THIS IS NOT A DRILL; HOW CAN WE DESIGN FOR SHARING? PSS METHODOLOGY FOR DESIGNING PHYSICAL PRODUCTS FOR SHARED USE, THE DRILL AS CASE

Janne WAES and Ivo DEWIT
University of Antwerp, Belgium

ABSTRACT
The design of products specifically for shared use remains underexplored. As issues such as pollution, resource scarcity, and shifting consumer behaviours intensify, shared goods present a promising avenue for sustainability. While research has examined shared consumption's economic and ecological impacts, its design methods have been underexplored. This study proposes a methodology for designing physical products intended for shared use, guided by the research question: *How can we design for sharing?* The approach emphasises adaptability, product-service systems (PSS), community-centred design, and psychological ownership to support circular and durable economies. Insights were obtained through a design-inclusive research approach, placing the design process at the centre as a research tool to link theoretical insights with practical applications. A commonly underutilised item—a power drill—was selected as a representative product to explore and refine the framework. Despite being frequently cited as an archetype of the sharing economy, the drill ironically lacks a design intended for shared use. Through iterative design exploration, further insights emerged, shaping the framework's development and leading to the creation of a toolkit comprised of the drill as a research artifact and actionable templates to assist designers. By integrating theoretical insights with hands-on experimentation, this research contributes to the design field by offering an educational toolkit that aids designers, researchers, and policymakers in fostering sustainable, shared product systems.

Keywords: Sharing economy, product-service systems, design methods, psychological ownership, circular economy

1 INTRODUCTION
In a world facing environmental degradation, social inequality, and scarcity, there is a growing need for innovative solutions. People have become aware that sharing goods can lead to a more sustainable future [1], and this view has led to an exponential growth of the concept of the sharing economy [2]. The topic has been extensively researched [3], more often with the pros and cons being the main point of discussion and emphasising its economic aspects. Today, business models of the sharing economy have become increasingly important and can improve our quality of life [4]. From the literature, we can argue that the sharing economy will occupy a dominant position in the future [5]. Despite the research, there are still gaps within these developments and studies. In most cases, products in sharing initiatives are not designed for shared use. Products are designed and later shared with no visibility into specific requirements or relationship to the sharing system. This forms the underpinning challenge of this paper and leads us to the research question: 'How can we design to share?'.
In essence, the majority of products in sharing initiatives (e.g., design libraries, sharing platforms, or items exchanged among neighbours) are not designed with sharing in mind. Furthermore, products specifically designed for sharing (e.g., in the area of shared mobility) are faced with significant challenges related to maintenance, repair, or (mis)use, and even safety. The lack of emotional attachment to the product or service can lead to the users' neglect and vandalism, which in turn shortens the lifespan of the products and contributes to reduced sustainability [6]. We can argue that it is not the user at fault, but the designer. According to the Ellen MacArthur Foundation, better alternatives could be achieved by applying circular economy principles at the design phase, rather than relying solely on long

warranties when purchasing tools. Solutions such as modularity, standardisation, and documentation offer promising opportunities for more sustainable and efficient product design [7].
The scientific relevance of this research lies in the opportunity to introduce new methodologies and perspectives on the concept of 'design for sharing' through a multidisciplinary approach [8]. Within the current sharing economy and the future expectations of growth of the sharing economy, this design research asks the question that has not been asked (enough).
This research addresses a critical gap in existing design methods related to collaborative consumption and shared-use models—such as user-centred design, eco-design, and Product-Service System (PSS) design, which, while valuable, often lack the specificity needed to effectively tackle the unique challenges of shared use. These approaches tend to be either too broad or too narrowly focused, failing to fully address the complexities of shared ownership, usability, and long-term sustainability. To bridge this gap, the power drill was selected as a case study, serving as a familiar and accessible example to explore and communicate complex design challenges and systemic considerations. By engaging learners through a recognisable, low-threshold product, the research introduces a human-centred and experiential method that resonates with ongoing shifts toward more sustainable and inclusive PSS solutions. It emphasises the designer's role in shaping effective shared-use strategies and offers practical tools to support future design efforts.

2 METHOD

To conduct this design research and offer an answer to the research question, a methodological approach was adopted, specifically 'Design Inclusive Research' (DIR), using the model of Horvath [9] (see Fig. 1). For this study, three phases were performed, of which the exploratory phase was repeated three times: (a) literature, (b) case comparison, and (c) design exercise of a drill. The second phase, corresponding to the 'create' part, focuses on transforming gained theoretical insights into usable tools for developing, shaping, and assisting the design process, resulting in a toolkit. In the third and final 'confirm' phase, this toolkit is subjected to verification to verify its effectiveness and usability.

