



Titre: Identifying the importance of UX dimensions for different software product categories
Title:

Auteurs: Ehsan Mortazavi, Philippe Doyon-Poulin, Daniel Imbeau, & Jean-Marc Robert
Authors:

Date: 2024

Type: Article de revue / Article


Référence: Mortazavi, E., Doyon-Poulin, P., Imbeau, D., & Robert, J.-M. (2024). Identifying the importance of UX dimensions for different software product categories.
Citation: Interacting with Computers, iwae001 (21 pages).
<https://doi.org/10.1093/iwc/iwae001>

 **Document en libre accès dans PolyPublie**
Open Access document in PolyPublie

URL de PolyPublie: <https://publications.polymtl.ca/57347/>
PolyPublie URL:

Version: Version finale avant publication / Accepted version
Révisé par les pairs / Refereed

Conditions d'utilisation: Tous droits réservés / All rights reserved
Terms of Use:

 **Document publié chez l'éditeur officiel**
Document issued by the official publisher

Titre de la revue: Interacting with Computers
Journal Title:

Maison d'édition: Oxford University Press
Publisher:

URL officiel: <https://doi.org/10.1093/iwc/iwae001>
Official URL:

Mention légale: This is a pre-copyedited, author-produced version of an article accepted for publication in Identifying the importance of UX dimensions for different software product categories following peer review. The version of record Mortazavi, E., Doyon-Poulin, P., Imbeau, D., & Robert, J.-M. (2024). Identifying the importance of UX dimensions for different software product categories. Interacting with Computers, iwae001 (21 pages).
Legal notice: <https://doi.org/10.1093/iwc/iwae001> is available online at: doi:10.1093/iwc/iwae001

Identifying the importance of UX dimensions for different software product categories

Abstract

Billions of users around the world use mobile applications and computer software to achieve their professional and personal goals. This situation drives User Experience (UX) researchers and practitioners to assess the importance of UX dimensions across different products, to facilitate the design, development and evaluation of new products. To that end, this study surveyed a group of 200 end users and 8 UX experts from Canada to document the importance of 21 UX dimensions for 15 software product categories. The results confirmed that the importance of UX dimensions varies between product categories. Comparing the findings to those of similar studies conducted in Germany and Indonesia revealed that, while culture influences the rating of UX dimensions, the importance of UX dimensions is still determined by the product category. Comparisons between the importance ratings of UX dimensions between end users and experts and within end users were not significant in 77% and 97% of cases, respectively. Results showed that task-based product categories rely more on pragmatic dimensions (i.e., functionality and usability) while leisure-based products value hedonic dimensions (i.e., pleasure) as well. This study benefits researchers and practitioners by enabling them to select the most important UX dimensions for evaluating their products.

CCS CONCEPTS: • Human-centered computing • Human-Computer Interaction (HCI) • HCI design and evaluation methods

Additional Keywords and Phrases: User experience, UX dimension, UX evaluation, culture

Research Highlights

- The importance of UX dimensions varies depending on the product category.
- UX experts considered more hedonic dimensions as important than end users.
- Task-based product categories rely more on pragmatic dimensions while leisure-based products value hedonic dimensions as well.

1 Introduction

User Experience (UX) has been defined as “a multidimensional construct that defines the overall effect over time on the user of interacting with a system and service in a specific context” (Robert & Lesage, 2011). This definition highlights that UX is gained through the actual use of a product. It also emphasizes the trinity of users, products, and contexts in shaping UX. The influence of users on UX is through “users’ emotions, beliefs, preferences, perceptions, physical and psychological responses, behaviors and accomplishments” (Standardization, 2019). Gross and Bongartz (Gross & Bongartz, 2012) argued that UX is product-specific and the importance of UX dimensions varies between products. Moreover, new products, services, and technologies can affect UX by introducing new UX dimensions that have not been considered before (H. B. Santoso & Schrepp, 2019). Context of use can also impact the UX in different ways, such as physical, social, technical, and internal contexts when using a product (Lallemand & Koenig, 2020).

UX dimensions that influence user-product interaction include, but are not limited to, pragmatic, hedonic, emotional, social, and physical dimensions. The pragmatic and hedonic dimensions, which respectively address functional and psychological aspects of UX, can be further divided into sub-dimensions. The more UX dimensions there are, the more time and effort participants will put into evaluation, and evaluators into analyzing the data. Some dimensions that are important for a product might be meaningless for another. Thus, knowing the important UX dimensions for different product categories helps keep UX evaluation focused and optimized. Depending on the product, one can evaluate only the relevant UX dimensions by using modular tools like meCUE 2.0 (Minge & Thuring, 2018) or UEQ+ (Schrepp & Thomaschewski, 2019) or a combination of UX evaluation tools. For instance, Gross and Bongartz (Gross & Bongartz, 2012) used a combination of UX tools to evaluate three different products, and found clear differences between levels of importance of UX dimensions depending on the product type, such as goal-oriented vs. leisure-based. Santoso and Schrepp (H. B. Santoso & Schrepp, 2019) compared the importance ratings of 16 UX dimensions for 15 software product categories and observed that differences in importance ratings exist at the category level. These studies pointed out the product specificity of UX. Additionally, we know that end users and UX experts alike can evaluate UX. It is interesting to know how these two groups rate the importance of UX dimensions for different product categories. In the case of similar judgments, one group could be chosen over the other based on the available time, cost, and goal of the evaluation. Jääskeläinen and Heikkinen (Jaaskelainen & Heikkinen, 2010) found that experts take more UX aspects into consideration when evaluating a product compared to end users, including environmental and emotional aspects.

Users’ cultural background should also be considered for UX evaluation, as people from different cultures have diverse perceptions, cognitions, and interaction styles with products (ShuQing Liu, Zheng, Liu, Jian, & Peng, 2013). Culture impacts the users’ values, such as non-verbal communication (Lachner, Nguyen, & Butz, 2018), and products’ design elements (S. Liu, Liang, Shao, & Kong, 2020) (Walsh, Nurkka, & Walsh, 2010). Recent efforts have been made to incorporate cultural aspects into UX tools, such as the work of Li et al. that developed the Chinese UX questionnaire based on the AttrakDiff questionnaire (ShuQing Liu et al., 2013). They added a new dimension called “Conformity”, which reflects the Chinese culture trait of giving value to others’ opinions compared to one’s own opinion in western societies. A major influence on the investigation of cultural aspects in UX studies is Hofstede’s theory on cultural dimensions (de Souza & Bernardes, 2016; Lachner et al., 2018), which defines culture as “the collective programming of the mind that distinguishes the members of one group or category of people from another”. It includes six

cultural dimensions, namely, power distance, individualism vs. collectivism, masculinity vs. femininity, uncertainty avoidance, long-term vs. short-term orientation, and indulgence vs. restraint (Hofstede, 2001). Santoso and Schrepp (H. B. Santoso & Schrepp, 2019) investigated the impact of culture on the importance ratings of UX dimensions for different software product categories in Germany and Indonesia. These two countries have distinct values on the six cultural dimensions of Hofstede's theory, making them suitable options for identifying the potential impact of culture on the importance of UX dimensions. Comparing the results of German (Winter, Hinderks, Schrepp, & Thomaschewski, 2017) and Indonesian (Harry Budi Santoso & Schrepp, 2018) students demonstrated that differences in importance of UX dimensions are caused more by product category than culture (H. B. Santoso & Schrepp, 2019). Therefore, we want to investigate to what extent these findings generalize to participants from another culture.

