Quantified UX: Towards a Common Organizational Understanding of User Experience

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ABSTRACT

User Experience (UX) is increasingly being recognized as an important factor for the commercial success of digital products. In fact, it has become a buzzword, which is interpreted differently by different parties. This lack of common understanding inevitably leads to misunderstandings and inefficiency in industrial practice. We therefore propose a quantifiable way of describing User Experience (QUX). Based on the analysis of 84 UX evaluation methods, a sample of UX characteristics from literature, and 24 interviews with experts from academia and practice, we propose a formalism and a corresponding tool to measure, visualize, and communicate a product's UX within organizations. We showcase the benefits of our approach by integrating it into the product development processes of companies from three different industries.

Author Keywords

User experience; evaluation; interdisciplinary teams

ACM Classification Keywords

H.5.m. Information Interfaces and Presentation: Miscellaneous

INTRODUCTION

With increasing maturity of an industry, usability is more and more taken for granted [55]. Pleasurable and hedonic product attributes are at least as important as pragmatic product attributes for commercial success and customer loyalty [2, 6]. Hence, it is not surprising that the concept of User Experience (UX) is widely discussed within the Human-Computer Interaction (HCI) community, among both academics and industry practitioners. Still, UX has remained a buzzword that is much rather used as a collective term for investigating the quality-in-use of interactive products [21, 38]. Furthermore, there is a variety of additional stakeholders with diverse perspectives involved in the creation of a product's UX [2, 25].

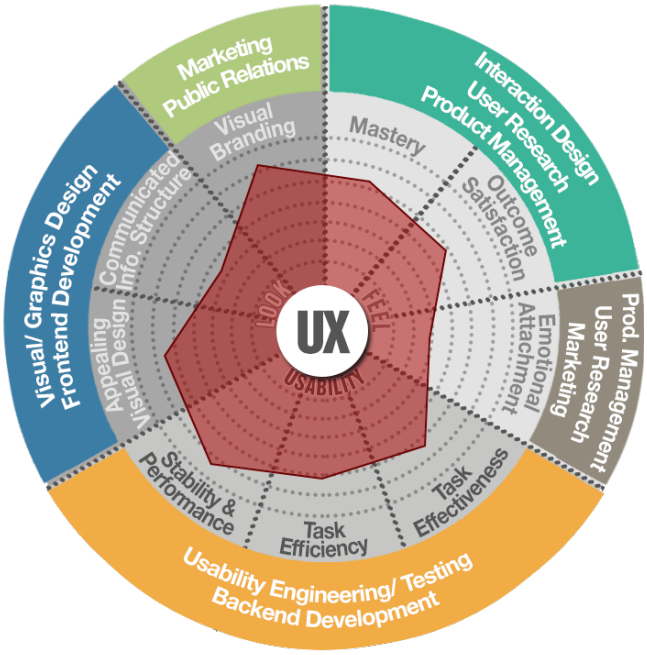

Figure 1. Quantified UX evaluation tool (radar diagram represents exemplary outcome for one industry partner after implementation).

In this paper, we present the development of a tool that aims to support a common organizational understanding of a product's UX and the selection of further in-depth UX evaluations (see Figure 1). Against this background, it is crucial to understand the role that UX plays in the process of product development. Traditionally, a company's product development has been structured as follows. First, user researchers and psychologists identify user needs and UX objectives. Second, designers and engineers translate these goals into product features and their design characteristics. Third, experts in mar-

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keting and branding define advertising messages to convey the respective experience [29, 66]. Finally, product managers incorporate the UX goals in the business context. Ideally, these steps are not separated from one another but strongly interlinked to ensure a holistic and consistent UX [25]. To create a certain UX, a systematic approach and an associated description of UX are needed to consider and measure the intended experience. Within this context, professionals demand a UX description that contains relevant criteria to support a transfer of UX into industrial practice. Existing development and design methods, however, rarely cope with the required degree of interdisciplinarity to reflect the different angles of e.g. engineering, design, marketing, or psychology [11, 38].

In the following sections, we will discuss the roles relevant for and the disciplines involved in the creation and improvement of a product's UX as part of design processes. Our goal is to address the following research question:

How can we help organizations to measure, visualize, and communicate a product's UX within interdisciplinary teams?

