Integrating User eXperience Practices into Software Development Processes: Implications of UX Characteristics

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Abstract

User eXperience (UX) is a key factor in the success of software systems. Many software companies face challenges in their work with UX and how to integrate UX practices into existing development processes. Existing research does not analyse UX practices and challenges in relation to other software quality characteristics or, in particular, in relation to usability. A better understanding of these challenges, based on empirical data, can help researchers and practitioners better address them in the future. In this empirical study, we have interviewed 17 practitioners with different backgrounds and occupations from eight software development companies. Their responses are coded, and analysed with thematic analysis. We report 8 themes of challenges that practitioners face in their work with UX. While some of these challenges partly overlap with those reported in existing literature about usability or software quality characteristics, the participants of our study either view many of the challenges unique to UX, or more severe than for usability or other quality characteristics. Although at a superficial level challenges with UX and other quality characteristics overlap, we differentiate these challenges at a deeper level through main characteristics of UX: *subjective*, *holistic*, *dynamic*, *context-dependent* and *worthwhile*. In particular, we identified at least 17 implications (i.e. extra difficulties) for these characteristics. These implications can explain why practitioners perceive the challenges to be more severe than for other quality characteristics. Most importantly, they can explain the industry's lopsided focus on pragmatic aspect of UX. Our findings can be useful for researchers in identifying new and industrially relevant research areas and for practitioners to learn from empirically investigated challenges in UX work, and base their improvement efforts on such knowledge. Identifying and investigating the overlaps underlines the importance of these challenges, and can also help finding research areas not only for enhancing practice of UX but also software quality in general. It also makes it easier for practitioners to spot, better understand as well as find mitigation strategies for UX, through learning from past experiences and developments in the area of software quality.

Keywords: software quality, user experience, usability, quality requirements

1. Introduction

As the software industry has matured, the demands that society puts on the quality of software systems has increased. It is no longer enough to focus only on the many functions that a piece of software should supply. To deliver a system that is consistent and of high quality there are a large number of characteristics that need to be considered [1]. Some, such as testability, are internal or relate to the development process and mainly concern developers, while others such as performance and usability, are critical for users [2]. At

the introduction section is improved

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an even broader level, the actual experience of the end users as they interact with the software needs to be taken into account.

Recently this widening scope of software quality characteristics has led to the introduction and study of the concept of user experience (UX). Even though different definitions of UX exist they share the same essence: *UX is a user's holistic perception of functionalities and quality characteristics of a piece of software* [3, 4, 5]. In general, UX literature emphasizes that assuring efficiency and effectiveness during use of the software, i.e high usability, does not guarantee that the end users will have a positive experience [6]. A good UX typically means that the software has high usability, but the latter does not automatically lead to the former. Moreover, the perception of UX is generally different in academic and industrial contexts: whereas the former concentrates on hedonic aspects and emotions, the latter focuses more on functionality and usability issues [7].

Current UX models (e.g. [3, 4]) differ in their view on how various underlying elements and processes contribute to forming the end user's overall experience with products and services. One of the well-known UX models is developed by Hassenzahl [3]. It breaks UX down into *pragmatic* and *hedonic* attributes. End user's perception of these attributes leads to a judgment about the product's appeal (e.g., "It is good/bad"), emotional consequences (e.g., pleasure, satisfaction) and to behavioral consequences (e.g., increased time spent with the product). While pragmatic attributes concern achieving *do-goals*, hedonic attributes concern satisfying *be-goals* [3]. Do-goals are the concrete outcome that the end user wishes to achieve whereas be-goals rest in essential human needs. To provide a better understanding of UX, Hassenzahl [6] emphasizes four characteristics of UX: *subjective, holistic, dynamic, context-dependent and worthwhile.*

All software systems deliver some UX, positive or not, whether the UX has explicitly been taken into account during development or not. Research has shown that certain practices can increase the likelihood of delivering a desirable UX [6] (hereafter, *UX practices*). But simply applying these practices in isolation is not enough [8, 9, 10]. Like methods and practices used to support other software quality characteristics [1], they need to be integrated into development processes and considered throughout projects. But UX is still often neglected in software projects and current UX state-of-practice is still immature [8, 11, 12]. One way to improve state-of-practice is to better understand and address current challenges that practitioners face in their everyday work with UX, hereafter *UX challenges*. Still a more complete picture and understanding of UX challenges is missing. Most importantly, despite the importance of the above characteristics and differences between usability and UX, only a limited number of studies have so far analyzed the implications of similarities and differences between UX and other software quality characteristics, particularly usability (e.g. [13, 11]). In addition, often studies on UX integration use the terms UX and usability interchangeably. These studies often claim to investigate UX state of practice, but tend not to differentiate usability and UX and how similarities and differences between these two concepts affect the practice (either in agile development processes [10, 14], or in software development in general [15, 16, 17]). The findings of such studies therefore do not necessarily provide sufficient understanding of UX challenges. Furthermore, researchers that study the practice of UX, and explicitly differentiate it from usability [18, 19, 20, 17] do not often compare and contrast UX challenges to similar ones reported for other software quality characteristics or even usability. Although one reason might be the scope of these studies, this can also indicate that these researchers, if not deliberately, accidentally report these challenges as unique to or extra difficult for UX.

Our study aims to complement current body of knowledge by investigating UX challenge while explicitly differentiating UX and usability. Moreover, we discuss these challenges in relation to the characteristics of UX, and analyze the related existing approaches and open problems for future research. We also contribute to current literature by providing an explanation for the industry's lopsided focus on the pragmatic aspect of UX. We specifically discuss implications of UX characteristics for these challenges. Also, in our analysis we pay certain attention to how the identified challenges relate to the practice of software quality characteristics in general, and usability in particular. Here, we report our findings and answers to the following research questions: *what challenges do practitioners face in integrating UX practices into software development processes and organizations?*, and *how do UX challenges relate to challenges in practice of software quality characteristics, in particular usability?* Our findings can be useful for researchers in identifying new and industrially relevant research areas, and for practitioners who want to learn from empirically investigated challenges in UX work, and base their improvement efforts on such knowledge. Although we focused on UX

2

challenges, the insights that can be gained from our findings may also shed light on the practice of software quality characteristics in general.

The structure of this paper is as follows: The second section summarizes the related literature. The third section describes our research methodology and presents the different research sites. The fourth section presents the results from our study: the identified challenges. The fifth section discusses our findings and puts them in relation to current literature and UX theories. In the last section, we conclude our study and suggest future research.

2. Related Work

This section elaborates characteristics of UX and their implications for practice of UX. In addition, it summarizes related previous empirical studies on UX and challenges reported in these studies. Understanding these characteristics is important when analyzing and discussing our findings on UX challenges because it provides a basis for comparing and contrasting practice of UX with usability and other software quality characteristics.

UX is **subjective** and heavily relies on human perception [4, 6]. For instance, one user may perceive particular features of the software as simple, novel, and admirable while another one may perceive the same features as complicated and old. This subjectivity plays less role in other software quality characteristics, and at least in theory, these characteristics can be treated objectively [21]. Still, the term 'subjective' has also been used in requirements literature to highlight that since quality characteristics are hard to measure, practitioners tend to judge them based on their personal opinion [1, 22]. Admittedly, such objective quality can be translated to subjective quality characteristics, i.e. experienced or perceived [6]. For instance, while performance can be measured automatically and without involving a human user, if we talk about a fast or slow software system, we are then taking the perception of users into account, therefore entering the scope of UX. Here, we use the term subjective to refer to its meaning in the context of UX.

UX is also **holistic** and UX work, in contrast to usability work, takes a holistic approach to design. UX work focuses on creating specific experiences that support users' be-goals (i.e. psychological needs) as well as do-goals through paying attention to both hedonic and pragmatic aspects of product use [6]. UX of a piece of software, among other things, emerges from underlying functionalities and quality characteristics, and the user's perception of them, in each certain situation. *Concrete* quality characteristics, therefore, can contribute to satisficing certain *abstract* quality characteristics that designers find relevant to the software, e.g. in order to be trustworthy (abstract) the system provides a good overview of the functions available (concrete) [23]. UX is not totally reducible to its complexly intertwined underlying elements [6]. This is even acknowledged by those researchers that model UX through a composition of elements (e.g., task-related/pragmatic and non-task-related/hedonic [3]). These researchers emphasize that however practitioners may 'manipulate' UX of a product through these elements, they cannot 'guarantee' a certain overall UX [4, 6]. Consequently, practitioners and researchers have different views on how UX should be designed or measured and whether they can predict the overall UX of a piece of software by merely manipulating and measuring these elements [24].

Holistic nature of UX resembles the cross-cutting nature of other quality characteristics. In both cases, more than one functionality is affected by the related requirements. For instance, a designer can select a group of specific functionalities in order to increase the likelihood of evoking a particular emotion in the end users. However, in case of UX, this interrelation is more complex specially considering that these underlying elements impact each other over time. As Hassenzahl [6] emphasizes, UX is an emergent phenomenon that is not totally predictable, or reducible to its underlying elements. This is more elaborated below through the dynamic characteristic of UX.

UX is **dynamic** (aka. temporal), meaning that it emerges and changes over time [6] since a user's perceptions, or emotions are likely to change over time and as the user interacts more with a piece of software [3]. For example, over time, the user may find the same novel features as old, or a complex feature as simple. Therefore in designing and evaluating UX, practitioners should pay certain attention

the related work section is shortened (e.g. theories on UX are more brief now), improved, and is now structured differently

characteristics of UX are more clarified

3

to different episodes of experience [6]; namely expected experience (before usage), momentary experience (during usage), remembered experience (shortly after usage) and accumulated experience (over longer period of use) [6]. Practitioners need to decide which episodes are more important than others for the software being developed and why; for instance, for an e-marketing website first impression is more important than it is for a work application. This knowledge then can help them suggest more suitable design solutions.

UX research uses the term **context-dependent** (aka. situated) to emphasize that any experience is unique, unrepeatable, and situated in its context [4]. Despite their uniqueness, experiences can be categorised because their essence is the same, i.e. they connect to essential human needs or be-goals [6]. Implications of being context-dependent largely overlap the implications we discussed for holistic nature of UX. For instance, UX practitioners[4] need to understand these categories of experience, i.e. be-goals, and have the skills to design for particular groups of experiences.

UX is **worthwhile** (aka. positive), meaning that it focuses on value and creating desirable experiences than only preventing negative ones, i.e. the focus of usability [6]. While through usability, HCI traditionally focuses on problems, frustration, stress and their removal (i.e., negative), UX research emphasizes that removal of dissatisfaction does not necessarily lead to satisfaction and pleasure. As Hassenzahl emphasizes, UX, through its holistic nature, addresses both, satisfiers (e.g., fulfilled needs, emerging emotions) and dissatisfiers (e.g., usability problem and technical problems) [6]. The implications of being worthwhile therefore to a large extend overlap the implications of its holistic nature.

Despite the emphasis of UX theories on the above UX characteristics and how they differentiate the two concepts of UX and usability, only a limited number of empirical studies have so far analyzed the implications of these differences. One example is the study by Vermeeren et al. [13] that compares challenges in evaluating usability and UX. Vermeeren et al. discuss extra difficulties practitioners face in UX work for example concerning how to evaluate UX in earlier phases when no functional software exists to interact with. They report a number of challenges practitioners face when using UX evaluation methods. They argue that some of these methods still need to be further improved and developed for better use in practice. According to Vermeeren et al., there is still a lack of suitable methods for evaluating UX in earlier phases or in the period before actual use (i.e. anticipated use). They also highlight that current methods are not often practical because they need special expertise, are time consuming, or their data analysis is hard. Similarly, Isomursu et al. [11] discuss that practitioners face extra difficulties in practice of UX compared to usability because they do not have access to tools and methods to objectively measure UX.

[margin note: only those empirical studies are kept that support our discussion]

Through an interview and survey study, Law et al. [24] explore the basic question of whether UX elements are measurable. Law et al. report that their interviewees expressed skepticism and ambivalence towards specific UX measures even if attitudes were more positive overall. They note that practitioners show opposing views on whether UX can or should be divided into composing elements, or whether it needs to be considered or measured as a whole. Results from their interviews show three categories of challenges concerning the interplay between UX evaluation and software development: (i) *theoretical* (measuring UX holistically or in elements, and conceptualizing long-lasting versus momentary experience), (ii) *methodological* (differing preferences for quantitative versus qualitative data by design- and engineering-oriented stakeholders), and (iii) *practical* (lack of knowledge and competence for interpreting measurement outcomes).