In this study, we replicated the work of Santoso and Schrepp (H. B. Santoso & Schrepp, 2019) and extended it by adding five new UX dimensions, ratings from UX experts, and having participants from another country (i.e., Canada) as well. The results of a systematic literature review on the UX dimensions of interactive products revealed that social, informational and physical UX dimensions are underrepresented in current UX evaluation tools (Mortazavi, Doyon-Poulin, Imbeau, Taraghi, & Robert, 2021). Thus, we included the social dimensions of sociability and social acceptance among the five new added dimensions. We chose Canada for the comparison with other cultures because it stands between Germany and Indonesia regarding the values of Hofstede's cultural dimensions. Therefore, this study has three objectives. First, to identify the important UX dimensions for different software product categories. Second, to compare the importance rating of UX dimensions between end users and UX experts, and within the end-user group based on sociodemographic variables. Third, to perform a cross-cultural comparison.

This paper is organized in five sections. Following the introduction, section 2 presents the methodology for data collection and data analysis. Sections 3 and 4 show the results and a discussion in three subsections: importance of UX dimensions, comparisons between participants and cross-cultural comparisons. Section 5 presents a short conclusion.

2 Methodology

This study has been approved by Polytechnique Montreal's Research Ethics Committee (CER-2021-12-D). Participants read and signed an informed consent form before taking part in the study.

2-1 Participants

Participants formed two groups: end users and UX experts. End users were from the general public, whereas UX experts were trained in the discipline and had years-long work experience. We collected data in two phases. The initial sample included 8 UX experts and 25 end users who all lived in Canada and were recruited from the personal contacts of the authors. End users received \$20 per hour and UX experts received \$50 per hour. A second sample of 175 end users was recruited through the SurveySwap website but received no monetary compensation. This sample of participants was also limited to Canada, using the website's custom requirements feature. Based on the feedback from the first sample of participants, two more product categories were added in the data collection for the second sample. The first sample of end users was required to answer all the product categories, whereas the second sample had the flexibility to answer none. We combined results regarding end users from both data collections into one sample. Table 1 presents the demographic data of the final sample, which shows how diverse the

participants were in terms of age, gender, level of education, job status, familiarity with UX, and years of work experience in related fields for experts.

Table 1- Demographic data (n=208)

Criteria		End user (n=200)	Expert (n=8)
Age	18-29	116	0
	30-39	57	2
	40-49	19	4
	50-59	7	1
	60-69	1	1
	70+	0	0
Gender	Male	93	3
	Female	105	5
	Other	2	0
Education	High school or equivalent	17	0
	Bachelor	86	0
	MSc.	80	4
	Ph.D.	17	2
	Other	0	2
Job status	Employed	75	6
	Unemployed	8	0
	Working and studying	29	1
	Student	88	0
	Retired	0	1
Familiarity with UX/HCI	Extremely familiar	19	8
	Very familiar	39	0
	Somewhat familiar	92	0
	Not so familiar	43	0
	Not at all familiar	7	0
Experience in the field of UX (Experts only)	Less than 3 years	-	0
	3-5 years	-	1
	5-10 years	-	0
	10-20 years	-	3
	+ 20 years	-	4

The two groups were well balanced on gender. Unlike experts, most end users were under the age of 39, and were students (59%) with a university-level education. Overall, 75% of end users were at least somewhat familiar with the fields of usability, UX, and HCI. Experts were chosen from both academia (3) and industry (5) to ensure that both viewpoints were considered in the evaluations, with work experience in visual design, cognitive ergonomics, UX research and UI development. Cross-cultural comparisons were made with the German and Indonesian samples of the work of Santoso and Schrepp (H. B. Santoso & Schrepp, 2019) including 114 and 58 students, respectively.

2-2 Questionnaire

Data collection was done via an online questionnaire over a 2-month period for the first sample (September-October 2020), and over three months for the second sample (June-August 2021). It was designed on the SurveyMonkey website, and the initial participants accessed it through a link sent to them by email. For the second sample of end users, a list of product categories was made available for evaluation on the SurveySwap website. The questionnaire was written in English and designed based on the 16 UX dimensions from (H. B. Santoso & Schrepp, 2019) with the addition of five UX dimensions (i.e., ease of use, error tolerance, sociability, social acceptance, and self-satisfaction; see below). Participants had to rate the importance of 21 UX dimensions on an 8-point Likert scale, ranging from meaningless (0)

to extremely important (7). Participants were instructed to select Meaningless when they judged the UX dimension to be irrelevant for the product category. The first sample of end users and experts were asked to answer all product categories, whereas the second sample of end users was given the option to choose which product categories to evaluate. Moreover, two questions about the level of familiarity of participants with each product category and their frequency of use were also included in the survey. Participants had the option to write the UX dimensions that they felt were missing for each product category, as well as the name of the product in each category for which they filled the questionnaire.

In total, the survey contained 365 questions for the 15 product categories, and participants took on average 45 minutes to answer. The five UX dimensions added were chosen by three UX experts from a list of UX dimensions extracted from a systematic literature review performed earlier (Mortazavi et al., 2021). We decided to add **ease of use** as a new dimension. The description of perspicuity highlights the understandability and learnability of a product, so we wanted to investigate whether participants gave similar ratings for ease of use and perspicuity. **Error tolerance** was added as we expected this dimension to be important for productivity-related products like Word processing, Spreadsheet, and Online banking. The third dimension added was **sociability**, which is concerned with a product’s ability to enable communication with other people. **Social acceptance** investigates how acceptable using a product is from the viewpoints of others or from the user’s perspective. Finally, the dimension of **self-satisfaction** reflects the gratification a user gets when using a product. We expected this dimension to be seen in product categories involving learning or skill development. The list of 21 UX dimensions and their descriptions are presented in Table 2.

*Table 2- UX dimensions and their descriptions (new dimensions indicated by *)*

UX Dimension	Description
Beauty	The product is beautiful and attractive.
Ease of use*	It is easy to use the product.
Efficiency	I can achieve my goals with minimal time and physical effort. The product responds quickly to my input.
Error tolerance*	The product prevents me from making errors and helps me to recover from any that do occur.
Clarity	I find the user interface of the product looks tidy and clear.
Content Quality	The information provided by the product is always actual and of good quality.
Controllability	The product always reacts predictably and consistently to my input. I always have full control over the interaction.
Customization	I can adapt the product to my personal preferences or personal work style.
Identity	The product helps me to make contacts and to present myself positively.
Immersion	When I deal with the product, I forget the time. I completely sink into the interaction with the product.
Intuitive Usage	I can use the product directly without any learning or the help of other people.
Loyalty	Even if there are other equivalent products for the same tasks, I would not change the product.
Novelty	The design of the product is interesting and unusual. The original design catches my attention.
Perspicuity	It is easy to understand and learn how to use the product.
Self-satisfaction*	I feel satisfied with myself after using the product.
Sociability*	The product helps me to be sociable and connect with other people.
Social acceptance*	Using the product is socially accepted by others and my own norms.
Stimulation	I find the product stimulating and exciting. It is fun to deal with the product.
Trust	My data is in safe hands. The data will not be misused to harm me.
Usefulness	Using the product brings me advantages. It saves me time and effort and makes me more productive.
Value	I find the product makes a high-quality and professional impression.

We used the same 15 product categories as in Santoso and Schrepp’s study for the comparisons. However, two new product categories were added in response to end users’ feedback from the first sample.

Moreover, we selected examples of each product category to be more easily understandable by Canadian users (Table 3).

*Table 3- Product categories and their examples (new product categories are indicated by *). Products in parentheses moved to the new product categories for the second sample of the end-user*

Product category	Examples
Word processing	Microsoft word, Google Docs, Apple's Pages, LaTeX.
Spreadsheet	Microsoft Excel, Google Sheets, Apple's Numbers.
Messenger	WhatsApp, Facebook Messenger, Snapchat, iMessage, Telegram.
Social network	Instagram, Facebook, (LinkedIn).
Video conferencing	Skype, Zoom, Face Time.
Web shop	Amazon, Walmart, Best Buy, eBay.
News portal	CBC News, CTV News, CNN, NBC news.
Booking system	TripAdvisor, Expedia, Trivago.
Info web page	Canada.ca, Montreal.ca, Polymtl.ca.
Learning platform	Udemy, Udacity, Lynda, SkillShare.
Programming tool	Eclipse, Visual Studio, Android studio.
Image processing	Adobe Photoshop, CorelDraw.
Online banking	NBC, RBC, Scotiabank.
Video portals	YouTube, (Netflix, Crave, Amazon prime video).
Games	PUBG, Fortnite, Dota2, League of legends.
Professional social Network*	LinkedIn, Meetup
Video Streaming*	Netflix, Crave, Amazon prime video.

