COMPUTER SCIENCE | RESEARCH ARTICLE

User experience framework that combines aspects, dimensions, and measurement methods

Mohammad Zarour1* and Mubarak Alharbi2

Abstract: Successful software products necessitate users’ satisfaction when experiencing the use of the software. This is not only determined by the software functionalities and completeness, but also with the overall user experience when using the software product. Although user experience is widely adopted by practitioners and in industry, there is no scientific consensus on a definition or a theoretical model of UX. The dynamic nature of user experience is challenging both UX design and evaluation activities. Accordingly, further research is needed to study four non-orthogonal UX issues: definition, modeling, method selection, and the interplay between evaluation and development. Moreover, UX professionals need to identify means for compromising the difficulties of evaluating UX in a holistic manner. The purpose of this research is to consolidate the findings related to UX aspects and dimensions along with the identified measurement methods into one simplified UX theoretical framework. This work is related to the aforementioned modeling issue aiming to better understand the relationship between UX dimensions, UX Aspects and UX measurement methods. The proposed framework is vital for practical application of UX, the development of UX evaluation methods and further theoretical studies of UX.

Subjects: Software Engineering & Systems Development; User Interface; Computer Science (General)

Keywords: human-computer interaction; user experience; evaluation; framework; systematic literature review

ABOUT THE AUTHORS

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One of Dr Mohammad Zarour’s research interests focuses on studying the effect of user experience on the product quality. Current research in this domain aims to satisfy some needs in the academia and industry such as how to evaluate user experience based SQaRE standard and evaluation theory, how to integrate UX with CMMI, how to integrate UX with Agile development processes, and conduct more empirical studies and analysis in the UX domain to better understand UX dimensions and aspects.

PUBLIC INTEREST STATEMENT

Nowadays, software becomes an essential part of our lives. Successful software is determined by not only the software functionalities, but also by the overall user experience (UX) when using the software. Human-computer Interaction (HCI) has been shifted since 2000 toward measuring user experience and this formed the fifth generation of HCI domain.

Although user experience is widely adopted by practitioners and in industry, there is no scientific consensus on a definition or a theoretical model of UX. The dynamic nature of user experience is challenging both UX design and evaluation activities.

On the sense that an accepted and broadly shared understanding of UX is still lacking, this research aims to consolidate various UX concepts into one simplified UX theoretical framework. Such framework is vital for practical application of UX, the development of UX evaluation methods and for conducting further theoretical studies of UX.
1. Introduction

Software nowadays becomes an essential part of our lives; it is one of the most important delivered products or services that we use on daily bases. Software differs from any other product that we use; its intellectual nature makes it a developed, not a manufactured product and results in its having one of the most labor-intensive, complex, and error-prone products in human history (Kumaresh, 2012).

Many software engineers believe that software quality is not improving over time (Mann, 2002). Software users often experience code bloat, ugly, inefficient and poorly designed software resulting in software dysfunction (Ogheneovo, 2014). Because of its intellectual nature, users’ involvement in the software process becomes evident to achieve a better understanding of users’ needs (as in agile methodologies) and to result in successful products. Despite the importance of user involvement in the software process, successful software products necessitate users’ satisfaction when experiencing the use of the software. This is not only determined by the software functionalities and completeness, but also by the overall user experience (UX) when using the software product. UX is an emerging research area that is still immature (Law, Schaik, & Roto, 2012) and forms the fifth generation of HCI domain which has been shifted, since 2000, toward measuring user experience (Law, 2011; Yong, 2013). Although user experience is widely adopted by practitioners and in industry, there is no scientific consensus on its definition or a theoretical model of UX. This, for instance, has resulted in difficulties in classifying user requirements as pragmatic or hedonic. Even requirements engineers and UX professionals do not agree whether a user requirement focuses on pragmatic or hedonic quality (Kremer, Schlimm, & Lindemann, 2017).