This paper offers two main contributions: First, we propose a specific, quantifiable way of describing user experience, which we call quantified UX (QUX). Second, we develop a graphical tool that connects these UX characteristics with associated disciplines in a visually appealing way to support the compact communication of UX goals within an organization.

UX THEORY

After several years of UX research, scholars seem to have reached consensus with regard to experience-oriented concepts that exceed traditional functionality and usability considerations [23]. UX evaluation ranges from the analysis of psychological needs to task-oriented user goals or guidelines [2]. The satisfaction of human needs is seen as a driver of experiences [60]. However, the consideration of such psychological needs is rather suitable for a *macro perspective*, i.e., the product's overall purpose. For the evaluation of a product on the market, a rather focused *micro perspective* on specific product characteristics, i.e., visceral characteristics, should be analyzed in detail [21, 50]. We argue that it is inevitable for a practically oriented UX evaluation and communication process in interdisciplinary teams to narrow down the broad scope of UX to a quantifiable level. Therefore, we base our research on the concept of product-oriented user goals and define UX as the result of enjoyable interactions and/or anticipated interactions with a product.

Different perceptions of UX are not limited to academia. Many newcomers to the field of UX, and a large number of UX practitioners, struggle with the complexity and vague definition of UX as well [18]. Furthermore, industry practitioners are presented with another challenge: to cope with the inability to talk to users directly while they interact with their product, as (prototype) workshops or laboratory experiments are often cost-intensive and time-consuming. Interdisciplinary project settings may increase the level of complexity even further.

To achieve the intended UX, a large variety of different UX tools and methods are used along the distinct phases of product development processes [66]. In general, organizations are thereby particularly interested in long-term UX as they want to foster a positive overall experience rather than focus on temporary emotions [38]. Most academic researchers concentrate on investigating UX from a theoretical perspective. Industry practitioners, in contrast, need tools and methods that make UX assessable and manageable. As a consequence, it has remained a challenge to close this gap between theory and practice [66].

EXISTING UX EVALUATION METHODS

Traditionally, research and development (R&D) departments focused their user research and product testing on usability requirements and quantitative methods, whereas marketing and advertising departments were responsible for communicating a certain experience [66]. However, along with a shift from a usability-focused to an experience-oriented perspective on product interactions, a shift within evaluation methodologies seems to have taken place [5].

The aforementioned gap between academic and practical interpretations of UX leads to substantial differences in the question of how UX should be evaluated [66]. First, user researchers typically disentangle evaluation processes from metric-based methods and focus on qualitative data in order to evaluate UX. However, the practicability of such methods is comparably low since the analysis of associated data may be hard and time-consuming. Thus, organizations and UX practitioners need evaluation tools which are quick to use and provide validated UX measures [25, 69]. Second, since UX evaluation is usually considered costly, UX research often addresses evaluation methodologies for early product stages to identify requirements as early as possible. In industrial practice, however, UX evaluation is mainly pursued to improve and refine existing products [2, 8, 66].

Against this background, we analysed 84 UX evaluation tools from `http://www.allaboutux.org/` [1], a collection of tools of a holistic study of UX measuring methods used in academia and industry [69]. In general, the landscape of UX evaluation offers a wide variety of tools and methods. From the viewpoint of an organization and its interdisciplinary product teams however, we conjecture that it is still hard to measure, visualize, and communicate a product's intended UX. In order to deduce requirements that meet the needs of interdisciplinary teams we examined the focus of the 84 UX evaluation tools from [1]. Thus, we were able to identify requirements for an interdisciplinary QUX approach based on five different evaluation clusters:

1. Measuring Sensation

A range of methods, such as *Emocards* or *Emofaces* [15] as well as *PrEmo* [14], overcome the intangibility of measuring emotions by substituting verbal measurement dimensions with cartoons. Evaluators describe their experiences of using a product by choosing one out of a number of predefined cartoons. Furthermore, *FaceReader* [13] is a tool that automatically tracks facial expressions of users or evaluators. With a focus on feelings and sensation, pragmatic characteristics

recede in the background of UX evaluation. For QUX, however, we want to focus on both hedonic and pragmatic product characteristics.