Participants in the first sample of end users commented that some examples of product categories were confusing. For instance, having Instagram and LinkedIn in the same Social network product category made the rating exercise challenging for them. The nature of these two applications is different, as one is focused on entertainment, while the other is professional and work-related. The same applied to YouTube and Netflix in the Video portal category where the former allows users to express their thoughts in comments and discuss with others under each video, whereas the latter only allows like and dislike reactions to each video. This difficulty led us to add two more product categories to the survey of the second sample of end users, namely Professional social network and Video streaming services, in order to determine whether or not the differences were meaningful. This decision resulted in moving LinkedIn to the Professional social network category, keeping YouTube in the Video portal, and moving the rest into Video streaming.

We categorized the UX dimensions as in Table 4. The three UX dimensions of content quality, trust and loyalty did not have the same quality as the other dimensions included in the pragmatic and hedonic categories. Content quality is different from pragmatic and hedonic categories in that it is more concerned with the content a product provides rather than the product itself. Trust and loyalty are UX dimensions that take shape after a period of working with a product. Furthermore, we grouped product categories into groups based on the contexts in which they are most commonly used (Table 5).

Table 4- Categorization of UX dimensions (new dimensions indicated by *)

Pragmatic	Hedonic	Other
Ease of use*	Beauty	Content Quality
Efficiency	Identity	Trust
Error tolerance*	Immersion	Loyalty
Clarity	Novelty	
Controllability	Self-satisfaction*	
Customization	Sociability*	
Intuitive Usage	Social acceptance*	
Perspicuity	Stimulation	
Usefulness	Value	

Table 5- Grouping of product categories (New product categories are indicated by *)

Work-related	Personal task	Entertainment	Communication	Information
Word processing	Web shop	Social network	Messenger	News portal
Spreadsheet	Booking system	Video portal	Video conferencing	Info web page
Programming tool	Learning platform	Games		
Image processing	Online banking	Video streaming*		
Professional social network*				

2-3 Procedure

The participants read the instructions on how to fill out the questionnaire, and then proceeded to rate the importance of 21 UX dimensions for different product categories. To ensure a common understanding, a short description of each UX dimension was provided (Table 2), along with examples for each product category (Table 3). It was also mentioned that each category was not limited to those examples, and participants could give their judgment about other products belonging to the category. Instructions highlighted the fact that there was no correct or incorrect answer, and the answer should reflect the participant's personal assessment. The survey provided the option to go back and forth in the questionnaire or to stop at any time and resume later.

2-4 Data cleaning

In the first step, data was cleaned by removing the results of 39 participants who left the questionnaire incomplete, apparently answered randomly¹ or responded to the questionnaire in too short a time, i.e., under 25 minutes for answering all product categories for the first sample of end users and under 3 minutes for answering one product category for the second sample. The second step was to make sure that the participants actually used the product category they evaluated. To that end, for each product category, the results of the participants who indicated having "never" used a product, regardless of their familiarity with it, were removed. In addition, the results of those who indicated being "not so familiar" and "rarely" used a product category were eliminated. The final sample includes 200 end users and 8 UX experts. Table 6 shows the number of end users based on the frequency of use and familiarity with each product category.

¹ We used red-herring questions to find participants who randomly answered the survey.

Table 6- Number of end users' responses based on the frequency of use and familiarity per product category

Familiarity	Frequency of use	Word processing	Spreadsheet	Messenger	Social Network	Video Conferencing	Web shop	News Portal	Booking System	Info Web page	Learning Platform	Programming tool	Image Processing	Online Banking	Video Portal	Game	Professional SN	Video streaming
		Extremely familiar	Always	16	6	20	23	8	8	1	2	0	1	5	0	11	26	4
Usually	2		2	1	6	3	4	4	1	1	0	1	3	2	3	4	3	7
Sometimes	0		1	0	0	1	2	2	2	0	0	0	0	0	1	1	2	0
Rarely	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Very familiar	Always	12	6	7	5	2	0	5	0	0	0	2	0	6	8	0	1	2
	Usually	13	7	7	6	12	8	5	7	6	4	3	4	11	11	5	6	8
	Sometimes	3	2	1	1	5	7	2	5	4	7	1	4	0	4	1	4	2
	Rarely	0	1	0	0	0	0	1	1	1	2	1	1	0	0	0	0	0
Intermediate	Always	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1
	Usually	3	2	1	0	3	1	3	0	2	0	1	1	2	1	1	2	0
	Sometimes	2	11	3	2	5	9	13	10	8	11	6	10	6	5	9	8	3
	Rarely (4)	1	2	0	1	2	2	7	4	10	14	14	16	1	3	17	13	2
Total number of end users		53	40	40	44	41	41	44	32	32	39	34	39	39	62	42	40	41

2-5 Data analysis

In order to ensure that the newly added dimensions are not redundant we calculated Variance Inflation Factors (VIF) from the participants' ratings to assess multicollinearity among the 21 UX dimensions. Small VIF values indicate that the UX dimensions have low correlation with each other and thus are not redundant. Different thresholds of 10, 5, and 3 are provided for VIF to indicate multicollinearity between variables (Hair, Black, Babin, & Anderson, 2014). As in (Field, 2013), we can use only the collinearity diagnostics feature of the linear regression dialog box of SPSS to calculate VIFs. The VIF values in this study were all less than 3 which is acceptable regardless of the selected cutoff value.

We used cluster analysis to categorize UX dimensions into important and unimportant for each product category. Among the clustering methods, we chose hierarchical clustering, which is suitable for a small amount of data and represents clusters in a tree-like visual graph called a Dendrogram. Using an agglomerative approach, each dimension is in a separate cluster at first. After each clustering step, dimensions with more similarities are grouped together until the end, when all dimensions are collected into one cluster (Grimm & Yarnold, 2000). We used Ward's method, which is similar to k-means clustering in that it minimizes the variances of members within a cluster. One characteristic of Ward's method is that it tends to produce even-sized clusters, which in the case of our study helps to have both clusters with more representative dimensions (Grimm & Yarnold, 2000).

We used Multi-Dimensional Scaling (MDS) to show which product categories have similar UX dimension ratings. This visual technique puts product categories with comparable UX dimension ratings in closer proximity. Following the method used in (H. B. Santoso & Schrepp, 2019), we used Pearson correlation of importance ratings as the similarity matrix for MDS to show the distance between products. We also used MDS to group UX dimensions into two groups of hedonic and pragmatic dimensions.

According to the Central limit theorem, we can assume normal distribution for sample sizes over thirty and use parametric tests (Field, 2013). Although there are at least 30 end users per product category, the total number of UX experts is only 8. Therefore, we used the Mann-Whitney U test, the non-parametric equivalent of the independent t-test, to compare the ratings of UX dimensions between end users and

experts. To investigate the differences within the end users' group, we repeated the Mann-Whitney U test based 1) on users' frequency of use and familiarity with the products and 2) on gender, for all 17 product categories. The first group included users who were extremely or very familiar with a product category and always or usually used it and the rest belonged to the second group (see Table 6).

