

Designers' experience and collaborative design: Two case studies

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Abstract: Experience underlies all kinds of human knowledge and determines how people interact with products and environments. It also influences designers' knowledge and their design process. An issue not fully addressed in current literature is about the way in which designers' individual experience influences design tasks.

This paper presents two qualitative design case studies that involve experiments employing collaborative design approaches. Case study one focuses on product usability and case study two, sustainable design. Both studies applied an empirical approach; data collected consisted of sketches and audio- and video-recordings. The studies share a common research approach that opens the discussion about designers' interactions; the way those interactions reveal knowledge and experience, the influence of these interactions upon the design process and approach to design tasks. This paper will present the correlations and discrepancies between these two case studies and the collaborative design approach used in each study, outlining future research endeavors.

Key words: *Design process, collaborative design, experience, design expertise*

1. Introduction

Designers' experience, the design process, and participatory design are topics that have been extensively investigated in design research. Designers' experience has been studied from various perspectives, much of these efforts have focused on the design thinking and reflective aspects embedded in the process of making visual representation of design concepts [1, 2]. The use of visuals in design research have assisted the investigation of design process and the investigation of knowledge and experience revealed by them [3-6]; images produced during design have been studied as representations of reality — who, where, and what [7].

Previous studies about experience and knowledge embedded in the design process have also led to the identification of different types of design knowledge [8, 9]. Recent studies about the differences between expert and novice designers and how their individual experience affects their design process have also been studied through the study of design sketches [10, 11]. Most research conducted under the umbrella of user-centered design, participatory design or collaborative design has primarily investigated the methodology employed and the type of design outcomes achieved. Such investigations have focused on the design process or the user-

centered design approach – in which not much evidence can be found about the designers' collaborative design process (designer-designer) in relation to the study of designers' experiential knowledge.

This paper discusses two empirical design studies; that focus on different design issues being explored. Both studies involve observation of collaborative design tasks. In both studies, the topic of designers experience was identified as a prominent aspect requiring further study.

Case study one deals with identification of relationships between human experience and context-of-use and the ways in which these inform the design of products. Design tasks involved in case study one required consideration of particular usability issues for a given user group. The methodological approach was based on previous research [12], and consisted of sketches, retrospective verbal reports and interviews. It was observed that: (a) variance between concepts was influenced by the designers' individual experience of using or knowing about similar products; and that (b) the collaborative design approach prompted designers to a reflective design activity and assisted them in refining their design concepts. For expert designers, this process was rich in details allowing them to converge ideas into one that satisfies usability requirements. For novice designers, the process stimulated new ideas based on assumptions about features and functions. This concurs with Author [11] study on expertise development based on the analysis of designers' visuals generated during the early (conceptual) stage of the design process. The differences between novice and expert designers demonstrated that novice designers' representation tended to be fragmented and superficial. Contrary to this expert designers' were looking for different possibilities based on their experiences.

Case study two involved a sustainable design task. Participants were grouped into pairs and divided into two cohorts; Cohort A the control group and Cohort B the experimental group. The objective was to observe the degree of variance between participants' responses during a design task. It was observed that including sustainability issues as part of the initial design problem (as an additional constraint) affects design activity by influencing the number of ideas generated during the session [13]. Furthermore, like case study one, it was observed that expert and novice designers applied differing approaches to collaboration. For example, expert designers spent a significant portion of the time re-defining the boundaries of the brief, whereas novice designers place high importance on meeting the objectives of the brief.

The following section provides an overview of relevant literature. Following this, each case study is introduced and the methodological approach is presented. From this the conclusions are discussed focusing on similarities and differences between the two cases studies, and the most influential aspects emerging from the each case study is presented. Finally, future research directions are outlined.