User experience is a context-dependent, and subjective domain. It has been noted that users’ perception of different product qualities as well as emotions that arise before, during and after using a product is changing (Minge & Thüring, 2018) which makes UX a dynamic concept as well. Due to this fact, “the user experience is seen as something desirable without defining what something means”, and this has led to difficulty in agreeing on a user experience definition (Law, Roto, & Hassenzahl, 2009). The dynamic nature of user experience is challenging both UX design and evaluation activities (Kujala, Obrist, Vogel, & Pohlmeyer, 2013).

In literature, definitions for user experience were proposed, but those definitions were affected by the researcher’s background and interest (Law et al., 2009) and could not be used as a common definition. ISO 9241–210 defined user experience as “A person's perceptions and responses that result from the use or anticipated use of a product, system or service” (ISO, 2010). This definition is a promising one as stated by Law et al. (2009). It is in line with the view by most researchers about the subjectivity of UX, but the used terms require more explanation to list possible objects that affect user experience (Law et al., 2009). User experience is tightly coupled with usability (Rajeshkumar, Omar, & Mahmud, 2013), and it can be conceptualized in three different ways (Bevan, 2009b). Below, we discuss and illustrate visually these three ways:

(a) UX can be viewed as an elaboration of satisfaction component of usability (see Figure 1). Usability has different attributes such as efficiency, effectiveness, and satisfaction (Bevan, 2009a). Satisfaction attribute refers to the likely, pleasure, trust and other similar attributes. UX extends this usability attribute and from this perspective, the UX is considered as an elaboration of usability.

(b) UX can be viewed as distinct from usability. Usability emphasizes objective measures, while user experience emphasizes subjective measures (see Figure 2). This differentiation is based on the usage of measurement methods. It is unnecessary that usability methods measure UX as there is a clear difference between usability characteristics and UX characteristics (Roto, Obrist, & Kaisa, 2009).

(c) An umbrella term for users' perceptions, whether measured objectively or subjectively (see Figure 3) follows ISO 9241–210 definition which covers perceptions from the user, either objectively or subjectively (Law et al., 2009).
The purpose of this research is to consolidate the findings related to UX aspects and dimensions discussed in (Zarour & Alharbi, 2017) along with the measurement methods documented in the literature, into one framework to better understand the relationship between UX dimensions, UX Aspects and UX measurement methods.

2. Literature review
UX has various concepts and terms that can be confusing for naive readers. The use of UX terms is “partially confusing and there does not exist a clear framework that takes the different results into account” (Mahlke, 2005). This section aims to define these terms and synthesize findings of a conducted systematic literature review.
2.1. Conducted systematic literature review process
A systematic literature review to identify various UX terms has been conducted and published in (Zarour & Alharbi, 2017). Figure 4 summarizes the adopted systematic literature review process to select primary studies. A total of 114 primary studies out of 2,331 papers have been collected and analyzed, based on a defined set of inclusion/exclusion criteria. A list of primary studies that resulted from the systematic literature review is given in Appendix A.

The result of the analysis revealed various UX dimensions (see Table 5) and aspects (see Table 7). For more details about this phase, please refer to (Zarour & Alharbi, 2017). These findings are summarized in the subsequent sections and are used to develop the core UX framework as discussed in Section 4 of this paper.

2.2. UX perspectives
Perspective is the main element used to build UX definition (Law et al., 2009), and it will help to identify who has been affected by the changes of the UX. UX related perspectives are (Law et al., 2009):

(A) Organization: Organizations aim to provide valuable products for the users.
(B) User: User looks for a valuable and appropriate usage of the product.
(C) The context of use: This has an impact on both elements (organization and user) and is the intermediate bridge between them.

(D) Product: Focusing on how to design the product for better user experience.

Taking into consideration the main components of interaction between technology and user, namely: system or product, user, and the context of use (Jetter & Gerken, 2007; Moller, Engelbrecht, Kuhnel, Wechsung, & Weiss, 2009; Zhao & Balagué, 2014), the relationships between these components and UX perspectives is depicted in Figure 5. Note that the UX is a value-centric concept and all UX perspectives are related to the value.