2. Specific Use Case

Further methods focus on a specific use case, e.g., a specific product or feature: The *Aesthetics scale* [37] helps to evaluate websites, whereas the *Perceived Comfort Assessment* [24] is a method of measuring the comfort level of, e.g., car seats. In contrast, we want to ensure the applicability of our QUX approach for various types of products.

3. Extensive Analysis

The *Experience Sampling Method (ESM)* [59] asks participants at certain times during the day to take notes about their current experiences. The *Outdoor Play Observation Scheme* [3] integrates video recording to analyze childrens' experiences with outdoor games. Both methods indicate the time-consuming analysis of UX evaluations. However, fast-paced industry projects generally require cost-efficient evaluation methods [65].

4. Qualitative Evaluation

The *Day Reconstruction Method (DRM)* [33] is a self-report method where participants note experiences in form of a diary. The *UX Curve* [36] respectively *iScale* [32] measures the quality of an experience over time. Thereby, researchers understand when and how an experience changed but cannot easily analyze why a certain experience was formed or triggered.

5. Questionnaire-based Methods

Questionnaires are widely used in the field of UX evaluation [5]. The *Product Attachment Scale* [48], for example, represents a questionnaire-based evaluation tool to measure the hedonic emotional bonding of a user to a product. On the contrary, *AttrakDiff* [22] analyzes hedonic and pragmatic product attributes via semantic differentials. The summative visualization then again makes it difficult to deduce concrete plans for action in interdisciplinary development projects. For a holistic QUX approach we want to ensure the communication of objective UX goals by incorporating a concrete set of UX characteristics as well as a formative visualization of UX measurements into a visual tool.

METHODOLOGY

The main goal of this paper is to create a tool that helps interdisciplinary development teams to measure, visualize, and communicate a product's UX. We, therefore, aim to reduce the gap between academia and industrial practice by following a systematic methodological approach (see Figure 2).

To start with, we pursue an elaboration of UX characteristics based on the analysis of published work in the field of UX. This literature analysis represents a two-phase process with the goal of identifying relevant published work and extracting prevailing UX characteristics that serve as a basis for discussion in the third phase. The third phase of our analysis process consists of expert interviews with practitioners and researchers in the field of UX. Based on that approach,

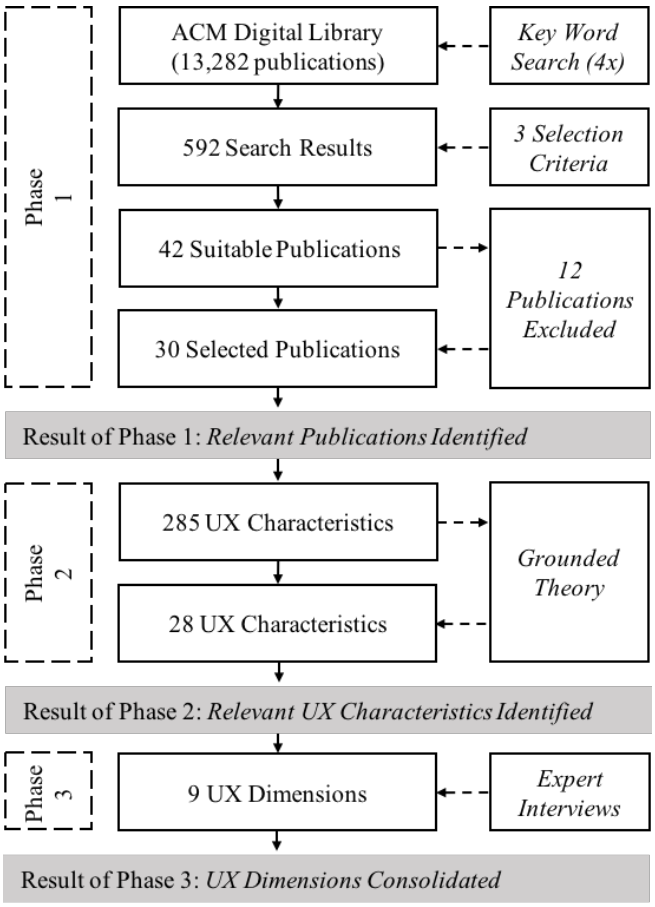

Figure 2. Three-phase methodological approach.

we were able to review a diverse spectrum of UX perspectives and consolidate the extracted characteristics into nine substantial components of UX, which we refer to as "UX dimensions". All in all, the literature analysis does not claim collective exhaustiveness of all possibly existing UX specifications but represents an elaborate foundation to support the subsequent interview process in phase 3.