2. Background

Experience underlies all kind of human knowledge and it is context dependant. People's experience within a particular social, cultural and physical context-of-use determines how they interact with products [10]. Previous studies investigating designers' experience and its relevance for the design of products concur with this view [5, 14-16]. Also, other studies dealing with designer's experience and mental models [17, 18] have considered that designers' representation of reality [19] influence their design practice. Such studies also considered that

designing is a social process where designers communicate with one another. According to Badke-Schaub [17], a designer's mental model helps him/her to act and think in order to understand, predict and explain the world. When connecting the topics of experience and collaboration in design, Van Gassel et al. [19] have studied interventions during design meetings and found that by sharing their views designers can get other designers to react to those views. Van Gassel argues that by integrating action, reaction and thought around ideas that are shared with other designers, their experience grows and their individual mental model changes.

The design process and methodologies involved in participatory design have been extensively investigated [20, 21]; its practice and theory has been applied and developed into diverse contexts [22], from design to information technology fields. Traditionally, participatory design related studies have focused on engagement of designers and user representatives during a design process [21, 23], and has evolved towards the study of the design process of engagement and dialogue with people outside the design community [24]. It has been described as an attitude about a shift in the creation and management of environments for people, a social process [25], and it has involved collective intelligence as a factor leading to favorable participatory design outcomes through the process of group interaction [23]. Participatory design and collaborative design have been viewed as a 'sharing design activity'; to collaborate is to work together with a shared goal [26]. This is different from 'to cooperate', which is defined as 'to work side-by-side with mutual goals.' In collaborative design designers with individual backgrounds, objectives, and motivations make an effort to achieve a shared goal by making optimal use of each others knowledge and experience [27]. While the study of participatory design issues has taken place for nearly three decades, there has been less emphasis in the study of the collaborative design process between designers when undertaking design tasks. Studies around this topic are more related to the Human Computer Interaction (HCI) or Information Technology (IT) fields. Those studies have looked at the collaborative design activities (shared activities) that take place with the support of technologies; see for example Bly's study [28] about two-person design sessions and the use of technology to support remote design collaborations.

Methodologies involved in the study of collaborative design processes are grounded in the methodological approach employed in participatory design. As explained by Luck [25], during participatory design sessions people are engaged as part of the social process of designing and they play a part in the discussion and decision making process, overcoming the boundaries between designers and making this process an inclusive environment for all who take part in it [25]. While there are diverse methodologies and creative tools that can be applied to a participatory design approach [29], one of the most important components revealing the design process in place, is the verbal exchange of design ideas revealing both iterative reflection and knowledge. This is supported by previous studies in which it was observed how properties of design are produced verbally through design interactions [25]; or studies in which the close analysis of designer-user conversation reveals the ways in which agreements over design decisions are negotiated [30]; or studies in which the social role of the participants influence their design interactions [31, 32]. In the case of designers' collaboration, there is limited evidence about the way social roles, individual experience or level of expertise influences design interactions.

Expert behavior relates to the study of knowledge levels. It is founded on the study of how experts process information, and how domain-specific knowledge is represented during the problem solving. There is considerable evidence about differences between novices and experts in knowledge representation; it's processing and the way that knowledge is used. Expert performances have been studied in many different domains and different scientific approaches have been used to investigate outstanding performances [33-35]. There are diversities observed in experts' performances which are elaborated by Ericsson and Smith [34]. These authors reviewed the approaches in expertise research with an emphasis on different approaches undertaken in expertise domains. Therefore in the context of design (product design), expertise is "*understood as possession of a body of knowledge and the creative and analytical ability to extract, analyse and apply relevant knowledge*" [11].

The following sections introduce two case studies dealing with collaborative design and designers' experience. The studies are unrelated but share a common research approach that allows for discussion about designers' interaction during early stages of the design process; the ways those interactions reveal knowledge and experience, and the influence of these aspects upon the design process and approach to two differing design tasks.