2.3. UX disciplines and dimensions

Dimension is the category of a research discipline that has been followed in the primary studies to study UX. The main disciplines identified from the primary studies are (Zarour & Alharbi, 2017): Values & Experience, Brand & Experience, User Needs & Experience, Development Process & Experience and Technologies & Experience. UX dimensions suggested to cover these disciplines are (Zarour & Alharbi, 2017):

(A) Value: This is related to the studies that have been focused on the gained value.

(B) User Needs Experience (NX): This is related to the studies that have been focused on user needs and gained qualities.

(C) Brand Experience (BX): This is related to the studies that have focused on the organization’s brand image.

(D) Technology Experience (TX): This is related to the studies that have focused on the technology that has been used to deliver the product or the service.

(E) Context: This is related to the studies that have focused on the context of use and the interaction between the previous dimensions.

Table 1, summarizes mapping between the suggested dimensions and the UX disciplines.

<table>
<thead>
<tr>
<th>Discipline</th>
<th>Dimension</th>
</tr>
</thead>
<tbody>
<tr>
<td>Values &amp; Experience</td>
<td>Value &amp; Overall Experience (VX)</td>
</tr>
<tr>
<td>Brand &amp; Experience</td>
<td>Organization Brand Experience (BX)</td>
</tr>
<tr>
<td>User Needs &amp; Experience</td>
<td>User Needs Experience (NX)</td>
</tr>
<tr>
<td>Development Process &amp; Experience</td>
<td>Technology Experience (TX)</td>
</tr>
<tr>
<td>Technologies &amp; Experience</td>
<td>Technology Experience (TX)</td>
</tr>
</tbody>
</table>
### 2.4. UX aspects

Aspect is the quality attribute that has an impact on UX. The aspects identified in the literature and their description is given in Table 2.

Taking into consideration the UX disciplines’ dimensions, the aspects that affect the UX can be categorized into one of the below types (Zarour & Alharbi, 2017):

- **User’s needs aspects:** This is related to the user dimension and can be divided into two categories (Väänänen-Vainio-Mattila, Hassenzahl, Landau, & Fort, 2008; Sproll, Peissner, & Sturm, 2010):
  - Pragmatic aspects: These are related to the usability and the do-goal qualities.
  - Hedonic aspects: These are related to the stimulation and be-goal qualities.