Phase 1: Relevant Publications Identified

Source selection. We conducted a selective literature analysis inspired by the methodology of [5] with the ACM Digital Library (DL) as a research database in order to develop a guideline for our expert interviews (phase 3). Within the ACM DL, we selected five conferences and one journal for our source research: The Conference on Human Factors in Computing Systems (CHI), the Conference on Computer Supported Cooperative Work (CSCW), the Symposium on User Interface Software and Technology (UIST), Human Computer Interaction with Mobile Devices and Services (MobileHCI), Transactions on Computer-Human Interaction (TOCHI), and the International Joint Conference on Pervasive and Ubiquitous Computing (UbiComp).

We identified the mentioned venues as sources for top HCI publications based on the h5-index indicated by Google Scholar, and the relevance for the underlying research ques-

tion. Besides the top three mentions CHI, CSCW, and UIST on Google Scholar we integrated UbiComp and MobileHCI in our analysis as they focus on HCI topics that we considered as highly relevant for our research (i.e., mobile/handheld devices). Furthermore, TOCHI complements insights from conference proceedings with findings from an established HCI journal.

Search procedure. We used a set of four combinations for every venue using the ACM DL input mask. The first combination consisted of the key words "*user experience*" (all of this text) plus "*communicate, measure, measuring, visualize, framework, tool, guideline, emotions, usability, evaluate, evaluating, evaluation, satisfaction*" (any of this text). The second combination consisted of the key words "*measure, emotions*" (all of this text), the third of "*measure, usability*" (all of this text), and the fourth of "*user, satisfaction*" (all of this text) plus "*measure, framework, visualize*" (any of this text). The combinations were used to search the publications' abstract in order to focus on publications that are highly relevant for the underlying research question. Furthermore, the particular combinations allowed us to focus on a precise selection of publications to develop a suitable interview guideline for phase 3. We did not limit our search procedure to a specific time span.

Venue	*Database (ACM DL)*	*Results per Combination*				*Selected Publications*
		1	*2*	*3*	*4*	
CHI	7,080	192	4	21	70	11
CSCW	3,061	39	3	1	12	2
UIST	1,214	28	0	2	5	1
MobileHCI	991	131	0	6	27	10
TOCHI	518	24	1	5	6	4
UbiComp	418	13	1	0	1	2
SUM	*13,282*	*592*				*30*

Table 1. Number of identified publications in phase 1 (per venue).

Search results. At the time the search was conducted, the ACM DL provided 13,282 publications for the six venues in total. The search process resulted in 592 relevant papers, articles and works-in-progress as illustrated in Table 1.

Selection process. Before we selected relevant publications from the overall number of search results for phase 2, the authors of this paper (three with an HCI background and two with a business background) jointly defined the following three criteria for a structured selection process: Select publications that (1) describe a UX-related framework, such as in [45], (2) analyze UX characteristics of a specific product, such as in [62], and (3) directly discuss UX-related characteristics, such as in [71]. However, we excluded 12 publications (e.g., [67]) that met one of these criteria but had a focus on UX metrics that have already been covered in our analysis by other identified publications to limit double results. The selection was conducted by the first author, who has extensive knowledge in the field of UX research. Thus, we were able to narrow down the number of relevant publications to 30: [19, 26, 27, 35, 39, 45, 53, 54, 56, 61, 16] from CHI, [9, 30] from CSCW, [47] from UIST, [31, 40, 41, 43, 46, 51, 58, 64, 68, 71] from MobileHCI, [20, 34, 52, 63] from TOCHI, and [62, 70] from UbiComp.

Phase 2: Relevant UX Characteristics Identified

Screening. In this phase, our goal was to detect general UX characteristics within the 30 identified publications. For this purpose, we listed all characteristics that (1) represented UX elements within a theoretical framework, (2) were used to describe a product or service specific UX and (3) were directly mentioned as UX characteristics in any of the 30 publications. In total, we identified 285 UX characteristics.