Comparing our results with those of Santoso and Schrepp (H. B. Santoso & Schrepp, 2019) required calculating the mean importance rating for each UX dimension of each product category that was featured in both studies. To that end, product-moment correlation of the mean importance rating of each product category between end-user samples of three countries was measured. We carried out the same procedure on the ranking values between samples for the comparison of UX dimensions' rankings per product category. Moreover, the average importance rating of UX dimensions for all product categories and the average importance rating of hedonic and pragmatic dimensions for the five groups of categories were measured to show the similarity and differences between the three cultures. Data analysis was performed on IBM SPSS statistics 27.

3 Results

Results are presented in three sections in accordance with the three objectives of the study. In the first section we identify the important and unimportant UX dimensions for each product category and investigate these dimensions for the two newly added product categories. In the second section we compare the ratings of UX dimensions between end users and experts. In the third section, we present cross-cultural comparisons between our findings and those of Santoso and Schrepp (H. B. Santoso & Schrepp, 2019).

3-1 Important UX dimensions for different product categories

After having added the five new dimensions, VIF values for all UX dimensions ranged from 1.15 to 2.13. Because they are all under the threshold of 5, they indicate low multicollinearity among the dimensions. Results of the hierarchical cluster analysis are shown in Table 7 for the end users' data. Ease of use, intuitive usage, and perspicuity were the UX dimensions that were important for all product categories, whereas novelty, beauty, and identity were only important for one or two product categories. Professional social network (SN in Table 7) was the category with the most UX dimensions rated as important (16) whereas Messenger had the smallest number of important UX dimensions (6). Among all product categories, Game had most of the hedonic dimensions categorized as important. In addition to clustering, UX dimensions with the highest rankings per product category can be used as the most important dimensions as presented in Appendix 1.

Table 7- Clustering of UX dimensions into important (checked) and unimportant (minus) per product category based on end-users' data

UX dimension (abbreviation)	Messenger	Info Web page	Booking System	News Portal	Web shop	Word processing	Spreadsheet	Image Processing	Programming tool	Online Banking	Learning Platform	Video streaming	Video Portal	Professional SN	Social Network	Video Conferencing	Game
Content quality (CQL)	-	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	-	✓
Customization (CUS)	-	-	-	-	-	✓	✓	✓	✓	✓	✓	✓	✓	✓	-	✓	-
Perspicuity (PER)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Efficiency (EFF)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	-
Immersion (IMM)	-	-	-	-	-	-	-	-	-	-	-	✓	✓	-	-	-	✓
Intuitive usage (INT)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Usefulness (USF)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	-
Novelty (NOV)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	✓
Beauty (BEA)	-	-	-	-	✓	-	-	-	-	-	-	-	-	-	-	-	✓
Identity (IDN)	-	-	-	-	-	-	-	-	-	-	-	-	-	✓	✓	-	✓
Controllability (CON)	-	-	✓	✓	✓	✓	✓	✓	✓	✓	-	✓	✓	✓	✓	✓	✓
Stimulation (STM)	-	-	-	-	-	-	-	-	-	-	-	✓	✓	-	-	-	✓
Clarity (CLR)	-	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Loyalty (LOY)	-	-	-	-	-	-	-	-	✓	✓	-	-	-	-	-	-	-
Trust (TRS)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	-	✓	✓	✓	-
Value (VAL)	-	-	-	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	-	✓	-
Ease of use (EOU)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Error tolerance (ERR)	-	-	✓	-	✓	✓	✓	✓	✓	✓	-	-	✓	✓	-	✓	✓
Sociability (SOC)	-	-	-	-	-	-	-	-	-	-	-	-	-	✓	✓	✓	-
Social acceptance (SOA)	-	-	-	-	-	-	-	-	-	-	-	-	-	✓	✓	✓	-
Self-satisfaction (SLF)	-	-	-	-	-	-	✓	✓	✓	✓	✓	✓	-	✓	✓	-	✓

Product categories with comparable importance ratings of UX dimensions can be identified in Table 7, however MDS's visual representation is easier to interpret (Figure 1). Product categories having similar ratings among all UX dimensions are located closer to each other (see Figure 1-left). Task-focused products, both professional and personal, informational, and video service are all placed near each other. Although not closely grouped together, product categories of a social nature are placed in distance from others (Triangles). Similarly, the Game category, being focused on hedonic dimensions, is located far from the rest.

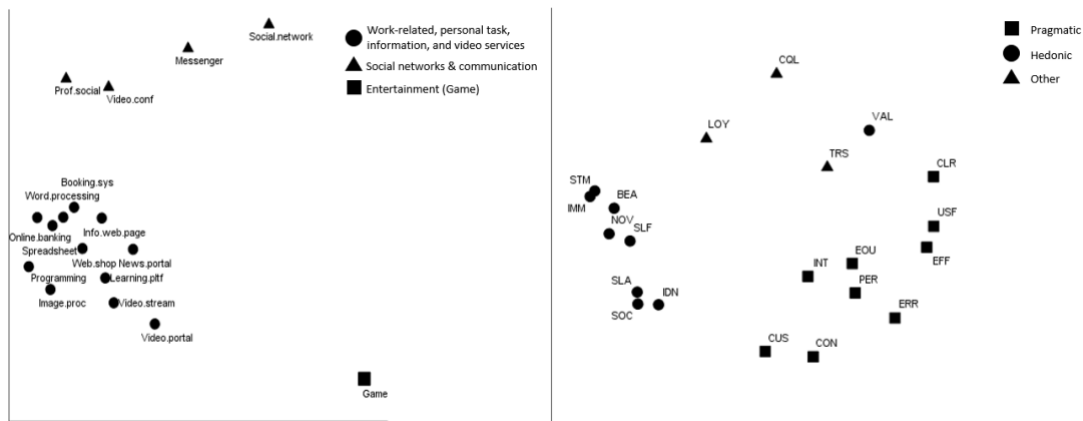


Figure 1- multi-dimensional scaling of product categories (left), UX dimensions² (right)

² beauty (BEA), clarity (CLR), content quality (CQL), controllability (CON), customization (CUS), ease of use (EOU), efficiency (EFF), error tolerance (ERR), identity (IDN), immersion (IMM), intuitive usage (INT), loyalty (LOY), novelty (NOV), perspicuity (PER), self-satisfaction (SLF), sociability (SOC), social acceptance (SLA), stimulation (STM), trust (TRS), usefulness (USF), value (VAL).

The results of the MDS analysis on the UX dimensions are shown in the right half of Figure 1, with hedonic dimensions on the left (circles) and pragmatic dimensions (squares) on the right. The only exception was value (VAL) that was originally classified as a hedonic dimension, but it appeared closer to pragmatic dimensions. Moreover, loyalty, trust, and content quality (triangles) showed up in between the two groups. Results also show that social acceptance, sociability, and identity can be seen as a separate category.

Mean importance ratings and rankings of UX dimensions for the two social network categories show that users put more emphasis (i.e., more than twice in ranking) on usefulness, efficiency, value, sociability and customization of the Professional social networks compared to the Social network (see Table 8). The Pearson correlation of the ranking value of Social network and Professional social network was low at 0.455, but statistically significant ($p = .038$).

Table 8- Ranking and mean importance rating of UX dimensions for social network and professional social network categories (ranking from 1 to 21 and rating from 0 to 7)

Product category		Content quality	Customization	Perspicity	Efficiency	Immersion	Intuitive usage	Usefulness	Novelty	Beauty	Identity	Controllability	Stimulation	Clarity	Loyalty	Trust	Value	Ease of use	Error Tolerance	Sociability	Social acceptance	Self-satisfaction
Social network	Ranking	4	12	7	13	16	5	17	21	15	8	9	14	10	19	3	18	2	20	1	6	11
	Rating	6.0	5.4	5.8	5.3	5.1	5.9	5.0	4.7	5.2	5.7	5.7	5.3	5.5	5.0	6.2	5.0	6.3	4.7	6.5	5.9	5.5
Professional social network	Ranking	4	6	11	3	21	9	1	20	19	13	12	17	10	18	7	5	2	16	8	14	15
	Rating	5.8	5.7	5.5	5.9	3.3	5.6	6.3	3.4	3.5	5.4	5.5	3.7	5.6	3.7	5.7	5.7	5.9	5.2	5.6	5.4	5.3

Video portal and Video streaming categories did not show much of a difference, except the ranking of the value, stimulation, and efficiency dimensions, which were noticeably different (i.e., more than twice) (see Table 9). The ranking values of UX dimensions for these two categories had a strong correlation of 0.826, which is highly significant ($p = .000004$).