The survey by Law et al. [24] is duplicated in the context of the Latin American software development industry by Gerea et al. [25]. They conclude that practical aspects such as cost and time play a more important role in whether or not practitioners measure UX. Other challenges reported by Gerea et al. include: limited access to the end users, and lack of knowledge and experience in UX measurement similar to what Vermeeren et al. [13] found.

Through another survey study, Alves et al. [26] investigated how UX evaluation is performed in practice (i.e., by whom, in what phases of software development, and using what tools and methods). They report a number of challenges concerning UX evaluation. ~~For instance they highlight the challenge of low involvement of users.~~ According to their data, in around 50% of the cases UX evaluation is performed without involving the end users, and often evaluators 'assume' what the perception of users will be, rather than actually

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[4]Here, we use the terms 'UX practitioner' and 'non-UX practitioners' to respectively refer to practitioners who have UX-related roles and responsibilities in the organizations and those who do not.

Company Type	Number of Employees
(A) IT services, consultancy & outsourcing	>130,000
(B) Defense & security	¯14,000
(C) Wireless solutions & network testing	¯1,800
(D) Systems & software development company	¯120
(E) User Experience consultancy & training	¯50
(F) IT & management consultancy	> 1,300
(G) User Experience & Usability consultancy	34
(H) Telecommunication	¯114,000

Table 1: Overview of the companies that participated in the study

involving them. This challenge is attributed to the generic issue of limited resources (time, effort, and competence). Another challenge concerns low involvement of UX experts. Alves et al. report that sometimes evaluations are performed by software developers that do not necessarily have the required competence. Also, often tools and methods are selected based on cost rather than suitability for the project. Alves el al. used a list of evaluation tools and methods that are mainly usability specific (e.g., cognitive walk through and task analysis), or generic (e.g., observation, interview, and think aloud). ~~The list lacks tools and methods that are proposed~~ for evaluating hedonic aspect of UX or user emotional reactions (e.g., Attrakdiff questionnaire [27][5]). This can introduce a risk to the data because practitioners might have preferred the use of a generic method such as a questionnaire for evaluating UX, without necessarily acknowledging that such generic methods may purely produce usability-related data if not used with specific attention to UX-related concepts, such as the non-tasks-related aspect of use [28].

As we saw, those studies that explicitly take differences between UX and usability into account, often mainly focus on evaluation activities and the role of UX measures in challenges practitioners face. Studies such as the study by Law et al. [24] are valuable since they differentiate UX and usability and emphasize the role of various characteristics of UX. Nevertheless, because of their scope (i.e. focusing on UX measures and their implications for UX evaluation in practice) they do not sufficiently discuss other aspects of UX work, for instance requirements or communication and collaboration between UX and non-UX practitioners.

Hence, the related work strengthens the need for further empirical studies investigating UX practice in software development industry. In particular, there is a need for studies that investigate the role of UX characteristics and differences between UX and other software quality characteristics including usability. Such studies can help better understanding the practice of UX and related challenges. In response to this research gap, we investigate UX challenges in software development industry and analyze them based on UX characteristics. We also pay certain attention to similarities and differences between UX and other quality characteristics of software, in particular usability.

3. Methods

We have conducted an explorative, qualitative study [29] to investigate the challenges involved in integrating UX practices into software development processes. Below, we detail our research approach by describing the different companies where we conducted interviews, how the data was collected, and our approach to data analysis.

3.1. Research Sites

We selected a variety of companies with different characteristics for our study in order to improve the generalizability of our findings [30]. Table 1 shows an overview of these companies and their main characteristics and labels them (A-H) for easier reference later in the paper. The companies span various domains (company type) and vary in size (number of employees). The table also details the roles of the interviewees

a new table is added with more information on the interviewees

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[5]see http://www.allaboutux.org for more UX specific tools and methods

Code	Roles & Responsibilities	Education	Experience (since)
A-1	Business developer, UX lead & interaction designer	Cartoonist	2010
A-2	Interaction designer & UX designer	Computer science & interaction design	2005
A-3	Project leader & developer	Computer science	2006
A-4	Art director & graphical designer	Photography	1996
B-1	Software engineer & project manager	Psychology & electrical engineering	2007
B-2	Technical product manager	Computer science	2000
B-3	Senior project manager	Computer science	1995
B-4	Product manager & project manager	Computer science	2006
B-5	Technical project manager & requirements analyst	Computer science	2002
B-6	System developer & interaction designer	Computer science & interaction design	2011
C-1	UX lead & interaction designer	Cognitive science	1996
D-1	System developer & requirements analyst	Computer science	2000
E-1	Business developer, UX lead & interaction designer	Software engineering	1983
F-1	UX lead & human factors specialist	Cognitive science	1989
G-1	Manager, design strategist & UX lead	Design	1999
H-1	Manager, design strategist & UX designer	Multimedia & interaction design	1997
H-2	UX designer	Multimdeia & design	1996

Table 2: The interviewees who participated in this study.

at each company. The first two companies are active only in Sweden, and the rest are internationally active. We approached both consultancy and product development companies in order to cover both perspectives. Both A and E are well-known consultancy companies in Sweden, while B, C, D, and H are well-known product development companies in Sweden. Throughout the study, we were introduced to other companies by our interviewees, from which we also included a number of interviewees (F and G). Only one of the companies (E) was previously known to the authors based on previous research collaborations.

3.2. Data Collection

At each company we asked for interviewees with specific roles such as practitioners with technical or design backgrounds. The aim of the interviews was presented to our main contacts in each company to assure selected interviewees were suitable for our research. We had the option to ask for more interviewees, but since the study was explorative, after 17 interviews we were confident that we had covered the major challenges from a sufficiently broad range of perspectives. The selected practitioners (see Table 2) represent technical (e.g., developers), design (e.g., interaction designers), and management roles. [more details is provided on data collection]

We conducted semi-structured interviews [31] to collect more of the interviewees' viewpoints, which was important to the explorative nature of our study. In each interview, the interviewer presented herself and the aim of the study. The interview was then started by asking about the interviewees experience and background. The next question concerned the concept of UX and how in interviewees' eye it differs from usability. The interview was then followed by asking questions (provided in appendix A) that covered the main development process phases.

We prepared an interview guide with a set of pre-designed questions based on the knowledge gained from literature. In each interview, questions were rephrased, added, or skipped based on the interviewee's background and responses. Each interview covered all phases of software development processes, the activities performed in each phase, and the tools and methods applied. Thirteen of the interviews were conducted face-to-face, and four via video or telephone conference. Each interview lasted between 30-60 minutes, and was recorded and transcribed. The interviews were all performed in the spring of 2012.

3.3. Data Analysis

We analyzed the data by applying a combination of inductive and deductive approaches, generally known [more details about coding is provided]

as *thematic analysis.* Thematic analysis is defined as *"a method for identifying, analyzing and reporting patterns (themes) within data."* [29]. Thematic analysis is a popular method in qualitative research. In our thematic analysis, we followed the steps recommend by Braun and Clarke [29].

We *segmented* the interview transcriptions into meaningful paragraphs or sentences in a way that each of these segments presented one concept. We then *coded* these segments [29]. We used Microsoft Excel to document the coded data. Each interview transcript was recorded in a separate sheet. Segments of this transcript was recorded in separate rows, and different codes were assigned to each segment in separated columns, following that segment. After coding, categories of challenges, i.e. themes, emerged as we put together similar concepts presented in the coded segments. For this purpose, a mind-map of challenges and categories was created to better identify and visualize the relations. Different parts of this mind-map are included in Section 4.

Based on a pilot coding, we gradually and iteratively generated an improved coding guide for the rest of the coding and analysis process. The initial main codes that were used in this study include definition, challenges, solutions, tools and methods, evaluations, requirements, UX versus usability, and activities. These codes reflect a broader scope than merely challenges because we were interested to learn the identified challenges in context. Therefore, when applicable, during the interviews, follow-up questions were asked regarding the mentioned challenges. These questions aimed to gather more data on attempted solutions, or previous experiences with usability or other quality characteristics. We then further analyzed the segments that were coded as 'challenges'. The initial list of codes were generated based on our knowledge and experience in the field and after we became more familiarized with the interview data [29]. When the interviewees used different terminologies, or had limited knowledge concerning UX or usability, we mapped their statements to the relevant concepts based on the definitions of the concepts in literature.

Figure 1 depicts our data gathering and analysis process. To make our process more concrete, we give an example of how we performed coding and identified the challenges. The interview segment: *"There is a bit of confusion in the field and in the company as well, what's the difference? design is design"* (A-1) resulted in identifying key points: (definition of UX is not clear, practitioners do not know what UX exactly means), and was coded with 'challenge', and 'definition'. This segment was further analyzed because it was coded as 'challenge'. Together with other segments that related to understanding and definition of UX, this segment then resulted in emerging the theme 'lack of consensus on definition and construct of UX' (Figure 2).

Our analysis resulted in 8 main themes for challenges. There is a clear multifaceted relation between the identified themes. Some, for instance, could be seen as causes or at least underlying factors in relation to other themes. Some are more fundamental and concern the view, attitude and knowledge of stakeholders while some are more tactical and/or practical. Still, in this paper, the themes are presented as one linear list rather than as an interconnected 'web' of challenges. This is mainly because our data does not provide sufficient evidence to support the relations between identified themes. Future work should consider studying connections between the themes in more detail.

> a picture now depicts our data gathering and analysis

3.4. Threats to Validity

Threats to validity are outlined and discussed based on the classification by Runeson and Höst [30]: Selection process of subjects for interviews can cause a threat to *construct validity*. Selection bias is always present when subjects are not fully randomly sampled. However, here the subjects were selected based on their role, experience and availability so there is little more we could do to alleviate this threat. The presence of a researcher may influence the behavior and response of the subjects. This threat was alleviated somewhat by the guarantee of confidentiality of the data but is an inherent aspect of the research method used.

In any empirical study, incorrect data is a threat to *internal validity*. In case of the interviews, taking records in form of audio, which was then transcribed, mitigated this threat. The authors also analyzed the material in several rounds of independent as well as joint sessions to gradually reach consensus on the intended meaning of the respondents. We also shared the results of our analysis with the interviewees to validate and confirm the findings.
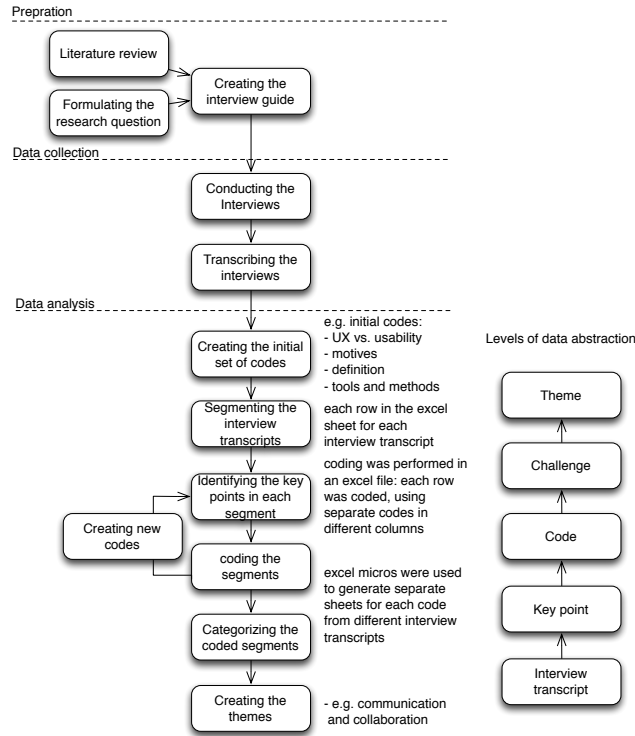
Figure 1: Process of data gathering and analysis

External validity concerns the ability to generalize the results beyond the actual study. Since the interviews are just a sample from a potentially very large population, they should be interpreted with some caution. Still we sampled a number of different organizations in different industrial domains to decrease the effect of this threat. However, qualitative studies rarely attempt to generalize beyond the actual setting and are more concerned with explaining and understanding the phenomena under study. Another concern is that our data gathering was performed in the spring of 2012. Therefore, our data may not reflect today's UX state-of-practice in these organizations. However, the data still is valid when interpreted in its own time frame. Also, to minimize the effect of time span on our analysis, we have included recent studies published since 2012 when analyzing the data and discussing the results.