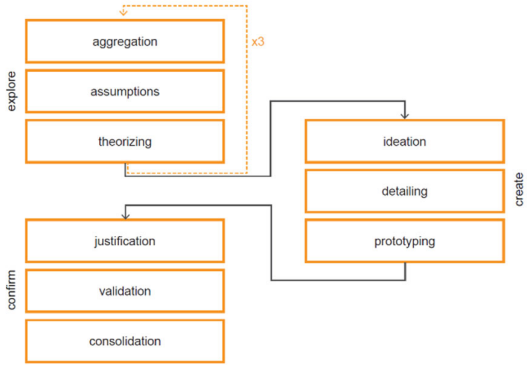

Figure 1. Design inclusive research, Horvath (2008)

The research began with a comprehensive literature review on the sharing economy [1-8], examining key concepts, contexts, and existing frameworks (Phase 1.a). Subsequently, an analysis of existing shared product cases was conducted to identify differences from their non-shared counterparts, as well as commonalities and variations. The selected shared-use cases included a comparison of the Lime scooter and Antwerp Velo city bikes. Based on these findings, requirements for shared products were defined and linked to the established theoretical framework (Phase 1.b). In the following phase (Phase 1.c), a power drill was selected as a case study to further investigate these insights. The drill was chosen due to its symbolic significance as an archetype within the sharing economy. Statements such as "people don't want to buy a quarter-inch drill. They want a quarter-inch hole!" [10] and "the average drill is used for only 13 minutes during its lifetime"[11] highlight its underutilisation among individual owners. Although these claims are not scientifically substantiated, they repeatedly emerge in discourse advocating for shared use, reinforcing the drill's relevance as a case study to explore the design challenges and opportunities of shared products. The research question was reformulated to 'How do we design a drill for shared use' to test the theoretical framework and gain deeper insight into the needs

of sharing behaviour about a specific product, where the design exercise itself is a research method that constitutes a way to gain new insights. This process involved a stakeholder analysis of the drill within the context of sharing. Personas were developed to identify specific user needs and requirements through scenario analysis. Additionally, a comprehensive product analysis and field research were conducted. The next step was to convert the theory and knowledge gained into a useful tool for designers, which would guide them in their design journey of a shared product (Phase 2). This was verified several times in small iterations and then tested in a design exercise with experts and students (n=10), followed by a general discussion, in which conclusions were drawn, a critical reflection was carried out, and guidelines for follow-up research were presented (Phase 3).

3 RESULTS

The research identified key factors that influence the successful design of products for shared use within Product-Service Systems (PSS). Three main aspects emerged: essential product parameters, frontstage touchpoints, and backstage mechanisms. The product parameters outline critical design considerations such as durability, accessibility, and adaptability to ensure shared products remain practical, sustainable, and user-friendly. The frontstage touchpoints define key steps in the user journey, from accessing and using a shared product to returning and maintaining it. Lastly, the backstage mechanisms address the underlying structures that support sharing systems. Together, these insights contribute to a comprehensive framework for designing effective and sustainable shared products. These findings align with principles from the circular economy [12], the Value Hill model [13], and traditional sharing economy frameworks, reinforcing the need for a systemic approach to designing for shared use.

3.1 Product requirements

Eight essential product parameters were identified that PSS concepts should meet or take into account during the design phase. These are (a) durability: shared products must endure frequent use by multiple users, making durability essential to withstand wear and tear, while extending the product's lifespan; (b) accessibility: products should be easy to acquire, use, and return, ensuring that sharing remains convenient and inclusive for diverse users; (c) trust and reliability: users must feel confident in the product's functionality and condition, alleviating concerns about damage or misuse; (d) psychological ownership: even without full ownership, users should develop a sense of responsibility and care for the product to encourage proper use and longevity; (e) transition readiness: products should be designed for seamless transitions between users, considering hygiene, preferences, setup, personalisation, and other factors; (f) transparency: clear information about product usage, status, availability, and history fosters trust and accountability in shared systems; (g) adaptability: products should be flexible to accommodate the varying needs of users and evolving use scenarios, enhancing their relevance and usability in shared contexts; and (h) maintenance and management: effective maintenance strategies ensure that shared products remain in good condition, minimising disruptions and maximising service life. These parameters are broadly applicable to both product features and system design and ensure that the Product-service System (PSS) concepts are optimised for practical, sustainable, and user-friendly shared use.

3.2 Front-stage touchpoints

Besides product parameters, nine recurring steps in the development of sharing systems have also been defined [14] [15] that in the context of PSS designs referred to as 'frontstage interactions' of the PSS. These are: (1) value proposition; (2) switch cost; (3) location; (4) availability; (5) claiming; (6) usage; (7) return and tracking; (8) maintenance; and (9) managing assets.

3.3 Backstage of the sharing mechanism

Chan and Ye [16] identify eight essential components of a sharing system, which align with the findings of this research and can be understood as backstage interactions or sharing mechanisms within Product-Service System (PSS) design: (1) The environment provides the necessary physical and digital infrastructure; (2) the goal defines the system's intended function; (3) guarantors ensure reliability and compliance; (4) performance measures assess efficiency and effectiveness; (5) stakeholders, including users, providers, and external influencers, shape the system's dynamics; (6) resources encompass the products and services available; (7) social forces, such as norms and values, influence sharing behaviours; and (8) opposing forces, including mistrust and economic barriers, present challenges to the

system's success. Understanding these interconnected mechanisms is crucial for designing effective and sustainable shared-use products within PSS frameworks.