### Table 2. UX aspects’ descriptions

<table>
<thead>
<tr>
<th>UX aspect</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Branding (Jetter &amp; Gerken, 2007)</td>
<td>Refers to the brand identity and the organization promises which have an impact on the trustworthiness</td>
</tr>
<tr>
<td>Everyday Operations (Jetter &amp; Gerken, 2007)</td>
<td>Refers to the real business work such as selling the product or serving the customer, which has an effect on the usability of the service</td>
</tr>
<tr>
<td>Marketing (Jetter &amp; Gerken, 2007)</td>
<td>Refers to communicating the brand identity and building an emotional link between the client and the organization</td>
</tr>
<tr>
<td>Business Communications (Jetter &amp; Gerken, 2007)</td>
<td>Refers to communicating the business goals clearly inside the organization to construct a valuable product for the client which meets the organization values at the same time</td>
</tr>
<tr>
<td>Context of use (Möller et al., 2009)</td>
<td>Refers to the situation and the environment around the user when he is using the product or the service, and it is dynamic and could not be explicitly defined</td>
</tr>
<tr>
<td>Spatio-Temporal (Mercuri, 2005)</td>
<td>Refers to the time-space, period of usage between user and product as it has an impact on the learnability and usability</td>
</tr>
<tr>
<td>User Journey (Väänänen-Vainio-Mattila, Hassenzahl, Landau, &amp; Fort, 2008)</td>
<td>Refers to the loyalty between the user and the organization as it has an impact on the emotions and trustworthiness</td>
</tr>
<tr>
<td>Cultural (Lee, Kim, &amp; An, 2008)</td>
<td>Refers to the user’s culture, which has an impact on the usability and emotions as well</td>
</tr>
<tr>
<td>Emotional (Mercuri, 2005)</td>
<td>Refers to all emotions during the product usage, and is explicitly mentioned in some studies</td>
</tr>
<tr>
<td>Hedonic (Mahlke, 2005)</td>
<td>Refers to the category of all non-goals aspects, and is explicitly mentioned in some studies and use it as is</td>
</tr>
<tr>
<td>Trustworthiness (Mahlke, 2005)</td>
<td>Refers to the trust between the user and the organization during the usage of its products, and has an impact on different aspects such as emotions</td>
</tr>
<tr>
<td>Aesthetics (Mahlke, 2005)</td>
<td>Refers to the sense of beauty and how the user feels about it</td>
</tr>
<tr>
<td>Fun (Mahlke, 2005)</td>
<td>Refers to the enjoyment of using the product, and it has an intersection with emotional aspects</td>
</tr>
<tr>
<td>Privacy (Swallow, Blythe, &amp; Wright, 2005)</td>
<td>Refers to the trust between the user and the product and how he is feeling safe and has an intersection with the trustworthiness</td>
</tr>
<tr>
<td>Sensual (Mercuri, 2005)</td>
<td>Refers to the experience derived from the sense when using the product</td>
</tr>
<tr>
<td>Usability (Mahlke, 2005)</td>
<td>Refers to the ease of use and learnability of using the product</td>
</tr>
<tr>
<td>Functionality (Mcnamara, 2005)</td>
<td>Refers to the state of being functional and can meet the goals of using the product</td>
</tr>
<tr>
<td>Usefulness (Mahlke, 2005)</td>
<td>Refers to the state of being useful</td>
</tr>
<tr>
<td>Platform Technology (Huy &amp; Van Thanh, 2012)</td>
<td>Refers to the software technology that has been used to build the product, which has an impact on the usability and the emotions as well</td>
</tr>
<tr>
<td>Infrastructure (Wigelius &amp; Väätäjä, 2009)</td>
<td>Refers to the hardware technology that has been used to build the product from both sides (client and Server) as it has an impact on the usability and it has interaction with Service Response Time aspect</td>
</tr>
<tr>
<td>Service Response time (Tung &amp; Yuan, 2007)</td>
<td>Refers to the time that the organization takes to respond to the user by a valuable result, and it is mainly here related to the technology</td>
</tr>
<tr>
<td>Visual Attractiveness (Mahlke, 2005)</td>
<td>Refers to the user interface, and it has an impact on the usability and emotions as well</td>
</tr>
<tr>
<td>Development Process (Roto, Rantavuo, &amp; Kaisa, 2009)</td>
<td>Refers to the development process and how it is covering the user’s needs and expectations</td>
</tr>
</tbody>
</table>
• Brand aspects: Aspects related to the marketing and the business communications between the user and the organization and can be linked to the organization brand dimension.

• Technology aspects: Aspects related to the development and production technologies that have an impact on the overall experience and can be related to the technology dimension. This category can be divided into four types:
  ○ UX designs (UXD) aspects: These are related to the UI designs.
  ○ Development technology aspects: These are related to the development technologies that are used in delivering the product.
  ○ Hardware aspects: These are related to the infrastructure of either the client side or the server side.
  ○ Operation aspects: These are related to the technologies that are used to monitor the production and response of the users.

• The context of use aspects: Aspects related to any aspect that is not related to one of the previous aspects but has an impact on them, and this can be linked to the Context dimension.

From the previous classifications and the identified UX aspects from the primary studies, Table 3 illustrates the relationship between the UX aspects, categories and dimensions.

### 2.5. UX measurements methods

UX measurement method is a method to measure UX aspects and to get information about the fulfillment level of a certain aspect. The primary studies have been used to identify the different measurement methods used by researchers to measure UX aspects, either as a separate method or mixed with other measurement methods. In some cases, the same method is used to measure more than one aspect.

Table 4 shows the measurement methods and a number of papers that used it.

