Rethinking User Experience Design: Sustainability in the Context of the User Centered Innovation Process in Power Tool Design

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Abstract. Sustainability is becoming increasingly important in product development: both for the manufacturing companies and for the users, who are increasingly questioning the product and its origin. While sustainability is recognised as a strategic factor in many companies, the focus in the operational process is still mainly on desirability, feasibility and profitability, while sustainability is not firmly anchored in the various process steps and thus not effectively operationalised. The aim of this research work is to develop a process that integrates sustainability as a common thread throughout the product development of power tools. For this purpose, a case study at Bosch Power Tools with 10 guideline-supported expert interviews and a workshop with 8 experts shows what requirements are placed on such a process and what such a process should ideally look like. The result is a multi-stage model that integrates the relevant sustainability aspects and thus makes them comprehensible and measurable for practitioners in innovation, design, and product development in medium sized and large organisations.

Keywords: Sustainability, User Experience Design, User Centred Design, Innovation Process, Power Tool Design, Eco-Design

1. Introduction
User-centricity is increasingly becoming one of the key factors in product development, including the development of power tools, where functionality, ergonomics and design details influence the everyday life of craftsmen. At the same time, sustainability in product development is becoming increasingly important: both for the manufacturing companies and for the users, who are increasingly questioning the product and its origin. The motivation of the present study is to anchor sustainability in the field of user-centred product development and thus into the daily operative work of designers and developers. An approach to analysing and defining the influencing areas is exemplified by the case of Robert Bosch Power Tools GmbH. The aim of this paper is to provide a procedure for process development that supports organisations in identifying company-specific factors for sustainable product development and facilitating dialogue between decisive stakeholders.
2. Background of study

2.1. User Centred Design

The basis for this research is the design thinking approach, which is an approach to complex problems [1] using the tools and thinking of designers to analyse and ultimately solve problems step by step [2] (see Figure 1). This process goes far beyond the classic design principles (shaping and designing), putting the technical solvability of the task behind the needs of the user, which often opens up new avenues. By using a 6-step process [3], a team sees through the eyes of a user and understands how they interact with the product or their problems with it, so that lessons can be learned for the rest of the process. [4] This process represents a recurrent iteration between the predefined target group and the development team, consisting of multidisciplinary experts. [5] Consequently, a DVF diagram (Figure 2 and figure 3) exists for this purpose in the development, which represents an equally defensible picture of the user, the market and the company's intentions. Only through an equal overlapping and inclusion of these three topics can one speak of innovation. The degree to which these three goals have been achieved is one of the most important indicators of a project's maturity. The respective maturity level can help to choose the right next steps in the product development process depending on the situation. [6]

2.2. Maturity Assessment Processes

In order to determine and monitor the maturity level across project phases, a predefined questionnaire with weighted questions on each of the three objectives is required in practice. Each question can be answered with a graded rating (from 'strongly disagree' to 'strongly agree') and explained in writing with
a subsequent explanation. Through this process, a project team understands the level of knowledge of the project stakeholders and can use the subsequent result to weigh the project effort for the department and its prioritisation (Maturity Assessment). Interaction between the teams is encouraged and clear work packages can be defined. The individual topics and their subgroups are explained in more detail below [7]:

- Desirability: the first set of questions in the questionnaire deals with the desirability of the product in customer terms. The questions discuss the level of knowledge about the target group and the impact that the product is ultimately intended to have.
- Viability: The second set of questions deals with the economic context. It asks what the cost implications will be, how closely the product fits with the company's strategy and brand, and how well known is the market in which the product will later be sold.
- Feasibility: The third set of questions deals with feasibility, taking into account the state of technological knowledge. It helps to ask how the development of the technical parts is estimated and whether parts from other product areas are to be taken over.

These questions follow an already anchored sequence in the development process, which are defined as Goals of a Gate and thus record the progress for the participants in order to establish a homogeneous picture for all involved. (see figure 4, Stage Gate Model)

![Figure 4 Stage Gate Model and the possible impact [6]](image)

2.3. Sustainability in Businesses

While sustainability is recognized as a strategic factor in many companies [8], the focus in the operational process is mainly on desirability, feasibility and profitability. Here, sustainability is not yet firmly established and therefore not effectively implemented in the various process steps. The reason for this approach is that sustainability is an overarching issue and thus cannot be established in the processes without additional effort. [9] To prevent the danger of greenwashing, corporate sustainability [10], which is summarized in various constellations, comes into play here. According to the triple bottom approach [11], the focus is on all three fields of social, environmental, as well as economic aspects. The integration between these aspects is emphasized with approaches such as eco-efficiency (integration of environmental and economic aspects), socio-efficiency (integration of social and economic aspects), eco-justice (integration of social and environmental aspects) and integrative sustainability (integration of social, environmental and economic aspects) [12].