Another threat concerns *reliability*, to what extent the data and analysis are dependent on the specific researchers. Although the coding process is performed by the first author, to improve reliability of the generated themes, the three authors individually and independently conducted a pilot coding of these segments using an initial coding guide as explained above. The outcomes of the pilot coding were discussed in several sessions with all three authors, and the differences in coding were analyzed and resolved. Also, we had carefully designed the interviews before running them, ==and the coding process before analyzing the data.== In ~~analysis, and generating themes,~~ we ~~assured~~ that the themes are not imposed on the data rather emerged from it. ~~To do so, we followed the recommended steps for thematics analysis [29] where more abstract themes emerged from the data in an iterative process.~~

4. ==Results==

This section presents 8 themes of challenges that emerged from the interview data. These themes are described and supported by the interviewees' quotations. ==Each quotation is marked by the interviewee code and also terms SE/HCI. These two terms reflect to which community the interviewee's view belongs.== This

8

The identified themes of challenges
Theme 1. Lack of consensus on definition and construct of UX
Theme 2. Lack of consensus on the value of UX
Theme 3. Low industrial impact of UX models, tools, and methods
Theme 4. More focus on objectively measurable aspects of software
Theme 5. Difficulties in engineering UX-related requirements
Theme 6. More focus on testing functionalities and usability than UX evaluation
Theme 7. Lack of consensus on UX-related competences and responsibilities
Theme 8. Communication and collaboration gap between UX and non-UX practitioners

Table 3: We identified 8 themes of challenges through interviewees with 17 practitioners in eight software companies

helps better understanding current state of practice from these two perspectives, hence better planning to bridge the existing gaps between the two fields of SE and HCI. In our interviews, we did not focus on the connection between challenges. Still, we can discuss a number of possible interrelation among these themes to the extent observable in our data. Future work is needed to detail and validate these connections.

Theme 1. Lack of consensus on definition and construct of UX

Our data shows that practitioners' understanding of the concept of UX differs and is, in some cases, even inconsistent and contradictory. According to the respondents, UX is a new concept and there is still a lack of general agreement on its meaning in the field in general, and among practitioners within organizations in particular (A-1/HCI). In some practitioners' view, UX is the same as, or is seen as, usability or Interaction Design (IxD). This is while these two concepts only concern details of the interaction, and/or the Graphical User Interface (GUI) design as the UX practitioners stressed. The lopsided focus on usability and IxD can be explained by their relative simplicity: *"I think discussions at large when it comes to UX design at common ground is still about IxD and usability. Usability is easy to talk about and everybody understands it."* (A-1/HCI).

One of the interviewees referred to UX as 'just another buzz word' (E-1/HCI). In her view, UX contains the same concepts that have been around for a long time under other names such as usability and 'emotional design'. On the other hand, some practitioners explicitly differentiated between UX and Usability (e.g. H-1/HCI) or IxD (e.g. F-1/HCI). One of the participants emphasized that usability is 'a minor subset of UX' and added: *"I've never, never called myself a usability expert, and I would never do that."* (H-1/HCI). Some of the participants emphasized that UX goes beyond 'cognitive aspects of design' (e.g. E-1/HCI), the main focus of usability. Similarly, another practitioner stressed that UX is not about 'IxD' and has a much broader perspective: *"[IxD] is just the end results, we do not call ourselves interaction designers, because that is only 10% of our work but that is an important element because that is the most visual part of our work ."* (F-1/HCI). Similarly, another practitioner referred to UX as: *"a wholeness with the emotional, social, economical, functional, and technical parts."* (A-4/HCI). Another practitioner described UX as: *"pretty much everything that affects a user's interaction with a product."* (H-2/HCI). He further emphasized UX is 'the whole package' and usability is only one part of it. Some practitioners related UX to the 'why' behind the functional requirements and the software in general. For instance, one practitioner described this through three main questions of 'what' to build, 'how' to build it, and 'why' to build it (A-4/HCI). Some practitioners related UX to the GUI by stating that it is about *"the cool things, the new things, the flashy things."* (A-3/SE). In their view, UX is mainly about *emotions* and *aesthetics* therefore not applicable to all types of applications, for instance 'productivity applications'.

In general, the practitioners with more technical backgrounds and roles showed less knowledge about UX. Their knowledge was often limited to cognitive aspects of design, i.e., usability. For instance, one of the technical managers stated: *" [our customers] talk about increased workload. That is a negative thing. I don't know if that qualifies as UX."* (B-2/SE). A number of practitioners stated that UX is a 'broad' and 'holistic' concept covering not only the user perspective, but also the business perspective (e.g. H-1/HCI). While the latter looks into how the design contributes to achieving business goals, the former assures ~~supporting~~ the end users' goals. The user perspective includes aspects such as 'emotions', 'values' and 'preferences'.

9

UX is seen equal to usability or IxD

practitioners have different understandings of UX

practitioners have inconsistent & contradictory views on UX

Theme 1: Lack of consensus on definition and construct of UX

there is a lack of consensus on meaning of UX both in research & practice
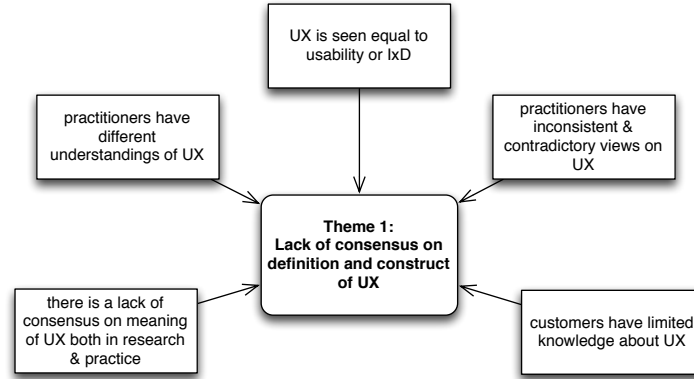
customers have limited knowledge about UX

Figure 2: Challenges identified concerning lack of consensus on definition and construct of UX (Theme 1)

The participants also discussed that customers' limited knowledge about UX is a challenge. Customers who have heard about UX can be too ambitious regarding emotional and non-task-related user needs. Customers' limited knowledge also means that they often specify the related requirements vaguely and using inconsistent and subjective terminology. They often indicate a need for quality characteristics such as 'cool', 'fun', or 'high-tech' mostly because they are affected by such 'buzz words'. They often neither have knowledge about what these terms actually mean, nor find them specifically relevant for their products. Regarding this one of the interviewees said: *"usually they say 'we want something like that app', 'we want it to be cool and high tech'. Then you have to initiate a dialog to find out what that means for this particular customer."* (A-1/HCI). Practitioners emphasized that to prevent misunderstandings, these UX-related requirements should, early on, be refined to more 'concrete' requirements, and specified in a measurable way (e.g. B-3).

A limited or lack of knowledge of UX can explain why it is not valued in development organizations or among customers as elaborated in Theme 2.

Theme 2. Lack of consensus on the value of UX

Generally speaking, our data shows that various stakeholders still have different views on whether UX is important or not. Nevertheless, according to several of the interviewees, an important motivation behind UX is the growing general importance of software in recent decades. Interactions users had with earlier software were limited to command-line interactions in software built to support existing manual work. This has now transformed into a multitude of interaction styles (mouse, touch, etc.) and applications. Software is now a large part of all aspects of most human life, and users are exposed to a huge variety of it. This exposure to various software systems affects the experience and expectations of users. Regarding this, one practitioner said: *"Users are meeting a lot of good things, and they are expecting good things all the time."* (E-1/HCI).

According to practitioners, various businesses are learning from successful products in the market. This has inspired not only market-driven but also business-to-business software projects. This is evidenced by one of the interviewees saying: *"A lot of business-to-business applications are being informed by business-to-consumer apps."* (G-1/HCI). In particular, in cases where a product has competitors, the motivation to improve UX increases. One of the practitioners argued that UX is nowadays a 'differentiator': *"Today I think that many companies do usable products, in order to distinguish a brand or a product we need to add an extra level to the product so that is really what I call UX. We need to take more things into account, e.g., emotions, and that it needs to look great, and it is not only about being usable."* (A-2/HCI). In market-driven products, branding, emotional concerns, and relations with end users are important. Therefore, these businesses are often more concerned about UX. Another interviewee argued that for market-driven software, in particular game development, UX is 'part of the common practice' (A-1/HCI) while this is not the case for business-

to-business software. He emphasized this approach of market-driven projects should be 'transferred to other projects' as well.

Some of the practitioners emphasized that UX is an important software quality characteristic that needs to be taken into account more in projects. But in some functionality-focused organizations UX is still considered something 'on the side' and not a core concept or value. According to these practitioners, when a product is more 'technical', the business units often focus on functionality, and UX becomes less important. As one of the interviewees emphasized, in this case the business unit is not 'that concerned with the look and feel' (A-4/HCI). The practitioners were generally positive that more and more organizations even the technology-focused ones are learning about UX and the importance of taking it into account in their products (e.g. H-2/HCI). For instance, one practitioner said that in their company, business units ~~are~~ now~~adays~~ show~~ing~~ less resistance towards UX and the importance of UX 'starts to be visible' (H-2/HCI) to these units.

In practitioners' view, often customers are less aware of UX and its value, and in particular how it differs from usability and IxD. In addition, they emphasized that preferences, values, and motivations of upper management involved in strategic decision making is, according to some practitioners, another reason why some organizations might undervalue UX, and show a less positive attitude towards it. Regarding this, one practitioner stated: *"I think it's sometimes just the reason people go into business in the first place . . . the people who are in it because they think that their product or service solves a real problem, they generally care about it more."* (G-1/HCI). He further discussed how individuals, in particular higher management, play an important role in whether UX is a priority in an organization or not. Regarding low support from other stakeholders, and in particular management, one of the interviewees stated that the inputs from their UX group in research and development is ignored by business units because some of the ideas are ahead of their time: *"business units are occupied with their very close, near time results so they look at what can they sell now."* (H-2/HCI). He further highlighted that some of these previously rejected UX ideas are now being incorporated in the products and are getting support from management because competitors are ~~now~~ implementing similar ideas.

Another challenge is that customers often resist taking on the costs of performing UX work (e.g. A-4/HCI). Often customers believe UX is an add-on rather than a core concept that will help them improve their businesses. Regarding difficulties in convincing customers, a practitioner said: *"It can be hard . . . If you have to have three weeks extra to make the graphics work in a certain way, they might think it's unnecessary. And maybe the software's going to work fine, but if they made these extra efforts or put in this extra amount of money, they would have actually gone much, much further maybe."* (A-4/HCI). Similarly, a number of practitioners from a technology-focused organization emphasized that their customers are often too technology-oriented to care about UX (e.g. B-6/HCI). On the other hand, it was not surprising to see that practitioners from the two UX consultancy companies found their customers more positive and open towards UX: *"Most people who invest in IT want to succeed, and those who are hiring us they know that you have to know the users."* (E-1/HCI).

As a way to convince customers to agree to the cost of UX practices, some practitioners use examples of successful products in the market (e.g., Apple) that are known for their good UX (e.g. A-4/HCI). As another solution, one case company uses fixed prices for their projects so that practitioners can freely spend part of this money on UX practices (e.g. F-1/HCI). Similarly, some practitioners emphasized that they talk about UX 'indirectly'. They connect UX to business goals, and argue for UX from the point of view of the business success, and not the end users. An interviewee motivated this by saying: *"if you start babbling about usability and strange kind of things, they will say 'oh! I don't want to pay for this'."* (E-1/HCI).