Table 9- Ranking and mean importance rating of UX dimensions for video portal and video streaming categories (ranking from 1 to 21 and rating from 0 to 7)

Product category		Content quality	Customization	Perspicity	Efficiency	Immersion	Intuitive usage	Usefulness	Novelty	Beauty	Identity	Controllability	Stimulation	Clarity	Loyalty	Trust	Value	Ease of use	Error Tolerance	Sociability	Social acceptance	Self-satisfaction
Video portal	Ranking	1	7	6	8	9	3	14	16	15	21	10	4	5	18	11	13	2	17	20	19	12
	Rating	6.4	5.5	5.5	5.5	5.4	6.0	5.0	4.4	4.9	3.1	5.3	5.6	5.5	4.1	5.1	5.1	6.1	4.3	3.1	4.0	5.1
Video streaming	Ranking	1	13	6	3	12	4	8	17	16	20	7	11	9	18	10	5	2	14	21	19	15
	Rating	6.6	4.8	5.6	6.0	5.2	5.9	5.6	3.5	3.9	2.4	5.6	5.4	5.6	3.5	5.5	5.8	6.3	4.7	2.3	2.9	4.7

3-2 Comparison of end users and experts' ratings of UX dimensions

Table 10 reports the results on the comparisons of end users' ratings with those of the experts for the 21 UX dimensions and the original 15 product categories, except for the Programming tool and Game categories due to a lack of expert data. The p-values for the Mann-Whitney U tests are shown in Table 10, with bold values denoting dimensions where the two groups differ significantly. Results show no

significant difference between end users' and experts' ratings for the five UX dimensions of identity, loyalty, value, sociability, and social acceptance, across all product categories. Spreadsheet and Social network had the lowest number of differences between two groups. The mean ranks of the experts were higher than those of end users for all 62 occurrences where a significant difference was found.

Table 10- P-values of the Mann-Whitney U tests between end users' and experts' ratings

UX dimension	Word processing	Spreadsheet	Messenger	Social Network	Video Conferencing	Web shop	News Portal	Booking System	Info Web page	Learning Platform	Image Processing	Online Banking	Video Portal
Content quality	0.278	0.483	0.692	0.274	0.105	0.014	0.082	0.043	0.151	0.194	0.163	0.030	0.197
Customization	0.251	0.074	0.625	0.990	0.200	0.433	0.969	0.053	0.695	0.042	0.024	0.287	0.687
Perspicuity	0.107	0.156	0.243	0.659	0.027	0.560	0.213	0.042	0.094	0.004	0.005	0.153	0.126
Efficiency	0.044	0.128	0.208	0.103	0.006	0.122	0.624	0.381	0.827	0.068	0.006	0.295	0.056
Immersion	0.444	0.191	0.039	0.137	0.485	0.891	0.011	0.433	0.393	0.307	0.060	0.399	0.006
Intuitive usage	0.106	0.184	0.120	0.055	0.003	0.089	0.028	0.031	0.030	0.006	0.006	0.032	0.038
Usefulness	0.045	0.089	0.351	0.022	0.029	0.089	0.533	0.362	0.753	0.079	0.023	0.389	0.400
Novelty	0.957	0.942	0.054	0.103	0.104	0.389	0.001	0.060	0.0002	0.145	0.989	0.043	0.122
Beauty	0.307	0.431	0.092	0.373	0.100	0.484	0.004	0.062	0.015	0.038	0.143	0.011	0.071
Identity	0.468	0.330	0.112	0.406	0.553	0.691	0.867	0.473	0.810	0.652	0.886	0.374	0.723
Controllability	0.012	0.008	0.002	0.031	0.018	0.044	0.072	0.032	0.352	0.001	0.004	0.119	0.006
Stimulation	0.802	0.519	0.160	0.774	0.130	0.387	0.078	0.644	0.280	0.056	0.428	0.509	0.048
Clarity	0.016	0.034	0.039	0.085	0.002	0.005	0.052	0.147	0.407	0.003	0.019	0.189	0.022
Loyalty	0.738	0.831	0.319	0.478	0.785	0.814	0.727	0.192	0.183	0.938	0.277	0.171	0.808
Trust	0.073	0.429	0.856	0.773	0.084	0.037	0.590	0.120	0.734	0.080	0.326	0.166	0.221
Value	0.092	0.429	0.856	0.773	0.084	0.037	0.590	0.120	0.734	0.080	0.326	0.060	0.308
Ease of use	0.167	0.292	0.766	0.722	0.095	0.790	0.335	0.404	0.616	0.005	0.042	0.096	0.014
Error tolerance	0.021	0.094	0.120	0.345	0.267	0.394	0.432	0.446	0.986	0.206	0.195	0.725	0.743
Sociability	0.753	0.490	0.190	0.920	0.772	0.621	0.887	1	0.251	0.220	0.826	0.650	0.940
Social acceptance	0.073	0.352	0.917	0.774	0.723	0.795	0.391	0.430	0.609	0.475	0.954	0.117	0.815
Self-satisfaction	0.007	0.085	0.143	0.160	0.377	0.149	0.624	0.049	0.292	0.062	0.003	0.034	0.427

The Pragmatic dimensions amounted for 43 out of the 62 instances where a significant difference was found, with controllability, clarity, and intuitive usage being the dimensions with the highest number of differences between the two groups of participants.

Results of the comparisons within end users with different frequency of use and familiarity with the products showed similar ratings, with only 15 pairs (out of 357) showing significant differences. The first group (i.e., more familiar) gave higher mean ranks for 11 pairs including both pragmatic and hedonic dimensions. Among product categories, Spreadsheet had the greatest number of differences for the pragmatic dimensions of customization, efficiency, usefulness and error tolerance was rated higher by those who were more familiar with it.

Regarding the gender differences, we only found 12 instances (out of 357) where a significant difference was found between two groups. The highest number of differences was found in Social network product category with perspicuity, immersion, and intuitive usage as dimensions with higher mean ranks for females. Error tolerance for Word processing, usefulness for Image processing, and clarity and sociability for Online banking were the only four dimensions with higher mean ranks for males.

3-3 Cross-cultural comparison

This section presents the results of the Canadian end users' evaluation on the original set of 16 UX dimensions and 15 product categories as in Santoso and Schrepp's study (H. B. Santoso & Schrepp, 2019),

whose participants were from Germany and Indonesia. Appendix 2 provides the ranking and the mean importance rating of each UX dimension for each product category.

Table 11 and Table 12 show the Pearson correlation between samples for the mean importance rating and the ranking of UX dimensions, respectively. The last column of tables 11-12 shows the correlation of the average importance rating of UX dimensions and the average ranking of UX dimensions for all product categories. Results showed moderate to very high correlations between samples in both tables. We found the highest correlations for Word processing, Spreadsheet, Booking system, Learning platform, Programming tool, Image processing, and Online banking between Canadians and the other two samples. The only exception was the Video portal category, with its correlation not being statistically significant between Canadians and Indonesians. Still moderate, we observed the lowest correlation for the Social network category between Canadians and Indonesians. Overall, correlations were higher between Germans and Canadians for both rankings and ratings.