2.4. Eco-Design

Eco-design combines economic and design relevance to create a more sustainable product across the board [13]. To support manufacturers in this process, tools such as life cycle analysis (LCA), Simapro, Ecofaire and Ecodesign Pilot exist [14]. Criticized here is the "jeopardy approach", which provides answers, but to which one must first think of the right question [13]. This makes the more natural approach to sustainability implementation not to give the right answers before the question is asked, but to work out the answer in an interdisciplinary way with the right questions at the right time. This approach not only elevates the idea/innovation to a higher level, but also gains greater acceptance among all stakeholders [15]. Requirements can be a major lever for integrating sustainability into design. [16] Sustainability Policy, Scope and Capability are often systematically anchored for requirements definition, while Process Implementation and Sustainability Criteria Selection Approach are often not
strategically addressed. [17] A similar picture is seen in Sustainaible R&D portfolio assessments: here, environmental, social, and ethical values are included in portfolio development. [18] In order to design the individual products of the formed sustainable portfolios also sustainably, further steps are needed to operationalize them in the design process and to adapt the specific criteria to the industry and product area. There are already some industry-specific criteria catalogs for sustainability criteria in design, e.g., in the automotive industry [19]. Here, influencers in the engineering, production, use, and end-of-life phases are classified according to their relevance as suppliers, departments, or customers to be considered more or less strongly. However, a transfer of such findings to other industries and product areas, such as the power tool area, is only possible with restrictions, because the technologies used differ fundamentally in some cases. At the process level, the state of research paints a similar picture: While existing Eco Design processes promote the integration of sustainability into the phases Need Identification, Functionality Detailing, Specification, Prototype Development and Validation [20], the phase of "Detail Development" is partly not researched or not always operationally applicable. This paper addresses this gap.

2.5. Sustainability in the Context of User Experience
Both users and organizations are becoming more and more aware of their responsibility for a sustainable world and are increasingly agreeing on basic rules of sustainable consumption [21]. Since the user experience department is an essential tool in product development at Bosch Power Tools, this defines itself as one of the possible levers for the implementation of sustainability. Another factor here is the development department itself, which strongly influences the specifications and thus also the sustainability of the final product through its specifications. Factors that influence the life cycle assessment are defined by the resulting product, the type of materials and their use, as well as by the manufacturing process. It is also important to understand what exactly the customer understands and perceives by sustainability, whereby existing market research was analyzed and consulted as a basis for the hypotheses. The possible influencing factors, which were defined as hypotheses for the later round of interviews, are shown in figure 5 (phase 1).

![Figure 5 Possible factors influencing sustainability in departments](image)

3. Method
The approach of the study includes an alternation between diverging and converging phases which is called a “double diamond approach” [1] (see figure 6). At the beginning, the internal processes, the state of knowledge about sustainability, the possible tools, the users and sustainable company models are examined in the understanding phase (phase 1). This is followed by a comparison with the company's
own goals, which is the basis for the first idea phase (phase 2). Through interviews/workshops with stakeholders, these initial ideas are interrogated and iterated. With the newly gained knowledge, the second idea phase follows, in which the topic areas are narrowed down (phase 3). Finally, iterative testing follows in order to adapt the results to the company environment (phase 4).

The concept for integrating sustainability into the process is presented in a case study at Bosch Power Tools in several stages: In phase 3, 10 guided expert interviews and then, in phase 4, in a workshop with 8 experts. In phase 3, the elements relevant to sustainability are collected before they are clustered and prioritized in phase 4. A stakeholder mapping is set up to define the relevant communication partners (see table 1 and figure 7).

| Position in Organisation                                      |
|---------------------------------------------------------------|
| 1. Excellence Owner Communication                           |
| 2. Excellence Owner Sustainability                          |
| 3. Sustainability Manager                                    |
| 4. Product Owner – Group 1                                   |
| 5. Excellence Owner User Experience Design Team              |
| 6. Business Owner                                            |
| 7. Product Owner – Group 2                                   |
| 8. Packaging Engineer                                        |
| 9. Communication Owner                                       |
| 10. Engineering Owner                                        |

The hypotheses are presented to the experts and discussed. The results of the study are shown in figure 8 (prioritized elements on white background).
4. Results and Discussion

4.1. Ideation: Generation of Topics
The results of the first round of interviews opened up new topics, but also ruled out other hypotheses, allowing them to be more sharply defined for the following workshop. Based on this diagram, the information is divided into categories and the individual statements are sorted. Here, too, the information is marked so that it can later be assigned to the source from which it originated. The wishes and suggestions are also recorded in order to question in the later workshop what relevance the topics have and whether they have a reason to be included in the later questionnaire on the maturity level. From the "clusters" (sorting by information content), learnings are mapped. These are introduced with the sentence "I learned that..." and filled in based on the findings. This opens up the opportunity to summarize each cluster in two to three short sentences and communicate them in a simple and understandable way.

It is equally important to also include the topics that proved not to be feasible for the target group in the interviews and to present them in the workshop. This creates the opportunity to discuss the exclusion of a topic not on the basis of an individual's opinion, but also with the expertise of the workshop participants.

4.2. Workshop: Rethinking the Elements
For a better understanding and onboarding of the participants, a first draft of the possible questions for each topic is prepared (see Figure 9).