According to some practitioners, UX practices should be sold to the customer as part of the contract to assure that covers the associated costs. This requires showing how such practices will add value to the software and have a return on investment (ROI) for the customer. Nevertheless, often presenting a ROI is difficult. This is evidenced by a UX practitioner who said: *"I don't think you can put ROI into a proposal necessarily. I think that's irresponsible, frankly. Because 95% of the time, we don't understand the true and false nature of an issue when we're writing a proposal. It's only after working with a client for a little bit of time that we begin to see the nuance there. That usually undercuts any kind of understanding that's used to generate proposed improvements in ROI, for example."* (G-1/HCI).
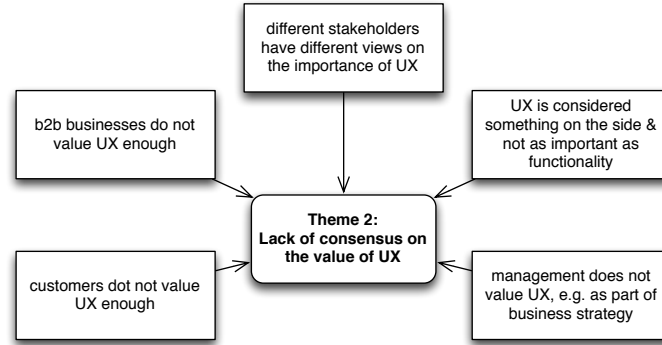
Figure 3: Challenges identified concerning lack of consensus on the value of UX (Theme 2)

Overall there ~~is a~~ very varied view, and a general lack of consensus, on the value of UX both between and within the investigated organizations. In addition, practitioners stated that customers also differ in their levels of awareness and how they value UX. The common pattern is that customers often down-prioritize UX and are either not, or less willing to pay for it.

Theme 3. Low industrial impact of UX models, tools and methods

While Theme 1 ~~(Lack of consensus on definition and construct of UX)~~ concerns the lack of consensus on the definition and construct of UX itself, this theme concerns difficulties in how this understanding is gained or put into practice. Challenges in this theme are also in direct relation to Theme 5. *Difficulties in engineering UX-related requirements* and Theme 6. *More focus on testing functionalities and usability than UX evaluation*, where our findings regarding testing or requirements activities are presented in more details.

We observed that often practitioners' knowledge regarding UX ~~is more~~ based on experience and work with similar concepts, not on any specific UX models or theories. This knowledge is sometimes shaped through their education on 'usability' and IxD, and has changed over the years ~~be~~ focus more on UX. For instance, one of the practitioners stated: *"When I first started in the 90s, there was no such thing as UX or IxD, actually ... [then] it has been IxD and then sort of merged into UX design."* (H-1/HCI).

Very few of the interviewees were familiar with currently influential approaches to UX and corresponding models, even those interviewees that demonstrated a relatively good understanding of UX. The interviewees handle users' emotions, values etc. ~~not~~ 'in an academic way' (e.g. A-4/HCI) or 'by the book' (e.g. A-2/HCI). They seem to mostly gain their knowledge about UX from individual experiences rather than from existing UX theories and research. A lack of ~~a~~ common reference and knowledge base can lead to ~~that~~ the concepts of UX and UX practices mean different things to different people, ~~i.e., a language gap~~. This gap may contribute to communication problems within software development organizations as indicated by the interviewees. A limited knowledge of UX (Theme 1. *Lack of consensus on definition and construct of UX*) is likely also connected with the low impact of UX models in industry.

Still, these practitioners generally showed a positive attitude towards applying new models, tools, methods and techniques to their work: *"we are lacking this, so this would be really nice to have more research results that we could apply."* (A-2/HCI). However, some organizations resist introducing new models, tools, methods, or techniques. Hence, in these organizations, practitioners can only rely on traditional interview and observation techniques in their work with UX (A-2/HCI). The interviewees referred to two models they use in their UX work: 'emotional design' by Donald Norman and Maslow's hierarchy of human needs. The latter is used as an inspiration when eliciting user needs. ~~The~~ interviewees mentioned such models can help creating a methodology to work with UX and 'build the right things in the right order' (F-1/HCI)~~. But~~ respondents with this type of experience were a clear minority.
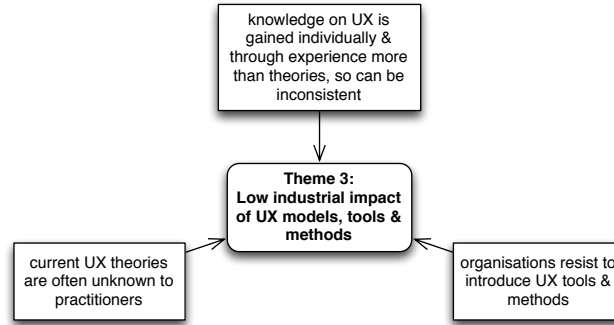
Figure 4: Challenges identified concerning low industrial impact of UX models, tools and methods (Theme 3)

Theme 4. More focus on objectively measurable aspects of software

A group of practitioners emphasized that the software development and engineering community has traditionally had much greater focus on software functionality than quality characteristics. In their view, functionalities of a piece of software are important in achieving a good UX but too much focus on them can often lead to ignoring UX (e.g. H-2/HCI). One practitioner stressed the relation between functionality and UX as follows: *"The quality of experience is really depending to some extent on how the functional requirements are met, but also actually on what the functional requirements are, also just the amount of them."* (H-1/HCI). This interviewee further emphasized: *"For us, technology is the material that we can shape in order to create experiences."*

The interviewees emphasized that satisfying functional requirements does not necessarily mean that ~~the~~ correct or valuable functionality is included in the software. This is evidenced by one interviewee saying: *"what do you know when you have signed [the technical specification]? Do you know that it is a good solution? No! you only know that it meets the functional requirements and to me it is silly!"* (E-1/HCI).

In addition, according to the participants, the software community still often focuses more on 'actual' qualities of software than its 'perceived' qualities. While the former concerns objectively measurable quality characteristics, the latter concerns how users subjectively perceive these qualities. For instance, users may perceive a five milliseconds response time (i.e., actual performance) as fast or slow (i.e., perceived performance). Regarding the role of perceived qualities in experience of users an interviewee stated: *"sometimes the perception of time is more important than the actual time, and these are the things you should pinpoint [to the stakeholders]."* (E-1/HCI).

Through this lopsided emphasis on functionalities and actual quality characteristics, we can explain the identified challenges concerning UX-related requirements (Theme 5. *Difficulties in engineering UX-related requirements*) and testing (Theme 6. *More focus on testing functionalities and usability than UX evaluation*). In addition, even if companies intend to focus more on UX, they do not always have the capability to turn this intention into action. For instance, they still lack required competences (Theme 7) or tools and methods (Theme 3) as we describe in the following.

Theme 5. Difficulties in engineering UX-related requirements

According to the practitioners, in many cases, the non-task-related needs of users (i.e. their be-goals) or their emotions are still either neglected or treated only informally. In one organization, emotional design goals are often only documented and communicated in the form of a 'post-it note on the wall', as a reminder. The practitioners highlighted that it is still an open problem as to how to map these types of needs to measurable requirements. For instance, one of the interviewees stated: *"I would say the emotional part of this is very very rarely formally put into words."* (A-1/HCI). Practitioners argued that these needs are hard to elicit, refine, communicate, and agree upon. Stakeholders in general have less knowledge about this type
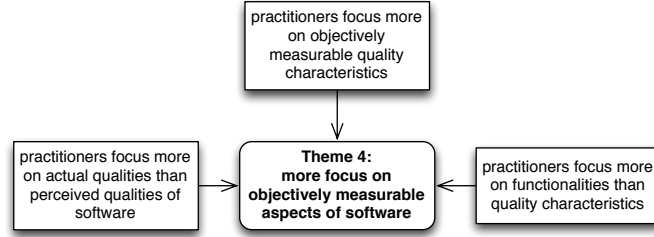
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Figure 5: Challenges identified concerning more focus on objectively measurable aspects of software (Theme 4)

of needs, organizations still lack the related competencies and have only limited access to tools, methods and techniques to deal with it (e.g. B-3/SE).

A practitioner stated that they use 'persona' to 'informally' document UX-related requirements: *"We'd specify this more in the persona descriptions; for example that this persona needs to, or wants to experience some kind of things. In the wireframes, we might specify an animation for example that it should feel smooth or something like that."* (A-2/HCI). They, however, further emphasized that this approach is not optimal and there is a need for more formal approaches to deal with such requirements: *"it should be good if we could formalize it a little bit more I think."* (A-2/HCI).

The practitioners generally agreed that to communicate UX-related requirements, they require forms of requirements other than textual (e.g., sketches, wireframes). They emphasized 'concrete and tangible' form of requirements facilitate communicating the 'fluffy' requirements. Regarding this an interviewee told us: *"we create 'mood boards' where you take an image-driven approach to the look and feel, and we use references of course, like 'that app has a good flow in it', and 'that app has a good feeling to it'."* (A-1/HCI). More technical practitioners also seemed to have a similar approach to UX-related requirements: *"If the customer said that they want it to 'look nice', then you have to make the graphical design first and then they can say 'hey! this looks nice' and then you have taken care of that requirement."* (A-3/SE).

Nevertheless, only in one organization were these non-textual UX-related requirements (e.g., wireframes) traceable to other requirements (F-1/HCI). Regarding this a practitioner stated: *"requirement list is not important for the business at the end, they wanna see the wireframes. So at the end we show the wireframes with all kinds of numbers and those numbers are linked to the excel sheets of the requirements, their descriptions and how they are linked with the CPR and business case."* (F-1/HCI).

Emphasizing the challenges concerning UX-related requirements, one interviewee stated: *"Functional requirements are easy to create, to merge into a design; more emotional things are more difficult."* (F-1/HCI). Similarly, one interviewee stated that features are 'easier to define': *"when it comes to both features and user experience requirements – features are a bit easier to define somehow, because you can say things like, 'Right, we need an email component with this capability'."* (H-1/HCI). Besides lack of knowledge and understanding, practitioners related these problems to a lack of competence in dealing with UX-related requirements within their organizations (e.g. A-3/SE). Regarding this, one practitioner highlighted: *"features are what most project managers, most managers can understand. You can count them, you can map them to customers, customer dialog for instance, and so forth, and you can compare your amount of features with the competitors."* (H-1/HCI). Similarly, another practitioner stated: *"I think it is largely a competence thing. Doing emotional aspects of design is quite a new concept, I have only heard about it in the last year, or last two years maybe, so I do not think that knowledge has really reached the industry yet."* (A-3/SE). In particular, when the software product is more innovative these problems are compounded. This is evidenced by an interviewee saying: *"This is a kind of project where nobody really can tell how this should be, what it should be like, nobody has done it before, there are no standards to refer to ... who can specify those [UX-related] requirements? You need to have a certain quality but what is the suitable level of that quality? We haven't really found what that level is."* (B-3/SE).

Some practitioners highlighted the challenge of finding a balance between UX-related needs, business

goals, and technological constraints. Regarding the importance of finding a balance between emotional and business needs, one of the interviewees stated: *"you can spend a lot of time, thinking about people's emotions and so on, but if you are going to succeed you have to look at business perspective."* (E-1/HCI). In addition, according to the interviewees, while customers should be involved to assure alignment of ~~the~~ projects to business perspectives, the end users should be involved to assure alignment to UX-related needs (e.g. B-3/SE).

This is while still users are often not involved enough in projects and this further hinders a better requirements work for UX. In addition, we observed some inconsistencies in practitioners' views concerning user involvement. While they all agreed on the importance of involving the end users, the view of more technical people regarding this matter was divided. In favor of involving users an interviewee stated: *"maybe you want to have the end user involved also with the developers so that developers understand what they are doing, instead of just following the specifications. I think that would be very very valuable."* (A-3/SE). On the other hand, a project manager stated that involving users in requirements discussions increases project costs. Therefore, it is better to negotiate requirements and sign a contract without involving the users. Regarding this an interviewee stated: *"[they] think they can say anything during [requirement] workshop and then get it. It is not the case. It is impossible for us to have this sort of infinity. So it leads to lots of long long long discussions afterwards."* (B-2/SE). As another example: *"it usually leads to features that you take on more than what you agreed from the beginning. So it's possible that the customer gets a better system but they still don't pay you more money for this."* (B-1/SE).

One developer stated that they often have less access to end users, which can be problematic for their work mainly because this means developers do not often understand the rationale for requirements: *"developers do not get that interaction [with the end users] cause they get their specification from the marketing people, and they get their specification from the interaction designers. But developers don't get the motivation behind the requirements because that gets lost during the way. So, the marketing people say that we must have this requirement, and interaction designers say we must do it this way, so you have the 'what' and the 'how' but you never get the 'why'."* (A-3/SE). Some practitioners emphasized relying too much on the end users' opinions might lead to less creativity in the design work: *"we have a quote sitting on the wall here, it's from Henry Ford [that says] 'If I had asked people what they wanted, they would have said a faster horse'."* (H-2/HCI).