Note that some of the measurements methods are mentioned by the general name, such as questionnaire, interview, etc., while other methods are mentioned as part of the commercial name, such as Attrakdiff (Roto et al., 2009) and UNeeQ (Fronemann & Peissner, 2014) which are Questionnaires. The purpose of usage frequency is to understand the methods’ popularity along with the UX aspect. Table 5 summarizes the general UX measurement methods.

After reviewing the measurement methods in Table 5 and their use in the primary studies, a categorization has been identified according to the applicability of the method to the UX dimension in general. Table 6 shows the main measurement methods and the corresponding UX dimensions that can be used to measure. These measurement methods have been used recently to evaluate various UX aspects, see for example (Kremer et al., 2017).

For the Context dimension, no measurement methods are assigned, because the UX aspects in this dimension are not applicable for measurement.

### 2.6. UX Frameworks available in the literature

UX frameworks provide a theoretical background for a thorough understanding of what UX is. Researchers have synthesized their UX research findings in a UX framework. As can be seen from Table 7, different frameworks focused on certain UX dimensions and aspects based on selective literature; this resulted in having incomplete frameworks that provide a fractional image of the whole UX concept. For instance, Tan, Ronkko and Gencel (2013) have developed a UX framework that focuses on user needs experience dimension and its related aspects: hedonic and pragmatic. Their framework is based on a selected literature review and Goal Question Metric (GQM) paradigm. On the other hand, GAO (Changyuan, Shiying, & Chongran, 2013) have developed their framework to focus
on user needs experience and Technology experience and their visual attractiveness, pragmatic and emotional aspects. Their framework is based on defining user experience under web environment.

Although various UX researchers have discussed various UX dimensions (see Table 3), none of them have developed a structured organization to understand UX aspects, dimensions, and measurement methods. It is stated explicitly by some researchers that their developed frameworks might not be fine-grained enough, and there can be a need to divide UX work into more unambiguous pieces, see for example (Gegner, Runonen, & Keinonen, 2011). Further aspects underlying the UX components need to be addressed to get a more holistic picture of the interaction between the different UX components and their relative importance for the overall UX, e.g. going beyond visual aesthetics for the non-instrumental qualities (Gross & Bongartz, 2012).

Accordingly, the work presented in this paper aims at handling this gap by identifying UX dimensions and aspects and link them to their corresponding measurement methods. Hence, the new framework specifications are given in Table 8.

### 3. Research methodology

The concept of user experience has been growing in the research community during the last two decades, and there is still no agreement about its nature and how to measure it (Gross & Bongartz, 2012). As stated by many studies in the literature, the “UX is dynamic, context-dependent, and subjective” (Law et al., 2009). This fact led to the need to scan this research area systematically to identify the possible dimensions that related to the UX and that have an impact on it.
### Table 4. Extracted UX measurement methods from the selected studies