Table 11- Pearson correlation of the mean importance ratings for each product category between samples

Country*	Word processing	Spreadsheet	Messenger	Social Network	Video Conferencing	Web shop	News Portal	Booking System	Info Web page	Learning Platform	Programming tool	Image Processing	Online Banking	Video Portal	Game	Average
CAD-IND	0.97	0.96	0.72	0.56	0.77	0.82	0.67	0.85	0.81	0.89	0.95	0.92	0.86	0.44	0.89	0.89
CAD-GER	0.95	0.95	0.80	0.72	0.88	0.82	0.72	0.94	0.81	0.94	0.92	0.87	0.92	0.62	0.86	0.94
GER-IND	0.94	0.95	0.76	0.65	0.83	0.91	0.91	0.89	0.93	0.93	0.92	0.91	0.94	0.84	0.89	0.93

*CAD: Canada; IND: Indonesia; GER: Germany

Table 12- Pearson correlation of the UX dimensions ranking for each product category between samples

Country*	Word processing	Spreadsheet	Messenger	Social Network	Video Conferencing	Web shop	News Portal	Booking System	Info Web page	Learning Platform	Programming tool	Image Processing	Online Banking	Video Portal	Game	Average
CAD-IND	0.97	0.93	0.77	0.54	0.76	0.85	0.60	0.93	0.79	0.91	0.92	0.89	0.87	0.54	0.80	0.87
CAD-GER	0.93	0.95	0.75	0.78	0.88	0.80	0.66	0.89	0.79	0.92	0.96	0.88	0.80	0.70	0.79	0.93
GER-IND	0.91	0.94	0.71	0.59	0.81	0.86	0.85	0.89	0.84	0.93	0.90	0.85	0.76	0.83	0.82	0.90

*CAD: Canada; IND: Indonesia; GER: Germany

Figure 2 shows the results of the average importance rating of hedonic and pragmatic dimensions for each group of products. Regarding the hedonic dimensions, the three cultural groups gave on average the highest ratings for the Entertainment products and the lowest for Work-related products (Figure 2– left). Indonesians consistently rated hedonic aspects the highest among all three cultures. Regarding the pragmatic dimensions, the highest mean importance ratings were associated with the Work-related products, whereas the lowest means were for Information products, in all three countries (Figure 2-right)

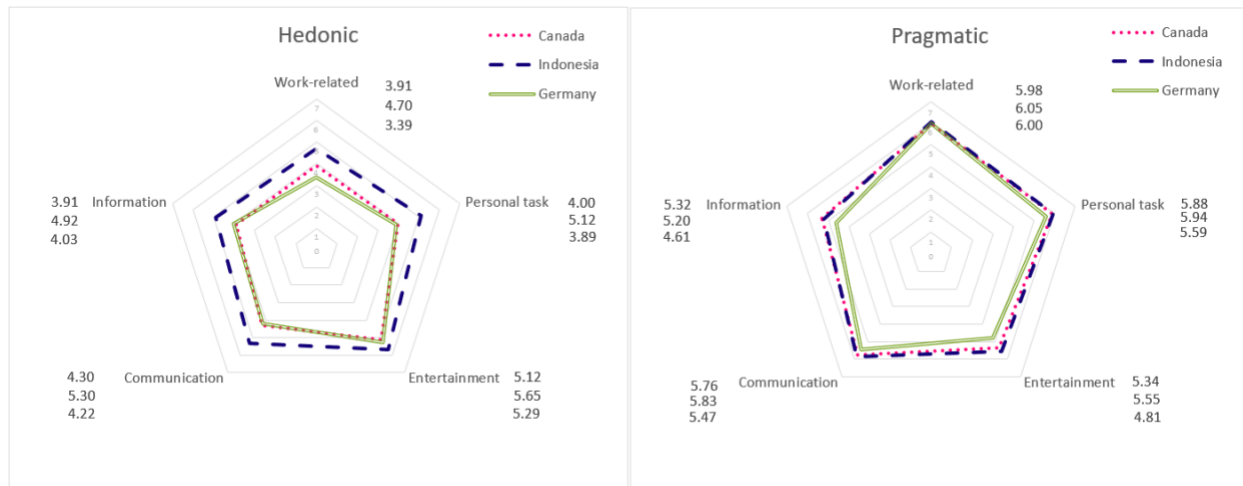


Figure 2- Average importance rating of hedonic and pragmatic dimensions for each group of products (ratings 0-7)

4 Discussion

In this section, we first identify the important UX dimensions for different product categories, then discuss the comparison of the UX ratings among participants and finally explore cross-cultural comparisons of the UX ratings.

4-1 Important UX dimensions

Identifying which UX dimensions are important for different product categories allows designers to improve the functions and features of their products. Focusing on the most important UX dimensions for a product category also facilitates evaluation by avoiding lengthy and costly evaluation sessions that measure irrelevant UX dimensions.

Our findings (Table 7) revealed that certain UX dimensions, such as ease of use, intuitive usage, and perspicuity, were important regardless of product category. Other dimensions like beauty, novelty, and value were important only for one or two product categories. These results are in accordance with Jordan's (Jordan, 2000) hierarchy of consumer needs, which begins with functionality and proceeds to usability and pleasure at higher levels. Based on our results, we can argue that task-based product categories rely more on pragmatic dimensions (i.e., functionality and usability) while leisure-based products value hedonic dimensions (i.e., pleasure) as well.

Product categories associated with Work, Personal tasks, and Information groups (see Figure 1) shared more UX dimensions except for the Professional social networks (see Table 13). We observed that newly added dimensions had an impact on better differentiating the product categories. For instance, error tolerance was important for task-based categories for which the possibility and cost of making errors were higher, that is, those that dealt with large amount of input by users (e.g., Word processing, Spreadsheet, Programming tool) and those that involved money transactions (e.g., Web shop, Booking system, and Online banking). Findings also showed that self-satisfaction is an important UX dimension for the product categories whose outcome involved learning (e.g., Learning platform), development (e.g., Programming tool, Image processing), or enjoyment (e.g., Game, Video streaming).

The two groups of Entertainment and Communication (Figure 1-left), in which hedonic dimensions were important, were noticeably different from the other three groups, with Game standing out from the

rest. The results of MDS for UX dimensions showed that identity, sociability, and social acceptance were grouped together (Figure 1-right). The same social dimensions distinguished Social networks and Video conferencing from other product categories. These dimensions have the potential to be evaluated separately from the hedonic dimensions, which is consistent with what (Mortazavi et al., 2021) stated regarding the need for increased attention to social dimensions in UX studies.

The UX dimensions identified as important for each product category (as in Table 13) can be measured either by using a combination of UX evaluation tools or a modular evaluation tool. UEQ+ (Schrepp & Thomaschewski, 2019) is an example of a modular framework that enables evaluators to select the most relevant UX dimensions for the evaluation of their products. Other studies (Boos & Brau, 2017; Klein, Schrepp, Hinderks, & Thomaschewski, 2020) have added more dimensions to UEQ+, demonstrating its potential to entail more dimensions and to be used for a wide range of products.