3. Case study 1: Experiential Knowledge and the design of product usability

Author1 investigates the ways in which users and designers' experience informs their interactions with everyday products. By employing visual representation of concepts, retrospective verbal reports and interviews to elicit users and designers' concepts of products use, this study identified causal relationships describing aspects of human experience that influence people's understanding of products usage [36]. This approach concurs with previous studies in which images produced during research have been studied as representations of reality [7], and as representations of experience or knowledge [3-6].

Case study one reports on Author1's ongoing investigation, which focuses on the observation of designers undertaking a usability design task [37]. This research aims to identify the experiential aspects of designers' knowledge and its influence on usability design process [10]. It sits on the premise that design knowledge consists of explicit and tacit knowledge and that it is not only a reference to past experience but also an anticipation of the future [38]. This study is set out to investigate: how do designers design for usability and how does their experiential knowledge influence their design process? To address these questions an empirical study was undertaken involving sixteen product designers representing differing age groups and levels of expertise.

3.1 Research approach

The study focuses on further exploring the causal relationships identified in Author1's preceding study [10]. The following table summarizes the research design:

Table 1: Design research summary

Objective	To investigate: <ul style="list-style-type: none"> - How do designers design product usability? - What informs their usability design process? - What is the role of their experiential knowledge in such process?
Participants	Product designers representing differences in age, gender and experience
Approach	Collaborative design
Data Collection methods	<ul style="list-style-type: none"> - Observation - Design task simulation (design scenario and design brief) - Retrospective verbal protocol - Interview
Instruments	<ul style="list-style-type: none"> - Flashcards presenting the nine causal relationships - Design scenario and design brief
Experiment session	<ul style="list-style-type: none"> - Part 1: design task 1, retrospective report - Break - Part 2: design task 2, retrospective report - Interview
Setting	People and Systems Laboratory (PAS)

The pool of participants comprised of practicing designers representing diverse gender, age, cultural background, and level of expertise. To assist the selection of participants a screening questionnaire is employed to collect demographic data and verify level of expertise. Participants are advised that the experiment session will involve two design tasks that must be undertaken in a collaborative environment with another designer.

The two design tasks involved are: (i) design of blood pressure monitor for elderly user (task 1), and (ii) design of coffee grinder for young professional multicultural couple (task 2). Tasks and scenarios chosen were supported with a persona mood board; in order to help contextualize usability issues that need to be addressed in both tasks.

Participants are instructed to undertake the design task collaboratively. They are paired up according to a combination of expertise and demographic characteristics (e.g. novice-expert or expert-expert). It is expected that discussing the task with another designer would prompt different perspectives about the design brief, usability and, the causal relationships. This approach would also generate richer data about designers' experiential knowledge. Figure 1 synthesizes the experiment steps.

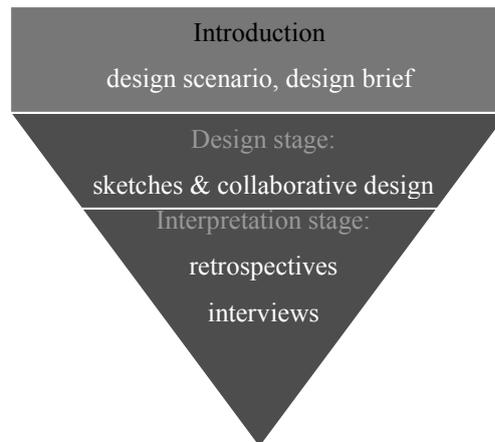


Figure 1: Experiment steps

In the introduction, a design scenario and design brief are presented to the designers. This aims to contextualize and focus on the usability aspects that need to be considered. A design brief is provided, outlining the design task. In this study the design task only comprises the initial conceptualization stage of the design process. Data collection methods employed during the design and interpretation stage includes: observations (audio- and video-recorded), design tasks simulations (design sketches and annotations), iterative protocol retrospective protocol and interviews (audio- and video-recorded). The design stage requires the introduction of some user information to assist designers addressing usability issues in each design task. This information is provided through a set of persona design mood boards relevant to each of the design tasks. The use of the Internet is advised to complement the user-research component of the design.