<table>
<thead>
<tr>
<th>Measurement method</th>
<th>Usage frequency</th>
<th>Measurement method</th>
<th>Usage frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Questionnaire</td>
<td>6</td>
<td>Experience Report (Open-ended Questions)</td>
<td>1</td>
</tr>
<tr>
<td>Interview</td>
<td>5</td>
<td>User’s Feedback</td>
<td>1</td>
</tr>
<tr>
<td>Experience report</td>
<td>5</td>
<td>Diary</td>
<td>1</td>
</tr>
<tr>
<td>Expert review</td>
<td>4</td>
<td>Valence Method</td>
<td>1</td>
</tr>
<tr>
<td>Attrakdiff</td>
<td>4</td>
<td>Expressing Experiences and Emotions (3E)</td>
<td>1</td>
</tr>
<tr>
<td>Electromyography responses (EMG)</td>
<td>3</td>
<td>Probe</td>
<td>1</td>
</tr>
<tr>
<td>Self-assessment manikin (SAM)</td>
<td>3</td>
<td>Fuzzy Cognitive Map (FCM)</td>
<td>1</td>
</tr>
<tr>
<td>Persona</td>
<td>3</td>
<td>UNeeQ</td>
<td>1</td>
</tr>
<tr>
<td>User profile</td>
<td>3</td>
<td>Survey</td>
<td>1</td>
</tr>
<tr>
<td>UX curve</td>
<td>2</td>
<td>System Usability Scale questionnaire (SUS)</td>
<td>1</td>
</tr>
<tr>
<td>Observation</td>
<td>2</td>
<td>Sentence Compaction Survey</td>
<td>1</td>
</tr>
<tr>
<td>PLEX</td>
<td>2</td>
<td>Emocards</td>
<td>1</td>
</tr>
<tr>
<td>Day reconstruction method</td>
<td>2</td>
<td>Emotion Words Priming List (EWPL)</td>
<td>1</td>
</tr>
<tr>
<td>Lean UX</td>
<td>1</td>
<td>PriMo</td>
<td>1</td>
</tr>
<tr>
<td>Prototype</td>
<td>1</td>
<td>Group Experience Evaluation Method</td>
<td>1</td>
</tr>
<tr>
<td>BadIdeas</td>
<td>1</td>
<td>Subjective Usability Measurement Inventory (SUMI)</td>
<td>1</td>
</tr>
<tr>
<td>Electrodermal activity (EDA)</td>
<td>1</td>
<td>SUXES</td>
<td>1</td>
</tr>
<tr>
<td>Specification document</td>
<td>1</td>
<td>Attrak-Work</td>
<td>1</td>
</tr>
<tr>
<td>Think-Aloud</td>
<td>1</td>
<td>Focus Group</td>
<td>1</td>
</tr>
<tr>
<td>AHP</td>
<td>1</td>
<td>Experience Sampling Method (ESM)</td>
<td>1</td>
</tr>
<tr>
<td>Tracking real-time user experience (TRUE) method</td>
<td>1</td>
<td>Goal Question Metric (GQM)</td>
<td>1</td>
</tr>
<tr>
<td>DrawUX</td>
<td>1</td>
<td>Experience Evaluation Model (EEM)</td>
<td>1</td>
</tr>
<tr>
<td>UX cards</td>
<td>1</td>
<td>User Experience Metric (UXM)</td>
<td>1</td>
</tr>
<tr>
<td>UX concept testing</td>
<td>1</td>
<td>SPUX</td>
<td>1</td>
</tr>
<tr>
<td>iScale</td>
<td>1</td>
<td>Self-Expression Template Method</td>
<td>1</td>
</tr>
</tbody>
</table>

### Table 5. UX measurement methods—general names

**General measurement methods**

- Questionnaire
- Interview
- Expert Review
- Persona
- Survey
- User profile
- Observation
- Prototype
- Specification document
- Focus Group
- Think-Aloud
- Experience report
- Users’ feedback
- Diary
Identifying these dimensions will build boundaries around the UX and will give directions on how to recognize the impact on the UX if it exists. Also, this may help to discover the methods that can be used to measure such an impact, or at least, understand its nature. Once identified, the dimensions that have an impact on the UX and the methods that have been used to measure them can be used to build a framework that covers these dimensions and methods to measure them.

Figure 6 shows the main stages of this research and the expected outcomes from each phase.

(A) Systematic Literature Review: Identify a set of selected primary studies which will be used to study UX aspects, dimensions and measurement.
(B) Demographical Analysis: Analyse and illustrate demographical data about the topic and the selected primary papers.
(C) Results Analysis: defines various UX concepts such as UX dimensions, aspects, and measurement methods. Moreover, in this phase, a more relational analysis will be conducted to relate findings to each other, and enhance our understanding of UX concepts.
(D) Build a theoretical framework that synthesizes findings and explains the relation between them.
(E) Report Results and outcomes in the form of research papers.

The first phase of this research has been completed and published in (Zarour & Alharbi, 2017) and a summary of this phase is given in Sections 2.1–2.3 as well as part of 2.4. The research work discussed in this paper focuses on developing the UX framework based on the main findings of phase one.

4. Proposed framework
In this section, the results of the extracted data from the literature review are analyzed aiming to synthesize all collected pieces of data into one theoretical framework.