Table 13- Important UX dimensions for different software product categories

Product category	Important dimensions
Word processing	ease of use, efficiency, error tolerance, clarity, controllability, customization, intuitive usage, perspicuity, trust, usefulness, value
Spreadsheet	ease of use, efficiency, error tolerance, clarity, controllability, customization, intuitive usage, perspicuity, trust, usefulness, value
Messenger	ease of use, efficiency, clarity, controllability, immersion, intuitive usage, perspicuity, trust, usefulness
Social network	ease of use, efficiency, error tolerance, clarity, content quality, controllability, identity, intuitive usage, perspicuity, self-satisfaction, sociability, social acceptance, trust, usefulness
Video conferencing	ease of use, efficiency, error tolerance, clarity, controllability, customization, intuitive usage, perspicuity, sociability, social acceptance, trust, usefulness, value
Web shop	beauty, ease of use, efficiency, error tolerance, clarity, content quality, controllability, intuitive usage, perspicuity, trust, usefulness, value
News portal	beauty, ease of use, efficiency, clarity, content quality, controllability, immersion, intuitive usage, novelty, perspicuity, trust, usefulness, value
Booking system	ease of use, efficiency, error tolerance, clarity, content quality, controllability, intuitive usage, perspicuity, trust, usefulness
Info web page	beauty, ease of use, efficiency, clarity, content quality, intuitive usage, perspicuity, trust, usefulness
Learning platform	beauty, ease of use, efficiency, clarity, content quality, controllability, intuitive usage, perspicuity, self-satisfaction, trust, usefulness, value
Programming tool	ease of use, efficiency, error tolerance, clarity, controllability, customization, intuitive usage, loyalty, perspicuity, self-satisfaction, trust, usefulness, value
Image processing	ease of use, efficiency, error tolerance, clarity, controllability, customization, intuitive usage, perspicuity, self-satisfaction, trust, usefulness, value
Online banking	ease of use, efficiency, error tolerance, clarity, controllability, customization, intuitive usage, loyalty, perspicuity, trust, usefulness, value
Video portals	ease of use, efficiency, error tolerance, clarity, controllability, customization, immersion, intuitive usage, perspicuity, stimulation, trust, usefulness, value
Games	beauty, ease of use, error tolerance, clarity, controllability, immersion, intuitive usage, novelty, perspicuity, self-satisfaction, stimulation
Professional social Network	ease of use, efficiency, error tolerance, clarity, content quality, controllability, customization, identity, intuitive usage, perspicuity, self-satisfaction, sociability, social acceptance, trust, usefulness

The importance of UX dimensions can be influenced by factors related to the context, users, and their activities. For instance, loyalty to a product can be mandatory, like using the banking app in which you have an account, or optional, like a programmer who uses a specific programming language. It can vary based on the user's skills, like pro-users who use shortcuts and customize their working environment in an image processing or spreadsheet software. It can also differ depending on the target user, for instance, a person whose job is content creation on social networks or video portals might give a different importance rating of UX dimensions compared to someone who uses these products for entertainment purposes only. In other words, although having a general overview of important dimensions for each product category is useful, one should also consider the subtle hints that differentiate products. UX

dimensions of products within the same product category, for example, can be rated differently should their purpose differ. To that end, we compared the rating and ranking of UX dimensions between entertainment-focused Social networks and business-oriented Professional social network as well as Video portals and Video streaming services. Our findings suggest that separating social networks into two categories allows better detection of differences. However, there was no need to have two separate categories for Video portals and Video streaming services because their ratings and rankings on UX dimensions were comparable.

4-2 Comparison between participants

Our second goal was to see how the two groups of end users and experts rated UX dimensions per product category. In 77% of cases, there was no significant difference between the ratings of the two groups (211 out of 273). For the rest, experts gave higher ratings for all UX dimensions compared to end users. We found that all the pragmatic dimensions that were significantly different between end users and experts (see Table 10) were clustered as important by the users (see Table 7), except for controllability and clarity for Messenger and customization for Learning platform categories. This finding shows that regardless of a significant difference, pragmatic dimensions were important to both groups.

Results showed that end users were more concerned with pragmatic rather than hedonic dimensions when it comes to task-based products. On the other hand, experts gave higher ratings for hedonic dimensions such as beauty and novelty for product categories like News portal, Information web page, Learning platform and Online banking. From the experts' perspective, these task-based products can benefit from the hedonic dimensions to be more inviting and attractive to the users. Our findings are in line with those of (Jaaskelainen & Heikkinen, 2010), demonstrating that experts take more UX aspects into consideration when asked to evaluate a product.

Comparisons within the end-user group yielded interesting results. Our findings showed significant differences only for 12 of the comparisons (out of 357) between genders. Similarly, 15 pairs (out of 357) were significantly different between the end users based on frequency of use and familiarity with the product category. We can argue that these two factors did not make a meaningful difference in the rating of the UX dimensions. However, the less familiar users are with a product category, the more likely they are to evaluate their expectations of a product rather than its actual use. For instance, users the least familiar with Spreadsheets rated customization, efficiency, usefulness, and error tolerance significantly lower, which is unexpected for a task-based product category.

4-3 Comparison between cultures

The last goal of this study was to investigate to what extent culture affects the evaluation of the importance of UX dimensions. The mean importance ratings of the UX dimensions were different between the three cultures. According to Figure 2, the Indonesians gave higher ratings for all UX dimensions, specifically hedonic dimensions, compared to the other two cultures. The findings of (Walsh et al., 2010) on the UX evaluation of smartphones based on Hofstede's cultural dimensions showed that users from high power distance cultures, such as China and India, are cautious in freely expressing their opinions and giving negative feedback. Moreover, cultural impact on website development showed that cultures with higher values on Hofstede's theory feminine dimension emphasize on the hedonic values such as website aesthetics (Vitols & Vitols-Hirata, 2018). Thus, the differences in ratings of the Indonesians can be traced

back to their culture, which has higher power distance and lower masculinity values compared to German and Canadian cultures (Hofstede-Insights, 2021). However, regardless of differences in mean importance values, the high correlation between the mean importance rating and ranking of UX dimensions (Table 11 and Table 12) proved that participants from all three countries had a similar judgment of the importance of UX dimensions for each product category. The only two product categories with a lower correlation were Social network and Video portals. As discussed in the previous section, depending on what products have been evaluated we could see differences in importance ratings most notably for the Social network product category.

Limitation

The limitations of our work are as follows: first, ratings were not done for a specific product per category. Although covering different products enabled us to measure the overall judgment of participants on a product category, differences between products in each group can impact the results. Second, we did not instruct participants to consider a specific device when evaluating a product category. The UX of an online word document (e.g., Google Docs®) can be different when using a computer with a cursor and mouse compared to a mobile phone. Third, based on our sample size, we could not investigate the impact of other factors like age on ratings since most of the participants were young. Fourth, since UX is flexible and evolves over time the list of important UX dimensions is not static and requires to be reviewed and updated over time. Last, we had to rely on the correlations between the rankings and the mean importance ratings of UX dimensions between different cultures because we did not have access to the raw data of Santoso and Schrepp's study.

Take-aways

Based on our findings, the main take-aways are as follows:

- The importance of UX dimensions varies depending on the product category.
- UX experts' important UX dimensions for different product categories overlapped with those of end users yet included more hedonic dimensions.
- The importance of UX dimensions for evaluating different categories of products was similar across different cultures. However, culture can affect the rating values for different UX dimensions.
- UX designers can use the list of important UX dimensions for each category of products to prioritize dimensions that will have the greatest impact.

5 Conclusion

This study investigated the importance of UX dimensions for different product categories and compared the evaluation results of 200 participants in Canada to those of 114 Germans and 58 Indonesians. We confirmed the conclusion of prior research that the product category had a greater impact on UX evaluation than cultural differences. Additionally, in most cases, there was no significant difference in the evaluation of the importance of UX dimensions when factors such as familiarity with UX (i.e., end user vs. experts), frequency of use of a product, familiarity with the product, and gender were investigated. This study highlighted the importance of five new UX dimensions, most notably sociability and social acceptance. The lack of attention to these dimensions in UX evaluation tools requires more studies to cover these social aspects. We are currently in the process of developing a tool for the evaluation of the social dimensions of UX.

Funding

This research was funded by NSERC (Natural Sciences and Engineering Research Council of Canada) Individual Research Grant awarded to Dr. Jean-Marc Robert (#RGPIN-2018-06733).