Upon completing the design task all drawings, annotations, and verbal reports were analysed and interpreted; this process aimed at identifying references made to usability and experience issues in visuals and verbal reports. This approach follows methodology employed in previous work by [39]. The interpretation and analysis of visual and verbal data is assisted by ATLAS.ti, specialised software to support qualitative analysis of data.

From the data collected usability issues were identified. They formed a system of coding categories. Specifically, a set of categories was identified in references to (i) the designers' individual experience (ii); specific experiences situated in particular context (individual or episodic experience), (iii) procedural knowledge, and (iv) anticipation of future experiences. The emerging categories provided the basis for a coding system that reveals different types of experience. Codes were analysed by their frequency of occurrence and relationships (Table 1).

3.2 Observations

It was observed that expert designers demonstrate a variety of design knowledge that informs their usability design. Such knowledge is evident in their representation and explanation of their concept designs, where solutions go from basic descriptions to detailed explanations of the rationale behind the functions and features of the product. Their knowledge comes from individual and episodic experience; it can be inferred that their usability design process is informed by the designers' tacit knowledge. Figures 2 and 3 illustrate a segment of

the expert-expert design team's concept design and a moment in which they are discussing and drawing from their experience and knowledge with similar products.

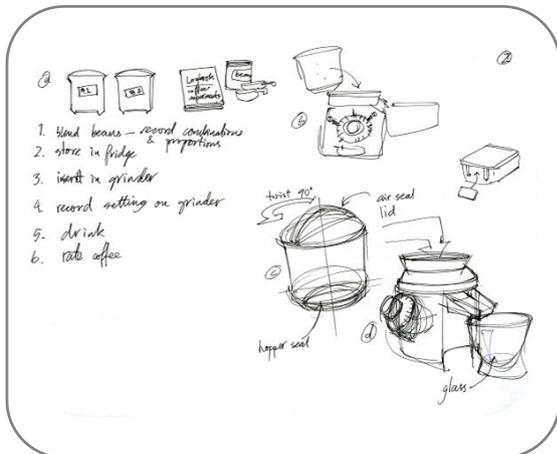


Figure 2: Coffee grinder design concept



Figure 3: Expert-expert design team

An initial comparative analysis corresponding to different categories of: age, gender and expertise are presented in order to discuss collaborative design and designers' experiential knowledge. This comparison consisted of the following: (i) Expertise: novice/expert designer compared against expert/expert team; (ii) Age: 20 year-old designers compared against 40 year-old designers team; and (iii) Gender: male/female designer compared against female/female team.

Expertise: Novice/expert team compared against expert/expert team

The novice/expert designers' concepts show details about features, functions and mechanism of the product. However, the expert/expert designers' concept demonstrated not only understanding of the principles behind the functions and use of this type of product, but also it presents a 'story' behind the product use. This story refers to a particular function of the product, a type of 'selection' or 'setting', which can be recorded for future uses. During the collaborative design, the expert designers made significant references to their individual experience. Comparatively, the group consisting of one expert (more than ten years of experience) and one novice designer (recent graduate) demonstrated an inconsistent application of knowledge. For example, the collaborative design prompted a rich of individual knowledge and episodic experiences. Although such discussion resulted in the consideration of future contexts of use, it produced a limited concept development, where usability issues were considered second to the mechanical and functional aspects of the design. Nevertheless, during the retrospective verbal protocol, both novice and expert demonstrated knowledge and understanding of the context of use and usability aspects, referring to diverse sources of experience; this was not evident in their concept design development.