Table 1 summarized the mapping between the suggested dimensions and the UX disciplines. Value dimension is the centric point for technology experience (TX), brand experience (BX) and user
<table>
<thead>
<tr>
<th>Framework's author</th>
<th>Year</th>
<th>Covered UX dimensions</th>
<th>UX aspects</th>
<th>Theoretical background</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vyas and Van Der Veer (2006)</td>
<td>2006</td>
<td>User Needs Experience</td>
<td>Hedonic and Pragmatic, User experience design</td>
<td>Domain of art is used to provide a metaphor to understand a user's experience and design strategies</td>
</tr>
<tr>
<td>Möller et al. (2009)</td>
<td>2009</td>
<td>User Needs Experience, Technology Experience</td>
<td>Hedonic and Pragmatic, Visual attractiveness, Service Performance</td>
<td>Multimodal human-machine interactions used to develop a taxonomy of the most relevant QoS and QoE aspects that can be used for assessment and evaluation</td>
</tr>
<tr>
<td>Schulze and Krommer (2010)</td>
<td>2010</td>
<td>User Needs Experience</td>
<td>Hedonic and Pragmatic</td>
<td>Analyzed direct and indirect influencing factors of User Experience</td>
</tr>
<tr>
<td>Chen and Zhu (2011)</td>
<td>2011</td>
<td>User Needs Experience, Technology Experience</td>
<td>Hedonic, Pragmatic, User experience designs, Development technology, Hardware and Operation</td>
<td>Analytic Hierarchy Process (AHP) to study mobile application user experience and quantitative assessment</td>
</tr>
<tr>
<td>Gegner et al. (2011)</td>
<td>2011</td>
<td>Brand Experience Technology Experience User Needs Experience</td>
<td>Business communication, marketing, technology, and design, Usability</td>
<td>Selective literature and case study to identify UX in the context of product development in larger organizations</td>
</tr>
<tr>
<td>Gross and Bongartz (2012)</td>
<td>2012</td>
<td>User Needs Experience, Value Experience</td>
<td>Hedonic and Pragmatic (instrumental and non-instrumental qualities), Context</td>
<td>Used the components of user experience (CUE) model of Mahlke, and Thüring to hypothesize that the impact of perceived product attributes and emotional reactions on UX vary among different product types.</td>
</tr>
<tr>
<td>Antha and Prabhu (2012)</td>
<td>2012</td>
<td>Technology Experience</td>
<td>Visual design</td>
<td>Discussions of some of the misconceptions and myths that exist in the industry regarding Requirements Engineering (RE) and User Experience Design (UXD)</td>
</tr>
<tr>
<td>Tan, Ronkko and Gencel (2013)</td>
<td>2013</td>
<td>User Needs Experience</td>
<td>Hedonic and Pragmatic</td>
<td>Selective literature review, Goal Question Metric (GQM)</td>
</tr>
<tr>
<td>GAO Changyuan et al. (2013)</td>
<td>2013</td>
<td>User Needs Experience, Technology Experience</td>
<td>Visual attractiveness, Pragmatic, Emotional</td>
<td>Defined the concept of info. platform user experience under Web environment, after reviewing some other similar frameworks</td>
</tr>
<tr>
<td>Kujala et al. (2013)</td>
<td>2013</td>
<td>Brand Experience</td>
<td>Temporal UX</td>
<td>Analyze the current state of the temporal aspect of UX, discuss definitions and theoretical models based on previous work</td>
</tr>
<tr>
<td>Kremer et al. (2017)</td>
<td>2017</td>
<td>User needs experience, technology experience</td>
<td>Hedonic, brand, user experience design, operation</td>
<td>Defined based on the ExodUX model (from Experience Oriented Disciplines to User experience) consisting of 41 experiences from disciplines outside engineering design (e.g. sports)</td>
</tr>
</tbody>
</table>
needs experience (NX) dimensions. Context relates all dimensions together and surrounding them. Accordingly, a relationship between these dimensions is built as shown in Figure 7.