Consolidation. To reduce the list to a usable number of UX characteristics for our interviews and to derive valuable UX dimensions in phase 3, we followed the interpretive grounded theory research approach by [17] and [28]. Grounded theory is based on a constant comparison of existing data throughout the analysis process and allows researchers to identify recurring key aspects of qualitative data [17]. We were able to recognize seven clusters as well as associated sub-clusters. The outcome of this methodological step is indicated in Table 2. Based on prior experience with the analysis of qualitative UX data, this step was carried on by the first author.

Some authors used rather general *emotions*, such as fun or satisfaction (see [19, 26]) as UX characteristics. Further clusters were based on *design-related*, e.g., color or aesthetics (see [19, 45]), *content-related*, e.g., information quality (see [61]), *technology-related*, e.g., controllable (see [16]), or *outcome-related* characteristics, e.g., error-free (see [64]). With the clusters *further disciplines* and *environment* we were able to evaluate UX characteristics such as status, brand, or context of use (see [20, 51, 68]).

Exclusion. We iteratively compared the clusters to narrow down the number of UX characteristics. To ensure a structured analysis process we jointly defined the following exclusion criteria: Exclude UX characteristics that (1) are specific for a particular product, such as network speed (see [40]), (2) overlap with other UX characteristics, such as social connectivity and social recommendation (see [16, 54]), and (3) are similarly used, such as efficiency of use and efficiency (see [20, 52, 43]). Thus, we ended up with a list of 28 UX characteristics, with all identified clusters represented in our shortlist (see Table 2). However, we realized that these characteristics had not yet offered a clear comprehension of an interdisciplinary QUX approach. To gain a better understanding about practically oriented UX dimensions for interdisciplinary design processes, we used this shortlist as a basis for the interviews in phase 3.

Phase 3: UX Dimensions Consolidated

Participants. Over the course of one week, we conducted expert interviews with 11 UX researchers and 13 UX practitioners to reflect their respective views. The listing below provides an overview of affiliations (less than 24 values due to companies who asked not be mentioned). With regard to expert status, all our academic interviewees are (or were) researchers at institutes with a significant track record of publications at leading HCI conferences. As for practice, our

Cluster	Sub-Cluster	*Exemplary characteristics from the selected publications*	28 consolidated UX characteristics
Emotions	-	e.g., fun [19], pleasure producing [35], happiness [56], ...	Satisfaction, Pleasure
Design	Form General	e.g., colour [19], clear [41], interface quality [61], ... e.g., natural [64], design [20], visual appearance [16], ...	Interface, Aesthetics
Content	Information General	e.g., information quality [61], information accessed [26], ... e.g., effectiveness [20, 43], usefulness [46], ...	Information, Effectiveness
Technology	Productivity Controllability Progression	e.g., efficiency [16, 35, 52], efficiency of use [20], ... e.g., data security [70], control [19], safety [43], ... e.g., easy to learn [64], usability problems [26], ...	Efficiency, Functionality, Ease of Use, Performance Usability, Utility, Security, Control, Learnability
Result	Outcome Expectation	e.g., task success [56], quality [45], product success [35], ... e.g., completeness [26], low error frequency [20], ...	Quality of Outcome, Error-free
Further Disciplines	Business User Social	e.g., money [63], brand [45], communication process [46], ... e.g., personlization [62], personification [39], ... e.g., social context [68], popularity [58], recommend [19], ...	Brand History, Advertisement, Price Expectation, Customization, Self-realization Group Affiliation, Social Connectivity
Environment	Temporal Context	e.g., time [19, 68], memorability [20], use frequency [26], ... e.g., device context [68], implicit interaction [30], ...	Memorability, Time Context, Location Context

Table 2. Clusters, sub-clusters, and consolidation of identified UX characteristics from the 30 selected publications.

sample reflects the perspectives of UX professionals from established firms as well as from emerging, digital startups in the fields of e.g. education, sports, finance, or smart home.

- *University Affiliations:* Aalborg University, University of Bristol, University of Lugano, New Jersey Institute of Technology, University of Oulu (2x), Queensland University of Technology (2x), University of Stuttgart, Tampere University of Technology (2x).
- *Industry Affiliations:* AirBnB, Allianz, GoCardless, Google, IICM, Nokia, Number26, Stylight, Tado, Talentry, Twitter.