UX practitioners argued that UX-related requirements should be elicited before refining functional requirements. For instance, one interviewee stated: *"First you have to define the business requirements, the user requirements, the IxD, then you can define the functional requirements."* (E-1/HCI). Another practitioner said: *"I think that the functional requirements should come as a result of a dialog between different types of domains such as user experience, business, and technology."* (H-1/HCI). Nevertheless, according to these practitioners, such an approach is not common in practice. This is expected since more technical roles emphasized that the requirement process should start by first eliciting and refining functional requirements then quality requirements.

Theme 6. More focus on testing functionalities and usability than UX evaluation

Our data shows that in general, our selected organizations is mainly focused on testing functionality. In addition, similar to the previous theme on requirements work, the interviewees highlighted that ~~still~~ limited involvement of the end users in projects is a challenge in evaluating UX. In particular, since evaluating UX requires gathering users subjective perception of the software.

We observed that practitioners with technical backgrounds are often less familiar with how their organizations handle UX or even usability testing. They also showed limited knowledge as to why such evaluations can be useful to the success of the software (e.g., B-2, B-4).

Generally speaking, the practice of UX evaluation is still immature in many organizations. In projects with limited time or budget, UX evaluation is either non-existent or rare compared to other testing activities: *"we have done much functional testing of course, system tests etc., but end user testing we have not performed much I'd say."* (A-2/HCI). In some organizations, UX evaluation is basically replaced by usability testing. Regarding this, one interviewee stated: *"I think user tests tend to be more focused on pure usability. I guess*
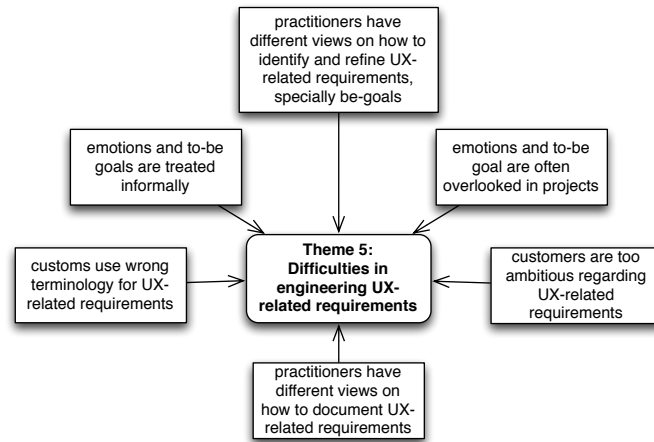
Figure 6: Challenges identified concerning difficulties in engineering UX-related requirements (Theme 5)

it's when you're releasing the product into the wild, that's when you start to get maybe the most valuable feedback or the most truthful ones." (A-4/HCI). According to these practitioners, usability testing is not enough to evaluate the whole UX of the software. Regarding this, a UX practitioner stated: *"when you evaluate usability, it's when you go into the nitty gritty details, and try to look at more efficiency within the user interface. My personal view is that that is not that relevant. I mean it's relevant, but not in what we do [i.e., UX]."* (H-2/HCI). To compensate limited formal UX evaluations, some organizations gather informal qualitative user feedback after release, for instance through comments in the App Store or on social media (e.g. A-2/HCI). Some organizations perform user surveys that are not necessarily designed for evaluating UX (e.g. A-1/HCI).

According to the practitioners we spoke with, UX evaluation is limited because it is more difficult compared to evaluating usability or other quality characteristics. Some practitioners related this difficulty to the fact that UX involves emotions, and non-task-related user needs (i.e., be-goals), and that limited tools and methods exists to support addressing these needs in evaluation work. In their view, emotion can be even impossible to measure using current quantitative approaches. One of the practitioners stated: *"it is difficult to sort out or really get the correct feeling that the user has because they will try to explain it but it perhaps is not the real emotion that we catch at the end, if it would be a method or approach to really get these from the user that would be great."* (A-2/HCI). Similarly, one interviewee said: *"some goals are more difficult to measure than others, e.g., if this is a feeling thing: 'I should be very well informed', but mostly you can measure [them] in the usage test through observations and interviews"* (E-1/HCI). This practitioner further emphasized that although they can specify quantitative measures for UX-related requirements (e.g., "10 out of 10 users should succeed, and they should be content"), they still need to observe users in order to gain better understanding of the experience: *"can the users perform the tasks? how do they perform the tasks? how do they feel afterwards? are they content?"* (E-1/HCI). This interviewee further emphasized that to measure feelings of users they need 'a rather complete prototype' (E-1/HCI). However, practitioners still have difficulties in accessing the end users: *"I think we should involve end users lot more but it is a political issue, the project needs to convince the customer that this is necessary."* (A-2/HCI).

Some practitioners related the difficulty in UX evaluation to the holistic nature of UX. Discussing cases where practitioners take a holistic approach to UX, one interviewee stated: *"how would you measure that sort of holistic experience throughout the process of designing it? Because, of course you cannot [implement or design] everything at the same time, and you know there are so many dependencies. How do you straighten those out and how do you understand what you're measuring and not measuring?"* (H-1/HCI). This interviewee further emphasized that the broader scope of UX negatively impacts evaluations: *"Evaluation is a problem of course, cause user experience is much broader in scope than usability, it's more difficult to*
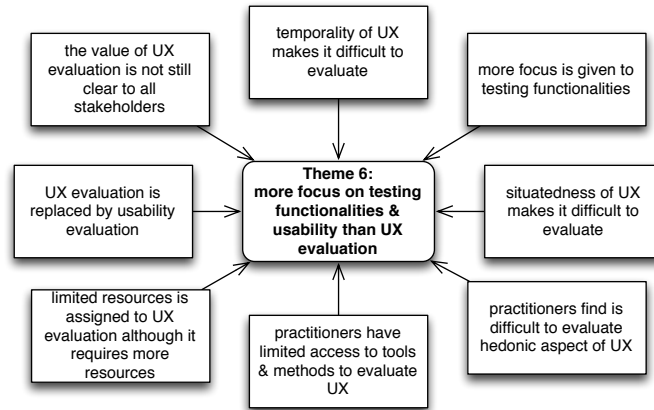
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Figure 7: Challenges identified concerning more focus on testing functionalities and usability than UX evaluation (Theme 6)

evaluate also. Like the phone example that I gave you before, how do you pick up on the fact that someone has experienced the competition unless you ask for it? Can you count on what a person would actually say about their experience? What if the person doesn't say anything? That's a problem, of course, because UX is much broader in scope, and if you have a wider scope on it, then you have a much more difficult task to actually frame it in an evaluation phase." (H-1/HCI)

Some practitioners related the difficulty in UX evaluation to the fact that users' expectations and their perception of a product change over time and are affected by various factors; e.g., introduction of new technologies or appearance of a competitor's product. In this regard, one of the interviewees highlighted: *"It's like when you try on new clothes. The shirt you were wearing going into the dressing room and looked fine, looks shabby when you've tried out the new shirt."* (H-1/HCI). The interviewee used this analogy to explain the subjective and dynamic nature of expectations, and that for each individual a new experience can affect the user's perception of other products.

The interviewees stated that there are still a number of open problems concerning UX evaluation. One problem in evaluation concerns the temporality of UX, another problem concerns difficulties in relating the result of laboratory evaluations to the real experience of users (e.g. H-1/HCI). Another problem concerns the relation between different episodes of experience, for instance first impression of users (initial UX) and overall UX or UX after using the software for a while (accumulative UX) (e.g. A-2/HCI).

Challenges in requirements work and testing are connected with challenges in involving UX practitioners in projects. It is more difficult to identify, refine, document, and test UX-related requirements (Theme 5) and companies still lack required competences (Theme 7). Even if UX practitioners with the right competence are present in a company, they often face power struggle, and lack of trust, therefore fail to effectively communicate and collaborate with non-UX practitioners (Theme 8).

Theme 7. *Lack of consensus on UX-related competences and responsibilities*

Our data shows that to facilitate developing software with better UX, organizations need to have access to a variety of competences including brand management, visual design, usability engineering, interaction design, and emotional and pleasurable design. The interviewees highlighted that their organizations still lack practitioners with competences for eliciting, refining, communicating, and testing be-goals or emotional needs of users. This can explain the identified challenges concerning requirements work (Theme 5. *Difficulties in engineering UX-related requirements*) and evaluation (Theme 6. *More focus on testing functionalities and usability than UX evaluation*).

Also, it is still not clear how organizations should manage this set of often quite differing competences. The interviewees showed two main perspectives concerning this. One group believes such a set of competences is hard to find in individual practitioners and all of the team members (with different competences) should

take a joint responsibility towards UX. Regarding this, one of the practitioners said: *"I'm not sure if that should be a specific role [. . .] so everybody should have a UX focus now. I'm not sure if we can have some sort of UX guy [who takes the final decisions]."* (A-4/HCI). He further argued that achieving a better UX requires a 'UX-mindset' in projects that even the most technical roles in the projects (e.g., programmers) should have. The other group believes there is a need for specific individual practitioners with these multidisciplinary competences (i.e., defining specific UX-related roles). Although in this case, often such practitioners find it difficult to 'be a little bit of everything', and 'juggle' their various competences (e.g. H-1/HCI). Regarding the importance of individuals with diverse set of competences, another practitioner stated: *"I, as an art director, have to have somewhat deep knowledge about UX, and also IxD . . . you can't separate them."* (A-4/HCI).

The participants also discussed the responsibilities UX practitioners may have in projects, and tasks they should perform. Our data shows that there is a direct relation between the extent of access to practitioners with various competences and responsibilities they take in projects. Depending on the organizations studied, the UX practitioners had various responsibilities including performing user research, concept development, designing GUIs, testing usability of the software, requirements gathering (including both business and end user needs), creating design principles and guidelines, and performing market research. As some UX practitioners expressed, they have varying responsibilities in and contributions to different projects; this depends on factors such as management support, available resources, and timing. We also observed that the more technical practitioners are less informed about the responsibilities related to UX.

In general, our data shows that the responsibilities of UX practitioners are very diverse, and depend on various factors such as resources available, or the maturity of the company in relation to UX practices. For instance, in one organization (C), the UX team is responsible for handling requirements and feeding them to the development teams. One UX practitioners described her responsibility as: *"that can loosely be described as discovery, research, overall strategy, and then high-level design."* (G-1/HCI). However, in another organization (H), the UX group is part of R&D where the group mainly focuses on future products, and long term vision of the company. As a parallel responsibility, the group gives feedback and support regarding UX to the development teams involved with current products. In some organizations, since the number of practitioners with UX knowledge is low, none of these practitioners are part of any particular project teams, and are instead shared resources among them (e.g. H-1/HCI). UX practitioners are also often responsible for spreading knowledge and awareness about UX in the organization. Regarding this, a practitioner expressed: *"I think on a very high level, our responsibility is to inform, influence and inspire."* (H-1/HCI). He further stated: *"we contribute to the process by running workshops, by providing provocative questions, or providing examples, engaging in discussions in which people from other domains dig down really deep into their own layers of knowledge, and we can ask really simple questions to poke them with our perspective."* (H-1/HCI).

Being able to gain an overall view of UX design was one of the concerns highlighted in the interviews. According to practitioners, this is often a difficult yet important prerequisite for creating a coherent UX. As the interviewees stated, to deal with the complexity of today's systems, the common approach in the software community is to break down the whole system into various sub-systems and work independently on them. Such an approach can harm the UX of the software since often in these cases UX practitioners lose the overall view on the UX design, how these different sub-systems fit together as a whole, and how they individually and in combination contribute to the experience of the end users. Regarding this, one interviewee emphasized: *"you have to tear it down, yeah! but what happens to the whole? who is going to define the whole?"* (E-1/HCI). The interviewees also highlighted that in agile processes, the decision-making process is more spread out both over time as well as among the team members. This further complicates the process of creating a unified and coherent UX design (e.g H-1/HCI). Further, agile processes enforce a focus on a few piece(s) of the design at each iteration. Regarding this, one interviewee said: *"you need to deliver wireframes for parts of the application but you still do not know how it all will fit together at the end."* (A-2/HCI).
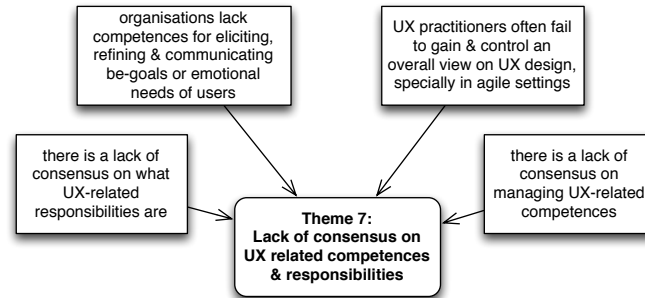
Figure 8: Challenges identified concerning lack of consensus on UX-related competences and responsibilities (Theme 7)

Theme 8. *Communication and collaboration gap between UX and non-UX practitioners*

According to the interviewees, for various reasons UX practitioners face 'power struggles' in relation to non-UX practitioners: wide range of UX responsibilities (see Theme 7. *Lack of consensus on UX-related competences and responsibilities*), the fact that UX should be taken into account from start to the end of a project, and that UX work is more visible than usability work and involves more strategic decision making.