Age: 20 year old team compared against 40 year old team

The design concepts show that usability aspects considered by the 20 year-old designers are mostly around the physical aspects of use of the product. They refer to the display, a portable device, the colour of the on/off button, and mention the 'ease of use' without identifying what makes this solution easy to read or to use. Differently, the 40 year-old team's design concept considered various 'use' aspects of the design problem. They considered the type of information that must be available for the user, and the format in which this should be presented for ease of reading; types of input and output, the issue of 'how to use' the device; and the context in which the device would be used. During the collaborative design, the team consisting of two expert designers in the 40 year-old age category applied a consistent design methodology which drew on a broad range of experience, knowledge sources and understanding of context of use to inform their usability design. This was evident in the discussion taking place during the design stage. The expert group made significant references to their individual experience throughout their design activities, and provided the highest diversity of usability design knowledge and application. This knowledge was evident in their design solutions, which they explained around the topics of ease of use, intended use, activity and context. Comparatively, the group consisting of two 20 year-old designers applied an inconsistent and moderate understanding of context of use, experience and knowledge to inform their usability design

Gender: Male/female compared against female/female team

Discussion during the collaborative design reveals that the group consisting of one male and one female designer refer to a diverse range of experience and understanding of context of use. They referred to various past and episodic experiences relevant to the use of the product showing different points of view about its current and future use of the product. This discussion produced different ideas, transferred into concept designs. Comparatively, the group consisting of two female designers demonstrated similar outcomes. Their design concepts were limited characterized with low variety of ideas. Usability aspects relevant to ease of use and context of use were mentioned but not developed. The visual representation of design concept from the female/male team shows a series of steps describing the different issues considered as part of the design process and three possible design directions. These solutions assume a future context of use. The female/female design concept emphasises mainly the parts and main function of the product. The design concept is based on personal experiences of context of use.

3.3 Summary

Initial observations show that designers' knowledge comes from their experience of using products or from episodic experience. It also demonstrates that designers transfer their experiential knowledge into solutions where tacit knowledge is represented thorough the procedure of a product's use, or into basic descriptions of features. It was also observed that designers prefer to develop design concepts based on anticipatory knowledge rather than generalizing known solutions. The collaborative design approach was significant not only to assist designers fill in the gaps of information emerging from the design brief, but also because it was instrumental for the identification of the role of designers' individual experience and the types of knowledge plays in informing usability design during the early stages of design process. This concurs with the case study two findings (Section 4.3).

4. Case study 2: Sustainable design

Case study two centered on a sustainable design task and involved twenty practicing industrial designers. Participants were grouped into pairs and divided into two cohorts; Cohort A the control group (n=10) and Cohort B the experimental group (n=10). Each cohort was issued with a corresponding design brief. Participants in Cohort A were issued with the *control* brief and not (explicitly) requested to address *sustainability* – whilst Cohort B were issued with the *experimental* brief and directed (within the project brief) to address *sustainability*.

4.1 Research approach

This study focuses on further exploring designers approach to sustainability during the early stages of the design process. It builds on previous work by the Authors2 [13]. Information surrounding background literature, research design and preliminary findings are detailed in the preceding work. Table 2 provides a summary of this study research design.

Table 2: Design research summary

Aims	1) explore how practicing designers apply sustainability issues to design problems; 2) understand how sustainability issues influence the early stage design process; and 3) identify if sustainability issues can contribute to a designer’s ability to innovate	
Objective	To observe the degree of variability between cohort responses to a set design activity.	
Participants	Product designers representing differences in age, gender and experience	
Approach	Collaborative design activity	
Instrument	Design brief (Cohort A issued control brief and cohort B the experimental brief)	
Data collection methods	<ul style="list-style-type: none"> - Participant profile - Observation - Concurrent protocol - Retrospective protocol 	<ul style="list-style-type: none"> - Textual data (transcripts) - Visual data (interactions) - Textual & visual data (transcripts, sketches& annotations) - Textual data (transcripts)
Data analysis tools	ATLAS.ti specialized software to aid analysis of textual and visual (sketches) data Observer.XT specialized observational software to assist the analysis of visual data (interactions)	
Setting	People and Systems Laboratory (PAS)	

The pool of participants included practicing industrial designers with a minimum two years industry experience. Standard good practice qualitative research and ethical protocols were followed, with participants invited to participate in a one-hour design activity. All participants volunteered and were not paid for their time.