Procedure. The first part of our interviews consisted of open questions about disciplines and departments involved in the product development process. In the second part, our experts were presented with our shortlist of the 28 UX characteristics and respective definitions. Participants were asked to complete this table by indicating the most relevant characteristics, reviewing our definitions, and linking them to responsible disciplines. On the basis of the interviews, we were able to narrow our list down to 9 relevant UX dimensions.

RESULTS

Below, we structure our findings into two interrelated sections. First, we propose a formalism to quantify UX based on our literature analysis and interviews. Second, we develop a corresponding tool to visualize QUX and to enhance communications within interdisciplinary teams.

Part 1: Quantifying UX (QUX)

We analyzed our expert interviews using a qualitative content analysis as proposed by [44], with a high inter-rater agreement (Cohen's Kappa κ = .84, see [10]). To start with, we presented our participants with a list of 28 UX characteristics and asked them to select the 10 they regarded as most important. This procedure allowed us to reduce the number of relevant characteristics to 15, which are reported in Table 3. Next, to add more structure and balance, we decided to cluster our dimensions into the categories of *Look*, *Feel*, and *Usability* similar to [50].

Look	*n*
Aesthetics / Design	14
Interface	7
Brand History / Brand Name	5
Information Value	5
Advertisement / Brand	3
Feel	*n*
Control	13
Ease of Use	13
Learnability	12
Pleasure	12
Satisfaction	12
Usability	*n*
Efficiency	11
Utility	11
Effectiveness	10
Functionality	9
System Performance	8

Table 3. Top 5 UX characteristics per category.

Based on recommendations by our interviewed experts, we then merged some dimensions that were close to each other and/or partly overlapping. This way, we ended up with a total of nine relevant UX dimensions (three per category) as reported in Table 4. In a last step, we developed three corresponding items/questions per dimension (based on existing, pre-tested scales from [7], who provide multi-item measures for consumer insight research) to quantify a product's UX via answers on 7-point Likert scales.

Area	Dimension	Scales	ID	Related Work
Look	*Appealing Visual Design*	How balanced and harmonic do you find the product? Do you like the design, colors, fonts used in this product? Do you find the text:image ratio appropriate?	*d1*	[11, 20, 37, 61]
	Communicated Information Structure	Does the product provide clear navigation and orientation? How consistently is the content and information organized? Do you find the provided information understandable?	*d2*	
	Visual Branding	Do you trust this brand? Do you think this is an honest brand? Do you feel the brand is safe?	*d3*	
Feel	*Mastery*	Do you find this product easy to use? Do you find it easy to learn (and to remember) how to use the product? Do you feel you have full control over the product?	*d4*	[29, 36, 35, 50]
	Outcome Satisfaction	How satisfied are you with the outcome? To what extent are you feeling successful with the outcome? How happy are you with the outcome?	*d5*	
	Emotional Attachment	How pleasurable do you find using the product? Does the process of using the product provide you with gratification? Do you feel excited when you are using the product?	*d6*	
Usability	*Task Effectiveness*	Do you think the product does what it is supposed to do? Do you find the product effective? Does the product help you fulfill your task?	*d7*	[26, 29, 49, 57]
	Task Efficiency	Is the product the fastest way to achieve your goal? Is the product the most convenient way to achieve your goal? Does using the product fit with your schedule?	*d8*	
	Stability and Performance	Does the system run smoothly? Are errors handled well? Does the product work fast and responsively?	*d9*	

Table 4. Interdisciplinary UX dimensions with corresponding questionnaire items and related work for in-depth, follow-up analyses.

Part 2: Visualizing and Communicating QUX

In addition, we asked all interview participants which disciplines should be involved in UX design processes. We identified the most relevant disciplines for each dimension using inductive category formation (see [44]). Besides HCI-related disciplines, such as Backend Development or Interaction Design, practitioners and researchers alike considered further disciplines, such as Marketing and Product Management, as highly relevant for the UX design process. Table 5 provides an overview of the top ten disciplines involved in the UX design process according to our interviewees. Furthermore, we asked all participants to link the respective disciplines to our list of 28 UX characteristics. Thus, we were able to assign responsibilities (i.e., disciplines) to our nine consolidated UX dimensions (see Figure 1).