In the workshop, not only are assessments of the respective possible effects on the proposed elements of sustainability collected, but new aspects can also be included. The participants of the workshop are experts of the user experience design department as well as experts of the sustainability department, which are thus essential for the final elaboration of the questionnaire. In particular, 8 additional elements
are condensed in this collection of additional aspects. In the workshop, each topic was critically examined and defined on the basis of the questions already developed. Following the basic task, the topics that emerged in the various interviews are presented and discussed against the background of the high relevance of the topics for the individual participants. After the workshop has been completed, it is possible to use the iterated questions to adapt them to the relevant topics and to fit them into the existing question catalog style. It is important to find generally valid questions that can be applied to the various products as well as to processes in order to make it usable throughout the organization. The newly iterated questions open up new subject areas and also refine their answerability for MAs. These are summarized in Figure 10. The list of topic areas that emerged from the workshop is shown in Figure 11.

Figure 10. Additional aspects of sustainability identified by the expert group

Figure 11. Final collection of clustered and prioritized elements

4.3. Testing: Concept Refinement

The test of the questions is designed in such a way that one puts oneself in the situation of filling out the question catalog in a conversation and thus considers whether the addressed points are answerable now or also in the course of a project. The questions are worked through in a joint conversation and it is discussed at which points an iteration still opens up and what is still missing in the created question catalog. To achieve this state, the questions are brought into the format of the question catalog so that the subject is directly familiar with the sight. The test is carried out in an informal interview and in doing so questions the individual positions, records the thoughts, examines the examples and evaluates the present iteration together with the interview partner. The test of the questions turns out to be a predominantly positive exchange. Attention is drawn to the fact that not only the questions but also their order are important and that they should follow a logical order. The questions (see table 2), which are sorted according to the logical procedure of a project, find approval, whereby here the question arises, where one is to get this information, which does not go out from the tool. However, this is exactly the approach of the tools, since this takes up the topic of sustainability, shows the departments topics, which they had so far less in the focus of the work, can go with this knowledge to the experts of the sustainability and start at it. The evaluation matrix also meets with approval, as it provides a clearer result than before and prevents one from getting lost in ambiguities (see Figure 12). Thus, these improvements are added and the catalog is revised.

Figure 12 Questionnaire structure and rating scale
Table 2. Results of the finalized questions.

| Criteria                          | Requirement                                                                 |
|-----------------------------------|-----------------------------------------------------------------------------|
| User Understanding of Sustainability | We understand what the user values / requires in terms of sustainability AND our concepts fulfills those requirements Regional aspects to be differentiated. |
| Reuse / Repairability / Refurbishing | We are certain that we have found a simple and cost efficient way to extend the life of a tool |
| Recycling                         | In development of our concept we assure recyclability of our products / packaging / materials. Easy separation of materials / components |
| Materials                         | We know the CO2 footprint of our materials / components and alternatives |
| Circular Business Models          | We know the value of our material after end of Life.                         |
| Risk and Opportunity in Retail    | We know the requirements of trade/retail AND can fulfill them.               |
| Transparent Communication         | We are certain that we have enough data to provide a transparent communication to our users. |

5. Conclusion
The structure of the questions and the explanatory examples make it possible for the user experience design consultants to ask about sustainability issues and thus also raise awareness as the first point of contact in the product owner's development for possible improvements both at the beginning of a project and when reviewing the progress of the project. This gives both departments insight into what can be done internally, which also promotes stronger networking between management and operations at Robert Bosch Power Tools GmbH. In collaboration with colleagues from the User Experience department, the questions are entered into the Maturity Indicator and the evaluation is formatted. Thus, the Maturity Indicator is ready for review by the Product Owners. Broken down, the following topics were addressed and improved:

Integrating sustainability into the maturity measurement alongside the existing three elements of desirability, feasibility and practicability allows all planners to be continually reminded of the importance of sustainability. The seven specific requirements of the questionnaire also help to highlight different sub-aspects of sustainability. The fact that this questionnaire is regularly used when assessing the maturity of a product development project obliges all those involved in development to make their best possible contribution to a sustainable world at all times.
Although this study highlights the development process of power tools and specifically that of Robert Bosch Power Tools, the approach is also applicable to other manufacturers and thus certain findings can be applied to other industries: While specific details such as materials, reuse and business models may vary from tool to tool and from manufacturer to manufacturer, the questions asked and requirements derived are often generally similar. For this transfer, the general sequence visualized in figure 13 can be used as a general guideline.

Since the argumentation is primarily based on human-centered aspects and the underlying motives are less based on organization- or industry-specific details, many of the approaches can also be generalized to other manufacturers and industries.

For future research, a further operationalization of the different criteria seems promising to promote sustainability in concrete projects. Following this idea, developers can be provided with more detailed analyses and examples of sustainable material use, circular business models or reuse applications of best practices in their or even other industries. Moreover, an approach of gamification like Lego Serious Play is possible here, which can simplify and also open the openness of the employees concerned to the topic.

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