The interviewees generally agreed that for achieving a better UX, it is essential to involve UX practitioners in projects early and continuously (e.g. A-4/HCI). They stated at least three benefits for that. Firstly, UX practitioners can get first-hand information about the customer and end users. Regarding this a practitioner stated: *"The worst case is when someone has met a client and talked a lot about the software, then I meet this guy who has met the client ... then it's secondhand information and everything gets distorted."* (A-4/HCI). Secondly, it is less likely that UX practitioners' input to the project is ignored. Thirdly, different stakeholders get to discuss the trade-offs concerning UX design, for instance business versus user goals, or feasibility of design concepts considering technical constraints. The practitioners however highlighted that involving UX practitioners in earlier phases is not a substitute for involving technical practitioners. In particular, the interviewees highlighted that early negotiation of trade-offs is of high importance for the success of the product in general, and UX in particular. For instance, if required, a design concept can then be updated based on the developers' feedback.

Still, UX practitioners stated they often come into projects only in later stages, and that this negatively affects their work. The interviewees highlighted that still there is a common misconception among various stakeholders concerning UX; they think UX can be improved with just minor GUI changes in later stages of development. But it is often impossible or difficult to make effective changes to the UX design in later stages. Because there is already a developed version of the software, or it is hard for developers to 'kill their darlings' (H-1/HCI). Also, the whole design concept might have been unsuitable, but a radical change at later stages may not be feasible due to time or effort constraints (e.g. H-2/HCI). This resembles how previously usability was treated in many organizations, as a 'detection' and 'fixing' step late in software development processes, ~~and~~ after the implementation was already done (e.g. H-1/HCI).

The group of UX practitioners highlighted that agile processes focus less on strategic decisions such as the overall UX of the software. Often these strategic decisions, including decisions concerning UX, are either 'skipped' or postponed. Because agile methodologies tend to prioritize immediate and current problem solving: *"agile is a lot about problem solving and that's what sort of gets priority."* (H-1/HCI).

According to the interviewees, even in cases when UX practitioners are involved in early phases, they may lose their connection to the project in later phases. For instance some proposed design ideas maybe be changed by non-UX practitioners in later phases without consulting the UX practitioners (e.g. G-1/HCI). A UX practitioner told us that during projects they continuously check the status of UX design: *"we try to have always at least one person who was part of the original dialog present during the weekly checkups, and basically just going by the desks and checking, informally."* (A-1/HCI).

As mentioned above, respondents argued that UX practices should start early in projects and considered

in all development phases, and different decisions. Nevertheless, this can be difficult for other project members to accept: *"sometime it can be perceived as we're trying to take control of the situation."* (H-1/HCI). According to the practitioners, this often means that working with UX is more difficult than usability: *"I think the reason why it was easier to work with usability to some extent was that you didn't take up any space. It was like being a woman in the early 20th century. You were there, but you didn't vote, you didn't do anything."* (H-1/HCI). Regarding the power struggle another practitioner stated: *"There are a lot of strong stakeholders that are really interested in doing those kind of things, programmers for instance, who like to be in control."* (A-2/HCI). He related this challenge to different motivations of these practitioners (e.g a developer wanting to develop more efficient code vs. a designer wanting to create a better design). Similarly, another interviewee stated: *"Everyone wants to start with their own domain, as soon as possible, from day one. Then, of course, you have the problem of ownership of the direction, where to go and what to do and why. That's something that we struggle with quite a bit."* (E-1/HCI). Similarly, another interviewee said: *"I think there is an ongoing struggle, cause we all have different drivers; like my driver is always about making technology that is interesting, useful, and brings some sort of value to users in the context in which it is being used."* (H-1/HCI). This interviewee further emphasized the situation has changed in their work as they moved from usability to UX in recent years: *"Compared to when we only worked with usability, I would argue that the situation is rather different, and part of it has to do with, being part of the early phases, but I think the biggest challenge and the biggest struggle nowadays is really the ownership of decision making, and who calls the shots, and I think we sometimes can be perceived as we're trying to take control of the situation. . . . Because usability didn't disturb the big process, the big decision-making, the prioritization of what to do, or what constituted a feature that was needed to be implemented. Usability wasn't part of that discussion. Usability was always part of like, how you should make a font, or the colors, like lipstick on the pig!"* (H-1/HCI).

The practitioners believed they can partially overcome this struggle by informing other stakeholders about UX-related responsibilities (what, why and how of UX practices), especially in relation to the overall goals of the organization. Clearly, there is a relation between this challenge and Theme 1. *Lack of consensus on definition and construct of UX* and Theme 2. *Lack of consensus on the value of UX*. Increased knowledge and awareness about UX and its value can address the power struggle between practitioners, at least to some extent.

A better UX practice, requires regular communication and collaboration among UX and non UX practitioners. These two groups of practitioners often have different responsibilities, education, motivation, and constraints in their work. Regarding the importance of communicating with developers, one UX designer stated: *"honestly the further we are away from the people that actually build the stuff, we run the real risk of becoming hand waving idiots."* (G-1/HCI). In his view, being disconnected from more technical roles, e.g., developers, runs the risk of not being aware of technological constraints when choosing and developing a design concept. Another interviewee said: *"we really try to make this giving and taking . . . we have constant communication, and I will say that we get always input from developers that we need to consider."* (A-2/HCI). Similarly a developer said: *"I think we need to be working tighter with the design department to help them know what can be done."* (D-1/SE).

Regarding the importance of communication one practitioner highlighted: *" The thing is that as human beings and organizations, the only place where just throwing something over the fence works really well is the military because you 'have to' do it. Other than that, you have to build relationships. It is a social thing. If you ignore that aspect of the construction of anything, you're going to run into problems."* (G-1/HCI). He further emphasized: *"So be a responsible human being! Talk to the people that are eventually going to carry your work forward 'cause otherwise you're not going to be successful."* (G-1/HCI). Similarly another practitioner stated: *"I realized quite early in my career that I have to communicate with these guys who program or develop something, and I have to understand what they're saying."* (A-4/HCI). The practitioners however emphasized that overcoming this communication gap should be a two-way effort: *"I'm not saying that we should be the only ones with this kind of multidisciplinary approach. I think the other ones should also have that, that's a big challenge, I would say."* (H-1/HCI). Similarly, another practitioner said: *"So I have to have some sort of knowledge about the technology because I have to know what my limitations are . . . . I have to have some sort of technical know-how so I can communicate with developers. I expect the*
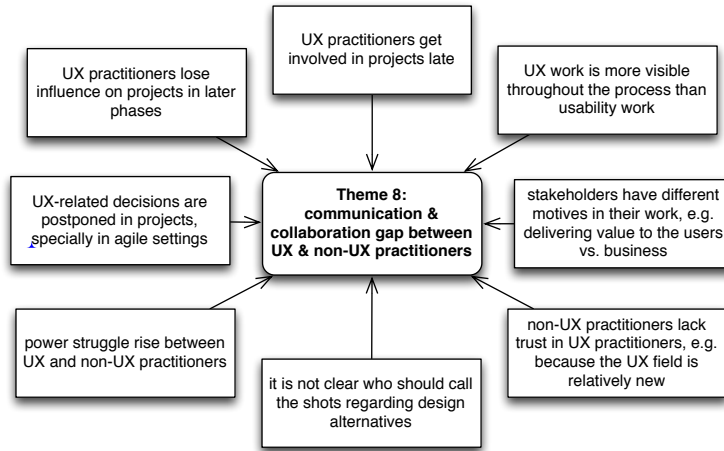
Figure 9: Challenges identified concerning communication and collaboration gap between UX and non-UX practitioners (Theme 8)

same from them. So they realize that the aesthetic choice has to be made and it can take time." (A-4/HCI).

According to practitioners, in order to facilitate a better communication, UX practitioners need to acquire basic knowledge about various technical topics., e.g., programming, testing, architecture etc. As emphasized by one respondent: *"You have to be like knowledgeable in many areas. . . . you have to be very holistic in the way you think about things, cause you have to speak with programmers in the language of programmers, to some extent . . . You also have to understand business."* (H-1/HCI). Similarly, another practitioner stated: *"you have to speak in engineer language. That's a real challenge for UX work, because you always have to translate it to terms that makes sense to an engineer or economist."* (A-1/HCI).

Respondents, however, emphasized that communication between UX and non-UX practitioners can be challenging for various reasons including lack of trust in UX practitioners. Regarding this, one interviewee emphasized: *"we have had problems with some of the developers sometimes. It has been a bit of conflict. I think we have some work to do to really get a 'we-feeling' that we, together, are developing an awesome product."* (C-1/HCI). One practitioner related 'lack of trust' to how the field of UX is a relatively new field and less established compared to more technical fields, e.g., SE. This also means that UX practitioners are often younger and less experienced than non-UX practitioners: *"most UX practitioners are quite young still, I do not think they have been that long in the market for development of their competencies yet."* (A-3/SE). One UX practitioner emphasized that they can gain more trust over time and as they accomplish more: *"[over time] we are adding on the pile of what we would call successful things we have done, and of course that gives us a bit more 'trust' I could say."* (H-2/HCI).

5. Discussion

Based on 17 interviews in industry, we identified 8 themes of challenges that practitioners face when trying to integrate UX into their software companies. In this section we firstly compare and contrast the identified challenges with the ones reported for usability and other quality characteristics in previous empirical studies. Secondly, we use Hassenzahl's model of UX and his proposed list of UX characteristics as an analytical lens to investigate the challenges in more details. Thirdly, we answer our research questions and describe the implications of our findings for research and practice.

5.1. UX Challenges in Relation to Challenges with Other Quality Characteristics

As we saw, practitioners face a number of challenges that concern their knowledge and awareness (Theme 1) and attitude towards UX, mainly its hedonic aspect and subjective measures (Theme 2 and

the structure of discussion is changed and the text is improved to clarify our contribution

21

Characteristic	Sample quotes regarding challenges
Subjective	*"it is difficult to sort out or really get the correct feeling that the user has because they will try to explain it but it perhaps is not the real emotion that we catch at the end, if it would be a method or approach to really get these from the user that would be great."* (A-2/HCI)
Hoslistic	*"Functional requirements are easy to create, to merge into a design; more emotional things are more difficult."* (F-1/HCI)
Dynamic	*"It's a fantastic feeling to sit in a brand-new car in a car shop. How do you feel about the same car if you've had it for a year, driving it around with two kids in the backseat, for instance? Experiencing all of the quirks from the interior, and all the things that don't work, the stupid things that make your hands go dirty every time you're supposed to close a door, for instance? That's part of user experience design. So it's a very floating scale."* (H-1/HCI)
Context-dependent	*"I think user tests tend to be more focused on pure usability. I guess it's when you're releasing the product into the wild, that's when you start to get maybe the most valuable feedback or the most truthful ones. So it's often good to make some sort of what we call a beta product and publish it. Let people interact with it. But that's a luxury also because that takes time. Often, in many, many cases, you have to just make something work. In an ideal world you should have a testing phase, of course. To get the users' perspective. That should be really nice to have."* (A-4/HCI)
Worthwhile	*"if I start with 'how', I will never get to the 'why'. If I start with 'what', with just making things, I will totally miss every important point there is. For me it tends to be very, very useful to focus on the why. So if I can sort of see this why, even if it's very, very unclear, I can sort of approach this 'how' and 'what' in a much better way.* (G-1/HCI)

Table 4: UX characteristic and their implications for the identified challenges as supported by our data.