Next, we were interested in practices and tools currently used to communicate goals and objectives in UX design processes. The majority of participants named meetings as the most important forum for discussing UX goals. Specific tools or visualizations are rarely used, whereas prototypes often serve as a basis to illustrate specific UX objectives. However, several UX practitioners described a kind of uncertainty when it comes to communicating UX within teams.

In sum, we were able to derive the following needs for our QUX approach from our interviews: (1) Combine measurement scales with a suitable visualization to enhance communication of concrete UX goals, (2) realize an easy-to-use application to support practitioners with different levels of expertise, and (3) consider the perspectives of different stakeholders as UX is multidisciplinary by nature. These needs are consistent with the findings of [65].

Top 10 disciplines involved in UX design process	*n*	*Percentage*
Backend Development	20	83%
Visual/Graphics Design	18	75%
Marketing	18	75%
Interaction Design	12	50%
Product Management	12	50%
User Research	10	42%
Usability Engineering/Testing	5	21%
UI/Frontend Development	5	21%
General Management	5	21%
Public Relations	3	13%

Table 5. Top 10 disciplines involved in the UX design process, sorted by number of occurance in expert interviews (multiple responses possible).

Based on our identified needs we developed a graphical tool to measure, visualize, and communicate UX goals within interdisciplinary teams. The visual foundation of our QUX tool is a radar diagram with the categories *Look*, *Feel*, and *Usability* as focus areas. Next, we included the nine UX dimensions as well as the associated disciplines in accordance with the respective category.

The outer circle of the radar diagram connects our dimensions with the respective disciplines and illustrates the need for an interdisciplinary exchange. We designed our tool following a goal-oriented approach (see [21]). The UX-related disciplines are therefore centered around the nine UX dimensions (i.e., the UX goals) which represent the core of QUX.

As a final step, the 7-point Likert scale that is used to evaluate a product's UX based on the nine UX dimensions is illustrated as dotted circles. We use the questionnaire as indicated in Table 4 to quantify a product's UX and calculate average scores for each dimension (based on the associated scale). To illustrate a product's quantified UX, the scores for every dimension (be it as mean, median, or confidence interval) can be inserted in the radar diagram, linked, and visualized as a spanned plane (see Figure 1). Thus, development teams can easily detect weak spots in a product's UX and communicate further required actions, from product management over usability engineering to marketing. The basic idea of this visualization is similar to the UX wheel (see [42]).

EVALUATION

The goal of our evaluation is to judge the practical applicability of QUX within organizations. This is why we integrated our tool in the design processes of our industry partners and asked for their feedback. We chose to work with partners in the fields of sports, event ticketing, and food delivery to cover a certain range of B2C consumer applications in fast growing industries that increasingly focus on mobile apps. To bring the tool to life (i.e., discuss with professionals over real QUX scores rather than theoretical ideas), we asked our partners to collect exemplary survey data from their users via a Google form containing our 27 questions.

	Sports	**Ticketing**	**Delivery**
n	616	18	21
Gender	(m) 24% (f) 76%	(m) 67% (f) 33%	(m) 67% (f) 33%
Age Range	9 - 56 yrs	n/a	n/a
Average	29 yrs	n/a	n/a

Table 6. Demographic Data.

Sample Description

Our partner firms collected one large sample (n=616, by providing a lottery of high-end workout equipment as an incentive) and two smaller samples (n=18 and n=21, with no further incentive). Table 6 summarizes the demographic data. For all three samples, we computed Cronbach's α for each UX dimension. As shown in Table 7, alpha values range from .74 to .96, indicating consistently high construct reliabilities [12]. This indicates that each three items/questions we developed from [7] seem to reliably measure the respective UX dimension derived from our methodology. We see this as a promising foundation for subsequent user-driven scale development and empirical studies, as discussed below in our section on future work.

UX Dimension	**Sports**	**Ticketing**	**Delivery**
d1	.87	.95	.75
d2	.89	.95	.81
d3	.90	.95	.92
d4	.88	.96	.86
d5	.91	.89	.93
d6	.93	.95	.86
d7	.88	.93	.85
d8	.84	.94	.92
d9	.88	.95	.74

Table 7. Cronbach's α by sample and dimension.