In Section 2.4, we discussed the UX aspects and summarized the relationship between the UX aspects, their categories, and dimensions in Table 3. Adding the UX aspects to their dimensions shown in Figure 7 will give the result depicted in Figure 8.

The context dimension refers to the interaction with other dimensions, and it has the following aspects:

(A) Spatio-temporal
(B) User journey
(C) Cultural
(D) Context of use

Cultural aspect affects hedonic and pragmatic dimensions of UX, hence the culture can be related to User needs dimension. User Journey and Spatio-Temporal aspects are related to the period of experience that the user has with the product or the organization, hence these two aspects are related to the brand dimension. The aspect “Context of Use” is a general aspect and could not be related to a particular dimension. For the TN dimension, the interaction between the technology and context of use can be represented by the development process, hence context of use can be placed within the Technology context space as development process.
The relationship between UX aspects and their corresponding dimensions can be rebuilt again as depicted in Figure 9.

Adding the remaining aspects described in Table 2 to their corresponding aspect’s category will extend Figure 9 as depicted in Figure 10.
Figure 10 is updated by augmenting the measurement methods, given in Table 6, to each UX dimension, see Figure 11. The resulted framework covers the gathered UX dimensions, aspects and measurement methods. When compared to the various studies listed in Table 7, we can say that this framework is a comprehensive one that covered all identified UX dimensions: Value, Brand Experience, User Needs Experience, Technology Experience.
5. Conclusion & future work

UX is an emerging research area, that extends usability, and is still immature. The absence of a theoretical framework that defines and links together various UX dimensions, aspects and measurement methods resulted in disagreement between software engineers and practitioners in defining UX concepts. In this research, we analyzed UX dimensions that have an impact on the UX either during the development or awhile the product is in use. In addition to the UX dimensions, we scanned the relationship between those dimensions and UX aspects that have a direct or indirect impact on the UX. We also studied various UX measurement methods and their relation to UX dimensions.

All findings have been analyzed and consolidated in one framework that explains the relationship between UX dimensions, aspects and measurement methods. Although we cannot claim that the developed framework solves all conflicting issues related to UX concepts, but it is vital to understand UX related concepts and to develop UX evaluation methods. More work is required in the future to cover the following related issues:

1. Use a cumulative method to measure the UX from a long-term usage perspective, as the methods in the proposed framework are mainly for short-term usage. The UX Curve method is mentioned in literature and can be used in such cases and needs to be included in this framework (Kujala & Roto, 2011; Sahar, Varsaluoma, & Kujala, 2014).

2. More research is needed to link UX concepts, depicted in the proposed theoretical framework, the software quality standard known as SQuaRE (ISO25000 series) and the evaluation theory concepts to develop rigorous UX evaluation methods.

3. Build a relationship and integrate the proposed framework with a common maturity model such as CMMI. This will help to improve UX work level (Peres & Meira, 2015).

4. Identify the proper development process that brings more consistency between the proposed framework and the Development Process aspect that exists in the Context dimension. Currently, no specific process is suggested, while the Lean UX is proposed as a UX-centric development process (Liikkanen, Kilpiö, Svan, & Hiltunen, 2014) in literature.
(5) For each UX measurement method, a template and general guidelines are required to assure that the questions and statements used in this method are covering all related aspects. This can be reached by identifying the goals that satisfy the aspect, and the Analytic Hierarchy Process (AHP) (Chen & Zhu, 2011) method can help in this case.

(6) Empirical studies on the commercial UX methods to assure its applicability to measuring the different UX aspects. This will help to simplify the proposed framework and give directions about which method can be used.

(7) More analysis in the Context dimension is needed to identify more UX aspects.

**References**


(2012). To measure or not to measure UX: An interview study. In CEUR Workshop Proceedings (pp. 58–63).


Appendix A

List of Primary Studies


65. T. Jokela, “The early phases of UX: Why they are important (more than evaluation), and what they are?,” in NordiCHI 2012, 2012.