Theme 4). These themes of challenges agree with previous empirical findings on other software quality characteristics, in particular usability. They therefore underline the importance of raising knowledge and awareness in industry regarding various quality characteristics, especially UX. Practitioners' lack of understanding and knowledge about software quality characteristics is a long known challenge in software industry. For instance, Karlsson et al. [32] show that still many companies are technology-focused and that functional issues are often perceived to be more important than quality issues. As another example, Berntsson Svensson et al. [33] also found that if practitioners lack understanding and knowledge about software quality characteristics, they tend to undervalue, and ignore these characteristics during development. They also report that practitioners are more likely to dismiss those characteristics that are considered less important, e.g. usability is more dismissed than performance.

a new tables with quotations is added

Similar problems have also been discussed in usability literature. For instance, Rosenbaum et al. [34] discuss that lack of knowledge and understanding about usability is one of the main obstacles to better integrating usability into software organizations. Bak et al. [35] report that 'developers' mindset' is a main challenge to better usability work. They explain that developers' minds are set more on the programming aspect of the product than its usability. Bak et al. discuss that their respondents misunderstood the term usability evaluation and often related it to functionality. Gulliksen et al. [36] report that limited awareness in different levels of organization in particular at management level can lead to down prioritizing usability work. To overcome this problem they suggest a number of solutions; for instance increasing knowledge and awareness about usability concepts among different stakeholders and in various levels of the organization, in particular management.

In contrast to the above studies, we see a general improvement in practice concerning knowledge and awareness about usability. Our analysis shows that nowadays practitioners have a fair knowledge and understanding of usability. The main problem today lies in lack of knowledge and awareness about UX in particular its hedonic aspect and how taking this aspect into account may add value to the software. Another problem concerns differentiating usability and UX in practice. As we saw, often more focus is given to objectively measurable quality characteristics (Theme 4) that leads to less focus on hedonic aspect. For instance, still UX evaluations mainly are limited to only evaluating usability.

Other challenges we identified concern dealing with UX in requirements (Theme 5) and testing (Theme 6) activities. For instance, we saw that practitioners find it difficult to document, refine or communicate

a new table on findings is added

22

UX Characteristics	Implications (i.e. extra difficulties)
• UX relies on human subjective perception • UX is temporal and there is a complex relation between various episodes of experience • UX emerges from complexly intertwined underlying elements • UX includes both hedonic (be-goals) and pragmatic (do-goals) aspects • UX is unique and situated in the context • UX is worthwhile, about adding value, and more than just preventing problems and frustrations	• UX work is more visible in the development process than usability work (our finding) • abstract UX-related needs (e.g., be-goals or emotional needs) are difficult to refine and translate into more concrete ones (our finding) • it is hard to translate abstract UX-related needs to concrete design solutions (our finding) • it is hard to frame UX in evaluations because of all the complex underlying dependencies between its elements (our finding) • there is a lack of consensus between UX and non-UX practitioners on whether abstract UX-related needs should be elicited before, after or in parallel with other needs (our finding) • translating abstract UX-related needs (in particular for hedonic aspect) to measurable requirements is more difficult than for functionalities or other quality characteristics (our finding) • more power struggle, and disagreements can rise between UX and non-UX practitioners (our findings) • it is more difficult to decide between design alternatives and resolve power struggles and disagreements that can rise between UX and non-UX practitioners (our findings) • requirements related to the hedonic aspect of UX are either neglected or treated informally (our findings) • UX-related needs of users are abstract concepts (literature, our finding) • practitioners do not have access to standardized and agreed upon set of UX measures and metrics (literature, our finding) • field studies are crucial in UX work, in particular to gather authentic user experiences but are more resource demanding (literature, our findings) • creating and using more sophisticated prototypes is vital in UX evaluations but requires more resources (literature, our finding) • practitioners are skeptical about effectiveness and reliability of current UX evaluation methods (literature, our finding) • practitioners do not always have access to enough users (literature, our finding) • practitioners do not always have access to sophisticated prototypes in earlier phases (literature, our finding) • practitioners do not often know how to measure the whole UX in relation to its underlying elements (literature, our finding) • users' memory of their experience is prone to fabrication and fading (literature, our finding) • a deeper understanding of the relationship between UX and time is missing (literature, our finding) • a deeper understanding of the relationship between UX and memory is missing (literature, our finding)

Table 5: In relation to characteristics of UX, we identified the above implications These implications can explain the extra difficulties that practitioners face in their work with UX compared to other quality characteristics, including usability.

requirements related to UX. Therefore these requirements are often treated informally in projects. These findings bring to light the fact that practitioners in general find it more difficult to perform requirements and testing activities for quality characteristics than for functionalities [22, 33, 37]. For instance, it is generally more difficult to document quality requirements in a measurable way [33, 38, 39]. Another problem concerns the dependencies between quality requirements and functionalities [32]. As Karlsson et al. [32] highlight, quality requirements often influence a larger part of the functionality or other characteristics of the system. Practitioners therefore find it difficult to deal with these dependencies, to know that these interdependencies exist but also to figure out how the requirements affect each other and how this can be dealt with. Researchers emphasize addressing these difficulties as a vital step for improving current state of practice. Otherwise these difficulties can lead to undervaluing, or abandoning quality characteristics in software projects, and consequently failing to deliver quality software [1, 22].

Usability literature have also reported similar problems. For example, previous empirical data on usability practice shows that practitioners find it challenging to document measurable usability requirements [14, 36]. Usability researchers also emphasize the importance of addressing challenges concerning requirements as a way to ensure considering usability in projects. Ardito et al. [16] showed that if practitioners fail to include usability in requirements documents, these requirements might be ignored in later phases, e.g., testing. It is therefore expected to have identified similar challenges for UX in our study. Although, our practitioners believe that these problems are compounded in case of UX, and that managing requirements and testing is more challenging for UX than for usability or other quality characteristics.

Other challenges we identified concern limited access to UX-related competences and unclear or overlapping responsibilities and that lack of such competences can lead to ignoring UX in projects (Theme 7). These challenges resemble the findings on other quality characteristics. For instance, Borg et al. [38] report that lack of competences to handle quality characteristics in projects often leads to ignoring related requirement in projects. Because, even if these requirements are properly quantified (specified in a measurable manner), they still require suitable competences to be tested and verified. In usability literature also the issues concerning competences and responsibilities are reported as obstacles to better usability work. For instance, Rosenbaum et al. [34] report that lack of usability professionals is one of the main obstacles organizations face in usability work. As another example, Boivie et al. [40] show that even in cases when organizations have access to the right expertise, usability professionals are not sure about their responsibilities in the projects, leading to uncertainties as to how to contribute to the projects.

However, our data shows that challenges organizations have today goes beyond what the above studies report. Today these organizations have limited access to practitioners with knowledge on UX, rather than usability. In addition, uncertainties practitioners face today is mainly about responsibilities related to UX and how they relate to other responsibilities for instance the ones for usability.

We also found challenges concerning communication and collaboration among various stakeholders in projects (Theme 8). The challenges we identified in UX work resemble the ones previously reported in literature on other quality characteristics [32, 41], in particular usability [34]. For instance, our UX practitioners highlighted the importance of their early and continuous involvement in projects. This issue has been previously reported as a success factor to work with usability [34] or software quality characteristics in general [1]. As another example, our interviewees highlighted that power struggle can rise between various stakeholders concerning decisions that impact UX of the product. Previous studies on usability also report power struggles between developers and designers as a challenge to better usability work. Chamberlain et al. [42] for instance report that power struggle rises as designers within a project defend their discipline in response to decisions made by the developers, and vice versa. But according to our interviewees, power struggle and disagreements are often more difficult to resolve in case of UX.

5.2. Characteristics of UX and their Implications

As we saw, similar challenges to those expressed by our interviewees are in fact reported in literature on usability and other software quality characteristics. Nevertheless, the participants of our study either view many of the challenges unique to or more severe in case of UX than for usability or other quality characteristics. As we elaborated in the related work, similar to our interviewees, current literature seems to present challenges as unique or more difficult for UX as well. We acknowledge the observed overlaps we saw

between challenges in working with quality characteristics, usability and UX, but argue that practitioners often face extra difficulties in working with UX because of inherent characteristics of UX. In other words, despite similarities at a superficial level, we can differentiate the challenges at a deeper level through these characteristics.

Characteristics of UX were in fact also highlighted by the interviewees when describing the challenges or discussing their work with UX mainly in comparison to usability. Some examples of the interviewees' quotations in relation to these characteristics are shown in Table 4. It is not surprising that these characteristics were pointed out only by those interviewees who have more knowledge and experience on UX. Below, we clarify how our practitioners experience the implication of these characteristics in their work with UX. We also support our findings with current literature on UX. Table 5 summarizes these implications (i.e extra difficulties). Clearly, our study did not focus on identifying these implications. Further research is needed to provide a more comprehensive understanding of them, and their interconnections. As Table 5 shows, some of the implications were only discussed by our interviewees while some were also reported in previous empirical studies. Our study in fact confirms all of the implications previously reported in literature. This emphasizes the importance of these implications and that the community needs to address them in efforts to improve practice of UX in software industry.

Holistic nature of UX means that practitioners should consider hedonic as well as pragmatic aspects of users' experiences (i.e., be-goals as well as do-goals) in designing software. But as we saw, eliciting be-goals and translating them into measurable requirements and design solutions is more difficult than for functionalities or other quality characteristics. In particular, practitioners still disagree on whether they should identify and refine these be-goals in parallel, before or after other requirements. Our empirical findings highlight that still there is limited research on how practitioners should pick underlying hedonic and pragmatic elements to increase the likelihood of delivering a certain overall UX, and that there is a general lack of guidelines, tools and methods for that purpose, as previous empirical studies also found [24]. Moreover, researchers believe that there is a natural uncertainty in working with UX. Practitioners can only to some extent increase the likelihood of delivering a certain UX through manipulating its underlying elements, and there is never a guarantee that they will in fact succeed [43]. This uncertainty also impacts evaluation and puts more emphasis on that still limited practical guidelines exist on how to choose suitable UX measures and metrics for UX underlying elements, and interpret their findings to improve the overall UX [24].

In addition to being holistic, subjectivity (i.e. relying on human perception) is an important characteristic of UX. But we showed that because of subjectivity, practitioners are in general skeptical about evaluating UX (both measuring overall UX and its hedonic aspect). In particular, they are skeptical about whether or not most common industrial methods (e.g. interviews or observations) can in fact gather realistic data on users' subjective perceptions or emotional reactions. For instance, our interviewees were concerned that what a user remembers about her emotions and shares in interviews may not reflect the reality. This is similar to the findings of Law et al.'s [24]. Their practitioners also argued that UX measures are essentially prone to fading and fabrication, or that they still have no means to measure the exact emotion of users at each moment [24].

Perceptions and experiences of users can change over time and after a longer usage period in a realistic context (i.e., dynamic and context-dependent nature of UX). As we saw, practitioners believe that the most truthful data about experience and perception of users can only be gathered in the field, and through using a functional version of the product in a real situation. But field studies, although more needed in case of UX, are still too resource demanding. Vermeeren et al. [13] also found that often field methods are considered to be too resource demanding for industrial use. The fact that field studies are not feasible in all projects negatively impacts UX evaluation.

In addition, we saw practical difficulties concerning the relation between different episodes of experience when evaluating UX; for instance, how practitioners should take into consideration both the short term versus long term experiences when evaluating UX. Our empirical findings highlight the limited research on how users' perceptions change over time and how different episodes of experience impact each other. Hence, we agree with Law et al. [24] that the community still lacks enough understanding of relation between UX, time and memory (the implications of subjectivity and dynamic nature of UX), and suitable UX metrics

and measures that can sufficiently support this relation.

In addition, our interviewees found it ~~extra difficult~~ to evaluate UX because of the need to access 'complete prototypes'. In their view, such prototypes are needed to properly gather users' subjective perception about their holisitc experience of interacting with a product. Similarly, participants in the Law et al.'s study [24] emphasized they need to use variety of media (e.g., video, TV, social media) to develop the required prototypes for measuring UX and that they often even need more than one such prototypes to gather enough input for design. Nevertheless, as our analysis show, practitioners often do not have access to such prototypes especially in earlier phases of software development. These practitioners were therefore even more skeptical about the ability to measure UX in earlier phases. This can lead to ignoring UX measurement in earlier phases, as other empirical studies also show [13]. One solution is to develop methods that do not require functioning or complete prototypes but can for instance rely on practitioners' imagination of how users may perceive the design [13]. This is however still an open research topic.