Exemplary QUX Analysis

We analyzed the data retrieved from survey respondents and visualized it using our QUX tool. Figure 1 shows an exemplary outcome for an application, which suffers from a rather poorly communicated information structure (users have problems with understanding the product's navigation and structure) and a lack of emotional attachment (users do not identify with the product, do not have any positive memories about the last use, etc.). Beyond this first diagnosis, our tool offers subsequent suggestions which departments or disciplines should be involved when conducting further in-depth UX evaluation. In this case, the *Visual/Graphics* department or *Frontend Developer* could initiate additional A/B-Testing to work towards a better information structure. Furthermore, *Product Management* might meet with *Marketing* to think about ways to improve emotional attachment of users (e.g., include animations or information that motivates recurring usage).

Qualitative Feedback from UX Professionals

We presented our findings at our partner companies to those responsible for UX (#1: a CTO, #2: a Vice President of Product and Design, and #3: a Senior Product Manager). Across all companies, our QUX tool received consistently positive feedback which falls into the following three categories.

Provides Overview and Helps to Prioritize

All our partners emphasized that the QUX tool provides a good starting point for thinking about UX: *"The tool provides a useful overview of different aspects of UX. I must admit that I haven't had all of them on my radar yet."(#2)* Furthermore, it *"helps to identify strengths and weaknesses, which in turn helps us to prioritize our next steps in development."(#1)* While the high-level overview was greatly appreciated, one product manager added that *"it would be really helpful if you could provide us with some additional, qualitative tools to analyze our weak spots in more detail."(#3)*

Allows for Benchmarking

Another key property of QUX seems to be its suitability for benchmarking: *"For us, it would be highly interesting to conduct the same kind of analysis with our competitors' products to understand where we stand relative to them."(#3)* One of

the partners can even imagine *"using the tool to track user experience over time, so that we can track progress in our product development efforts."(#1)* To better judge the significance of the results, he proposed that in a revised version of QUX, we should also think about visualizing standard deviations/variances for each dimension.

Facilitates Communication in Teams

Our partners also emphasized the benefits of our visualization: *"The radar diagram is a smart way of illustration. It helps to bring across the most relevant aspects at first glance. This visualization of UX provides a solid basis for deriving concrete actions."(#3)* Another partner expressed that he finds it helpful because he doesn't *"have to waste time and resources to prepare and visualize the data. So it really makes sense to agree on one single method, and stick to it."(#2)*

LIMITATIONS, FUTURE WORK, AND CONCLUSION

We see our approach as a first step towards achieving a more common view of UX within and beyond organizations. However, a unified measurement approach comes at the cost of potentially neglecting highly specific product details. While we acknowledge that every product is unique, we are convinced that QUX can be an important first step to obtain an overview and common understanding of a product's UX. In this regard, QUX can be thought of as representing a manual for a toolbox rather than a tool itself. In future work, it might prove useful to not only link QUX findings to the associated disciplines, but to also use them for suggesting evaluation tools and methods for further in-depth analyses.

In our expert interviews, we learned once more that product development processes and respective UX paradigms are still dramatically different from one company to another. Yet, we believe that our approach can be valuable in similarly different ways. For example, early-stage startups might share a much more holistic view on their product and UX, but lack structured processes. Here, QUX can provide a meaningful guideline. With companies increasing in size and industry sectors maturing, the need for departmentalization and number of involved stakeholders is rising steadily. Here, QUX can facilitate efficient communications.

To showcase how QUX works in practice, we integrated it into the product development process of firms from three different industries. We found it encouraging that we received positive feedback across industry sectors. Still, a much broader sample drawn from a variety of products, services and sectors might hold many exciting insights. Our primary goal was to design a tool for measuring UX which is both building on and intended for industrial practice. This is why we deducted UX dimensions from expert interviews and then designed and qualitatively evaluated a tool by integrating it into the workflows of our industry partners.

We acknowledge that an alternative approach would have been a user-driven scale development through factor analysis-based dimensional reduction of large-scale surveys (as in, e.g., [4]). Our work aims at deriving needs from UX experts and practitioners, which we see as a foundation for complementary empirical work that focuses on the end-user side.

Overall, we see QUX as complementary to the landscape of existing UX evaluation methods and as a solid foundation for future work towards a common organizational understanding of UX.

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