The design task requested participants to collaborate and design portable CD or DVD data storage. Participants were issued with a brief dependant on the Cohort to which they were assigned. Each brief provided general

design constraints and a list of online resources. As detailed the only difference between the two briefs was the inclusion of *sustainability* as an additional design constraint, issued to participants in Cohort B.

Like case study one, participants were instructed to undertake the design task via a collaborative design approach (working with another designer). Case study one screened and paired participants according to expertise and demographic characteristics – however, due to the number of practitioners required over an extended period, case study two utilized a random approach, and as a result participants were paired based on their availability to participate.

A collaborative design method was implemented because it was anticipated that this approach would most accurately reflect day-to-day design practices. This is important because this study seeks to identify how *practicing* designers approach *sustainability*, therefore the experiment needed to reflect (wherever possible) *practice* as if the designers encounter was *in situ* (or as closely as is possible, within a controlled environment with minimal variables – see Figure 4). Similar to case study one, case study two employed the experiment steps as illustrated in Figure 1.



Figure 4: Participants (Cohort B) engaged in the design activity and concurrent protocol

4.2 Observations

It was observed that participants explored a greater variety and more diverse range of ideas when issued with ‘sustainability’ as an additional design constraint (cohort B). This was reflected through visual data [larger number of sketches produced], verbal data [greater variety and diversity of ideas discussed] and observational data [broader variety of gestures utilised]. Essentially, participants in cohort A progressed throughout the design process with minimal deviation from the original concept whereas cohort B considered a broader variety and scope of ideas. However, when analysing the data against individual designer’s experience levels, interesting patterns began to emerge.

Surprisingly, it was observed that expert designers (participants with 6-10 or more years experience) approached the design task quite differently to their novice counterparts (participants with less than 2-4 years experience) irrespective of which brief they were issued. Similar to case study one, expert designers engaged in rich discussions during the design task. They discussed the brief in detail and worked together collaboratively. Novice designers, on the other hand (similar to case study one) focused on the specifics of the brief, and were

very *outcome* focused; in all, novice designers spent less time questioning the *reasons* for designing the product. It is noted that novice designers placed higher significance toward achieving the outcomes of the brief as well as placing a high importance on meeting the objectives laid out. They demonstrated backward reasoning [11]. Expert designers were less concerned with the specifics of the brief and worked toward achieving the best justifiable outcome. They exhibited greater confidence and spent a significant portion of the time allocated to them, re-defining the boundaries of the brief.

4.3 Summary

These observations concur with case study one, and therefore demonstrate that experience affects designers' knowledge and design approach. The significant finding of case study two is that expert designers tend to place greater importance on *understanding* the design problem. In some cases they produced limited to intangible design outcomes because the entire (collaborative design) session was focused on the complexities of the design problem (including *why* design this product). However, collaborations between novice designers' were observed to place higher emphasis on tangible *outcomes*. In this instance, novice designers were insisting on numerous concepts similar to case study one's findings (Section 3.3). They emphasized the physical aspects of the product.

5. Conclusions

This paper presented the correlations and discrepancies between two case studies. The studies shared a common research approach – collaborative design, which opened discussion about designers' interactions; the way those interactions reveal knowledge and experience, the influence of these interactions upon the design process and approach to design tasks.

The indicative findings from each study clearly illustrate that collaboration between expert designers' is different to that of the novices. It was found that expert designers collaborate and assist their concept development (early stage design) by building on their own individual experience and knowledge of prototypical solutions. Whereas, collaborations between novice designers are led by assumptions, which demonstrates limited experiential knowledge. These findings are significant and have potential to contribute to wider knowledge surrounding collaborative design processes. It is anticipated that the preliminary observations presented in this paper will be researched further to better understand collaborative design interactions. Future work will include a complete comparison of the final analysis and additional case studies.

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