4 TOOL DESIGN

Figure 2. Toolkit in use

A toolkit was developed to translate the research findings into practical resources for designers, to guide designers in creating meaningful product-service systems for shared products. Constructed through a DIR methodological approach, involving iterative prototyping, internal feedback loops, and informal pilot testing within a design education context. Initial versions focused on symbolic representation, while later iterations integrated various created tools and templates, selecting and refining them. Throughout development, feedback was gathered from design educators, recent graduates, and current students to refine the toolkit's usability and relevance.

The toolkit takes the form of a fully (3D-) printable kit, modelled after a traditional toolbox—playing on the literal idea of a 'toolkit' as a collection of tools. It contains various templates and a physical conceptual drill. The drill serves both as an illustrative example to explain the theory of shared PSS design and as a functional puzzle, with each component representing one of the eight key product requirements in practice, see Figure 2. This approach provides a compelling physicalised analogy or an experiential metaphor to effectively communicate key principles and guide designers in applying the methodology. It serves as an extension to existing PSS tools [17] and provides new (or adapted) tools and techniques (e.g., personas, lotus blossom, customer journey, FMEA and code of conduct) to address complex and interconnected design problems in sharing products. Developed as an open framework, it is adaptable to different contexts and provides scope for continuous extension and evolution.

Figure 3. Toolkit 'this is not a drill'

When opened, the toolkit consists of two complementary components: the theoretical and the practical, divided by a physical panel (see Figure 3). Upon opening the toolkit, the theoretical framework is presented first. The theoretical side holds a manual with insights and interactive templates for the design process. The practical side holds a physical, hypothetical example in the form of a drill prototype with

linked parameter cards. This drill, composed of 3D-printed components, is designed so that each part corresponds to one of the eight product requirements identified during the research phase. For instance, the parameter 'durability' is associated with the motor component, which features a brushless design to reduce wear and tear, enhance efficiency, and extend the shared drill's lifespan. This example illustrates how the concept of durability can be meaningfully applied in tangible design choices that contribute to sustainability in sharing scenarios. Together, these interconnected elements form a cohesive whole, serving as a tangible representation of the intended Product-Service System (PSS) design. This kit guides the user or designer through the design process by first presenting theoretical concepts, followed by interactive actions—such as flipping the middle panel—to reveal corresponding practical applications. This structured approach prevents cognitive overload by allowing users to control the amount of information they engage with at a given time, see Figure 4. The interaction between theory and the tangible example creates a powerful learning experience [18]. The theoretical framework provides structure and context while the physical model provides a visual and interactive demonstration of applying theory in practice. A design process is rarely linear, although the toolkit provides structure, it does not have to be followed step by step. Designers can adapt it based on the design brief or specific challenges, focusing on what is most relevant to their problem. The toolkit is fully digitally accessible[1], with 3D-printable STL files, templates, and theoretical materials available online.
Preliminary testing was conducted with design students (two times n=3) during two facilitated sessions. Qualitative feedback was collected through observations, structured reflections, and a follow-up questionnaire. Participants indicated that the tangible nature of the drill and the guided templates helped them grasp complex PSS relationships more effectively than traditional lectures or tools. Students engage with the toolkit during a facilitated 1-hour workshop that introduces a design challenge to redesign a trolley with sharing in mind.

Figure 4. Toolkit step-by-step

5 CONCLUSIONS AND FUTURE RESEARCH

This research introduces a structured design methodology for shared-use products within Product-Service Systems (PSS), bridging theoretical insights with practical applications. The developed toolkit provides an interactive, accessible way for designers to integrate sharing principles, combining theoretical structure with hands-on exploration. However, challenges remain in balancing durability, accessibility, and psychological ownership while ensuring commercial viability. Further research should explore trade-offs between these concepts and strategies and develop hierarchical frameworks—similar to Lansink's ladder, a waste hierarchy model widely used in circular economy contexts, to guide and critically evaluate lifecycle decisions from prevention to disposal [19]. While this study offers initial validation through expert and student testing, its scope was limited, and broader real-world application is needed to refine its effectiveness. Expanding case studies will help validate the approach, ensuring its adaptability across various product categories and sharing contexts. Ultimately, designers, researchers, and policymakers must collaborate to redefine traditional product design, fostering sustainable and inclusive sharing systems. "*This is not a drill*" serves as both a statement and a call to action, urging a shift in how we design for shared use. The developed framework and toolkit represent a step towards a

[1] https://www.designforsharing.org/

dedicated design methodology for shared use. However, real progress will require continuous innovation, collaboration, and systemic thinking.

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