Similarly, our interviewees found it extra difficult to evaluate UX because of a greater need to involve the end users while access to end users is still a problem in many projects. Limited access to end users can negatively impact UX measurement. For example, practitioners may ignore UX measurement, or only rely on their own personal opinion, or as previous findings show, substitute users' view with their peers' opinions [19]. Clearly, in such cases, the measurement results do not necessarily reflect users' perception. Currently, the most efficient and feasible approach to measure perception and emotion of users is to directly gather their opinions, and let them express themselves [24]. This is often performed through questionnaires or scales (e.g., AttrakDiff, Self-Assessment Manikin, Affect Gird [44]). However, to gain reliable results, practitioners need to gather responses from statistically significant number of heterogeneous users [24]. Therefore, involving the end users is even more important in case of UX compared to usability, meaning that the challenge of limited access to users is compounded in this case.

In contrast to what we discussed above for UX, practitioners can test other software quality characteristics in labs, and even without necessarily using a sophisticated prototype of the software or even involving the end users. For example, usability can be tested on simple paper prototypes, using heuristic or other expert evaluations, or performance problems can be avoided via early modeling of the architecture [45]. In addition, in case of other software quality characteristics, the focus is on actual measures and values not the users' subjective perception of these values. Additionally, in contrast to UX, other quality characteristics are not dependent on time. For instance, performance or security measurements will have the same results even when repeated over time, providing that the software, and the test context (e.g., CPU load) have not changed. In other words, the difficulties we discussed above concerning requirements and testing of UX are either less severe or not even present for other quality characteristics, making their practice less challenging.

UX also differs from usability in that it focuses on value and creating desirable experiences than only preventing negative ones, i.e. being 'worthwhile' or 'positive'. The UX practitioners highlighted this characteristic mainly when discussing their motives and responsibilities and their approach to requirements. For instance, they argued that their view on usefulness and value of the product may not be in agreement with those of other stakeholders for instance concerning the business value. They also highlighted that this aspect of experience, i.e., the value, or the 'why' behind developing the software for the end users, should be identified before 'how' and 'what' that is connected to usability and functionality. Nevertheless, this view is often in conflict with more traditional and common approaches to software development and still a minority approach in practice. As requirements literature also highlights, identifying functionalities, or other quality characteristics is more prioritized in software development [1].

Characteristics of UX can also lead to extra difficulties in communication and collaboration between UX and non-UX practitioners in organizations. As we saw, more power struggles and disagreements can rise between these two groups, and they are more difficult to resolve in case of UX. Everyone experiences different products and services every day. Therefore, even non-UX staff members can easily have opinions about what experiences a product should deliver, and how they should be delivered, i.e. through which design solutions. In addition, to deliver a certain experience, UX staff members may suggest a specific combination of functionalities and quality characteristics that is not necessarily in agreement with what other stakeholders suggest. For instance, a product owner may suggest a different set of quality characteristics to protect the customer's business goals.

In case of other quality characteristics, including usability, at least in theory, we can resolve these disagreements using objective evidence that shows why an alternative is better than another: i.e. through measurements. But, as we saw, measuring UX is more difficult than other quality characteristics and even impossible in earlier phases. In addition, while UX metrics and measures are not agreed upon or standardized yet, for other quality characteristics practitioners have access to standards, e.g., ISO/IEC 9126-4 [46]. Therefore, in case of UX, it is more difficult to decide among various alternatives, hence to resolve disagreements.

Through characteristics of UX and their implications for practice, we can also explain the industry's lopsided focus on the pragmatic aspect of UX. As we saw, practice of UX is often limited to working with the pragmatic aspect. Requirements related to the hedonic aspect of UX are either neglected totally or treated informally. UX evaluations also tend to be substituted by usability evaluation, or focus mainly on pragmatic aspect of the experience, for instance how the user perceives usability of the product or its functionalities. Previous research also shows that usability and purpose of use still often dominate over designing for an experience in software industry [7, 47]. For instance, Väänänen et al. [7] report that practitioners still focus more on functionality and usability issues in their UX work. Similarly, in Kuusinen et al's study in a large software organization, ease of use and efficiency were the most often reported sources of good UX [47]. Still an explanation for why this is the case was missing in current body of knowledge that we hoped to have provided through our analysis on implications of these characteristics for day-to-day work of practitioners and how they tend to add extra difficulties to these practitioners' work. Researchers and practitioners should take these implications into consideration in particular when developing tools, methods and guidelines to overcome the challenges.

5.3. Answer to RQ1 and RQ2

In answer to RQ1 (*what challenges do practitioners face in integrating UX practices into software development processes and organizations?*), we found 8 themes of challenges as summarized in Table 3. There is clearly a multifaceted and complex set of relations between the themes. Some for instance could be seen as symptoms (e.g., Theme 4. *More focus on objectively measurable aspects*) and some as explanations to other challenges (e.g., Theme 1. *Lack of consensus on definition and construct of UX* and Theme 3. *Low industrial impact of UX models, tools, and methods*). Some are more fundamental and concern the views, attitude and knowledge of stakeholders (e.g., Theme 1. *Lack of consensus on definition and construct of UX*) while some are more tactical (e.g., Theme 5. *Difficulties in engineering UX-related requirements*, and Theme 6. *More focus on testing functionalities and usability than UX evaluation*). We discussed a number of these interrelations to the extent supported with our data. Although more empirical data should be gathered in future to detail and validate these connections. Most importantly, we found that characteristics of UX play an important role in shaping these challenges and differentiating them from challenges to other software quality characteristics, in particular usability.

In answer to RQ2 (*how do UX challenges relate to challenges in practice of software quality characteristics, in particular usability?*), we found that there are in fact various overlaps between the identified themes and challenges reported for practice of usability and/or software quality characteristics in general. In addition, we showed that despite similarities at a superficial level, we can differentiate the challenges at a deeper level, through better understanding characteristics of UX: *subjective*, *holistic*, *context-dependent*, *temporal* and *worthwhile*. This can then explain why the participants of our study either view many of the challenges unique to UX, or more severe than for usability or other quality characteristics. Through implications of these characteristics, we explained the extra difficulties practitioners face in their work with UX. In total, we identified 17 such difficulties that mainly concern requirements and testing activities in software development. Moreover, through these characteristic and extra difficulties we could explain the lopsided focus of industry on pragmatic aspect of UX, at least to some extent (Table 5).

Our study adds to the current body of knowledge by providing a deeper analysis of UX challenges through the lens of UX characteristics. This analysis helps both researcher and practitioners better understand these challenges and plan overcoming them, assuring these characteristics are taken into account. Our analysis brings attention to the characteristics of UX and their implications for UX work. These implications explain extra difficulties practitioners face in their work with UX despite the identified overlaps among challenges.

we now discuss challenges in more depth in relation to UX characteristics to better differentiate them from previously knowns challenges for usability and other quality characteristics

We both described those implications that our interviewees mentioned but also those reported in previous empirical studies, mainly the work of Law et al [24]. The fact that our findings confirm these previous findings underlines the importance of these implications. The related work does not provide such an analysis nor does often make such a differentiation between UX and usability except for the few studies we summarized in related work (e.g. the work of Law et al. [24]). We therefore bring depth to the identified challenges by presenting their relation to UX characteristics. We hope to have helped the community to identify ways to systematically improve the current practice of UX.

As we elaborated in Section 2, those studies that explicitly take UX characteristics into account, often mainly focus on evaluation activities and the role of UX measures in challenges practitioners face. Interestingly, although our study had a broader scope and investigated the whole development process, we also found that many of the extra difficulties practitioners faces with UX work concern evaluation. In addition, we found that these practitioners also face extra difficulties in requirements work that can be explained through inherent characteristics of UX. In particular, they find it difficult to elicit, refine, communicate, or measure the requirements related to the hedonic aspect of UX. We also found that practitioners face more communication and collaboration problems in their work with UX.

5.4. Implications for Research and Practice

The identified overlaps in challenges with UX and other quality characteristics, in particular usability, underline the significance of these challenges and call for more research on how to overcome them in practice. In addition, by highlighting these overlaps, we can help finding research areas useful not only in improving the practice of UX but also software quality in general. They can also make it easier for practitioners to spot, better understand, as well as find mitigation strategies for UX, through learning from past experiences and developments in the area of software quality.

Designing and developing for UX is a multidimensional and multidisciplinary activity which has not yet gained an established position in software industry. Approaches for integrating UX work into software development, especially to address UX characteristics, require further investigation. Admittedly, UX requirements, design and evaluation methods are still developing. Methods such as emocards [48] for gathering users' momentary emotions about the interaction and UX curve [49] for long-term UX evaluation have been introduced but they are not widely accepted in industrial software development. Moreover, many of the present frameworks and guidelines for UX integration do not clearly separate between UX and usability. The characteristics of UX require wider understanding of the user than plain usability. The challenges and implications we present in this paper can guide future research on UX integration and creating more awareness concerning UX challenges.

Based on our work, there are at least two future studies that could be particularly interesting. First, it would be relevant to conduct an in depth study to investigate various approaches academicians or practitioners propose or apply to address the identified challenges, most importantly in relation to characteristics of UX. Second, it would also be valuable to discuss the differences between practice of UX and other quality characteristics in more depth. This requires a deeper case study that compare and contrasts the practice of other software quality characteristics (e.g. tools and methods used) can be compared and contrasted to practice of UX.

6. Conclusion

Our work answers calls for more empirically based studies on the practice of UX in particular, and software quality characteristics in general. We show that software development practitioners have a large number of challenges in integrating UX practices into their development processes and organizations. In total, we identified 8 themes of challenges as mentioned in 17 interviews in eight software organizations.

Our findings and analyses enhance previous empirical studies on challenges by both corroborating previously found empirical evidence and by providing a deeper explanation and understanding of these challenges. We realized that characteristics that are unique to UX, i.e. *subjective, holistic, dynamic, context-dependent, and worthwhile*, can explain the extra difficulties practitioners face in the practice of UX compared to other

software quality characteristics, in particular usability. Many of these extra difficulties, as our analysis shows, concern requirements and evaluation activities.

In conclusion, to make future progress in integrating UX practices into software development processes, the community needs to take into account these UX characteristics and their implications for day-to-day work of practitioners when developing guidelines, tools and methods to address related challenges. More importantly, our findings can shed light on the more general problem of how practitioners should integrate less mature and new knowledge areas, of which software quality characteristics and UX are examples, into software development processes.

Acknowledgments

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Appendix A: Interview guide

General Questions

- What is your education and work background?

- What is your role in this company?

- How many years have you had this role?

- Do you know any of these terms (see Appendix C)? if yes, how do you apply them in your work?

- How do you define UX?

- How do you define Usability?

Questions Related to Requirements

- How is the overall requirements process in your company?

- How do you approach functional requirements?

- How do you approach non-functional/quality requirements?

- How do you approach requirements related to UX?

- What challenges do you face in your work regarding requirements related to UX?

Questions Related to Design

- How is the overall design process in your company?

- How is 'design' related to 'requirements' in your work?

- What challenges do you face in your work regarding design, in particular in relation to UX?

Questions Related to Evaluation or Testing

- How is the overall evaluation/testing process in your company?

- How do you test functional requirements?

- How do you test non-functional requirements?

- How do you test UX?

- What challenges do you face in testing UX, or requirements related to UX?

Appendix B: Coding guide

- Every segment can have any number of applicable codes

- The codes should be selected from the list below. If a new concept appears in data the possibility of adding a new code should be discussed among the authors.

- Any uncertainty in coding a segment should be discussed among the authors

   List of Codes
   1. Challenges
   2. Solutions
   3. UX
   4. Usability
   5. UX vs Usability
   6. Motives
   7. Definition
   8. Organization
   9. Project
   10. Software
   11. Process
   12. Individuals
   13. Tools and methods
   14. Roles
   15. Responsibilities
   16. Collaboration
   17. Communication
   18. Requirements
   19. Evaluations

Appendix C: Terminology Table

The interviewees were asked to specify each and every term they know and whether they apply it in their work. They were also asked to add any relevant term that is missing from the list.

- Usability

- User Experience

- Quality in Use (QiU)

- Emotional design

- Pleasurable design

- Aesthetics of design

- Affective computing

- Affective design

- Usability requirements

- UX requirements

- Affective requirements

- Emotional requirements

- User values

- User emotions

- User motivations

- ISO/IEC 9126

- ISO/IEC 25010

- Hedonic and pragmatic

- Instrumental and non-instrumental