Aspect Product Innovation** clearly show that the participants see innovation and design as key drivers. Due to their importance in the evaluation, those aspects should continue to be emphasised through additional monetary rewards and honouring individual achievements. Innovation, in particular, could be considered as a new category for an awarding track. Furthermore, it can be deduced from the results that there is a desire for early exchange, which suggests the integration of mechanisms in the ideation contest that go beyond a mere comment function. The comment function implemented in the digital tool was rarely used, which indicates that it may not be the right tool for this community. One possible solution could be to implement a mandatory statement on ideas that have already been submitted in order to promote mutual exchange and peer review principles. The distinct traits of the characteristic *Product Innovation - Steadiness* underscore the need to grant idea providers a unique role in the ongoing development of ideas to ensure successful product development within open communities. MORITZ (2023) further developed and confirmed in his work the significant role of lead solvers in such an innovation envi-

ronment [16]. The participants tends to overvalue design and user value, while commercial success is often underestimated. In the future development of associated platform processes, mechanisms should be introduced to incentivise innovators to consider commercial success factors. Regarding the production process, it is confirmed that respondents favour a production process that is as simple as possible but not at the expense of the design. Therefore, the platform must promote producibility through specific mechanisms. These findings also confirm the desire for widespread access to manufacturing capacities, as envisioned by the FABCITY. The characteristics of process awareness show that almost all participants consider extensive knowledge of assembly and processes to be necessary. The extent to which this knowledge is supported by the assessments of the expert jury and how expertise can be effectively promoted and implemented needs to be examined.

5 Critical Analysis and Outlook

In this article, the evaluation results of 40 participants of a high-quality ideation contest with 103 submissions around 5,000 individual voters who cast 50,000 votes. The evaluation shows a clear difference in opinion among the participants. The proportion of neutral assessments is low. The primary finding of the survey indicates that commercialisation and producibility factors are accorded less significance than is typically observed in the industry. This suggests that within the Open Hardware (OH) context, traditional management and corporate governance functions must be executed by an intermediary (e.g. platform operator) or through innovative digitised development processes.

It should be noted that this study was limited to a number of 40 respondents from a single ideation contest. This survey represents only a small fraction of the global community of Open Hardware (OH) users and their participants in initiatives in the field.. A positive aspect of the contest was the diverse geographical spread of the participants in german speaking countries. To obtain a more comprehensive understanding and to improve the representativeness of the outcomes, further surveys are planned for future ideation contests. These are intended to provide deeper insights into the use and perception of Open Hardware (OH). The evaluation has revealed or confirmed various trends in the desires and needs of the community. As a next step, we will thoroughly review the results and the linked evaluation data from community votes and expert ratings. Additionally, all statements regarding the professionalisation levels of participants must be considered in further studies to determine if there are differences in the mindset of the participants related to their experience and how this impacts their success in the contest. This could lead to distinctions in the structuring of development processes on platforms for digital collaboration. The answer to the research question thus contributes necessary insights into the mindsets of people participating in OH creation that will allow the future optimisation of the digital, collaborative, and platform-oriented product development process. This will, in turn, further the overarching goal of increasing the producibility of Open Hardware (OH).

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