References

- Boos, B., & Brau, H. (2017). Erweiterung des UEQ um die Dimensionen Akustik und Haptik. In S. Hess & H. Fischer (Eds.), *Mensch und Computer 2017 - Usability Professionals: Gesellschaft für Informatik e.V.*
- de Souza, T. R. C. B., & Bernardes, J. L. (2016). *The Influences of Culture on User Experience*, Cham.
- Field, A. (2013). *Discovering statistics using IBM SPSS statistics* (4th ed.): Sage.
- Grimm, L. G., & Yarnold, P. R. (2000). *Reading and understanding MORE multivariate statistics: American psychological association.*
- Gross, A., & Bongartz, S. (2012). *Why do i like it? Investigating the product-specificity of user experience.* Paper presented at the 7th Nordic Conference on Human-Computer Interaction: Making Sense Through Design, NordiCHI 2012, October 14, 2012 - October 17, 2012, Copenhagen, Denmark.
- Hair, J. F., Black, W. C., Babin, B. J., & Anderson, R. E. (2014). *Multivariate data analysis* (7th ed.): Pearson.
- Hofstede-Insights. (2021). Retrieved from <https://hi.hofstede-insights.com/national-culture>
- Hofstede, G. (2001). *Culture's consequences: Comparing values, behaviors, institutions and organizations across nations: Sage publications.*
- Jaaskelainen, A., & Heikkinen, K. (2010). *Divergence of user experience: Professionals vs. end users.* Paper presented at the 1st International Workshop on the Interplay Between User Experience and Software Development, I-UxSED 2010, October 17, 2010 - October 17, 2010, Reikjavick, Ireland.
- Jordan, P. W. (2000). *Designing pleasurable products: An introduction to the new human factors: CRC press.*
- Klein, A. M., Schrepp, M., Hinderks, A., & Thomaschewski, J. (2020). Measuring User Experience Quality of Voice Assistants Voice Communication Scales for the UEQ plus Framework. In A. Rocha, B. E. Perez, F. G. Penalvo, M. D. Miras, & R. Goncalves (Eds.), *2020 15th Iberian Conference on Information Systems and Technologies.*
- Lachner, F., Nguyen, M.-A., & Butz, A. (2018). *Culturally sensitive user interface design: a case study with German and Vietnamese users.* Paper presented at the Proceedings of the Second African Conference for Human Computer Interaction: Thriving Communities, Windhoek, Namibia. <https://doi.org/10.1145/3283458.3283459>
- Lallemand, C., & Koenig, V. (2020). *Measuring the Contextual Dimension of User Experience: Development of the User Experience Context Scale (UXCS).* Paper presented at the Proceedings of the 11th Nordic Conference on Human-Computer Interaction: Shaping Experiences, Shaping Society.
- Liu, S., Liang, T., Shao, S., & Kong, J. (2020). Evaluating Localized MOOCs: The Role of Culture on Interface Design and User Experience. *IEEE Access*, 8, 107927-107940. doi:10.1109/ACCESS.2020.2986036
- Liu, S., Zheng, X. S., Liu, G., Jian, J., & Peng, K. (2013). Beautiful, usable, and popular: Good experience of interactive products for Chinese users. *Science China Information Sciences*, 56(5), 1-14. doi:10.1007/s11432-013-4835-4
- Minge, M., & Thuring, M. (2018). *The MeCUE questionnaire (2.0): Meeting five basic requirements for lean and standardized UX assessment.* Paper presented at the 7th International Conference on Design, User Experience, and Usability, DUXU 2018 Held as Part of HCI International 2018, July 15, 2018 - July 20, 2018, Las Vegas, NV, United states.

- Mortazavi, E., Doyon-Poulin, P., Imbeau, D., Taraghi, M., & Robert, J.-M. (2021). *Systematic Literature Review on UX dimensions and UX subjective evaluation tools*. Manuscript submitted for publication.
- Robert, J.-M., & Lesage, A. (2011). Designing and evaluating user experience. In G. A. Boy (Ed.), *The Handbook of Human-Machine Interaction: A Human-Centered Design Approach* (pp. 321-338). UK: Ashgate.
- Santoso, H. B., & Schrepp, M. (2018). *Importance of user experience aspects for different software product categories*. Paper presented at the 5th International Conference on User Science and Engineering, i-USer 2018, August 28, 2018 - August 30, 2018, Puchong, Malaysia.
- Santoso, H. B., & Schrepp, M. (2019). The impact of culture and product on the subjective importance of user experience aspects. *Heliyon*, 5(9). doi:10.1016/j.heliyon.2019.e02434
- Schrepp, M., & Thomaschewski, J. (2019). Design and Validation of a Framework for the Creation of User Experience Questionnaires. *International Journal of Interactive Multimedia & Artificial Intelligence*, 5(7).
- Standardization, I. O. f. (2019). ISO 9241-2019 (Ergonomics of human-system interaction). In *Part 210: Human-centred design for interactive systems*: International Organization for Standardization.
- Vitols, G., & Vitols-Hirata, Y. (2018). *Impact of Culture Dimensions Model on Cross-Cultural Website Development*. Paper presented at the ICEIS (2).
- Walsh, T., Nurkka, P., & Walsh, R. (2010). *Cultural differences in smartphone user experience evaluation*. Paper presented at the Proceedings of the 9th International Conference on Mobile and Ubiquitous Multimedia, Limassol, Cyprus. <https://doi.org/10.1145/1899475.1899499>
- Winter, D., Hinderks, A., Schrepp, M., & Thomaschewski, J. (2017). Welche UX Faktoren sind für mein Produkt wichtig? *Mensch und Computer 2017-Usability Professionals*.

Appendix 1

Ranking of UX dimensions per product category (1: the most important, 21: the least important)

UX dimension	Word processing	Spreadsheet	Messenger	Social Network	Video Conferencing	Web shop	News Portal	Booking System	Info Web page	Learning Platform	Programming tool	Image Processing	Online Banking	Video Portal	Game
Content quality	11	10	16	4	15	2	1	4	1	1	11	10	9	1	9
Customization	12	12	12	12	12	15	18	13	18	14	5	9	12	7	14
Perspicuity	4	5	3	7	6	4	7	7	8	5	7	5	10	6	8
Efficiency	3	2	6	13	3	5	5	2	5	3	2	4	3	8	18
Immersion	20	19	20	16	18	19	12	20	17	13	15	16	20	9	1
Intuitive usage	8	4	4	5	4	6	9	8	7	10	10	8	7	3	6
Usefulness	2	1	9	17	2	7	4	5	2	2	1	1	2	14	21
Novelty	18	17	18	21	21	18	20	19	20	18	18	17	16	16	10
Beauty	16	15	14	15	19	13	15	14	14	17	16	14	15	15	7
Identity	19	20	13	8	16	20	19	18	19	20	19	19	17	21	20
Controllability	7	6	10	9	7	10	11	9	10	12	4	3	8	10	4
Stimulation	15	16	17	14	20	16	13	17	16	11	17	15	18	4	2
Clarity	5	7	8	10	9	9	2	6	4	8	8	6	5	5	11
Loyalty	14	14	19	19	17	14	10	15	13	19	14	18	13	18	17
Trust	6	9	2	3	8	3	3	1	6	9	13	13	1	11	19
Value	9	11	21	18	11	8	8	10	9	7	9	11	11	13	13
Ease of use	1	3	1	2	1	1	6	3	3	4	6	2	4	2	5
Error tolerance	10	8	15	20	13	11	17	11	12	15	3	7	6	17	16
Sociability	21	21	5	1	5	21	21	21	21	21	21	21	21	20	12
Social acceptance	17	18	7	6	10	17	16	16	15	16	20	20	19	19	15
Self-satisfaction	13	13	11	11	14	12	14	12	11	6	12	12	14	12	3

Appendix 2

Mean importance rating (bottom) and ranking (top) of UX dimensions for different product categories (ratings from 0 to 7, and ranking from 1 the most important to 16 the least important)

UX dimension	Word processing	Spreadsheet	Messenger	Social Network	Video Conferencing	Web shop	News Portal	Booking System	Info Web page	Learning Platform	Programming tool	Image Processing	Online Banking	Video Portal	Game
Content quality	9	8	11	2	10	1	1	3	1	1	9	8	7	1	7
	5.26	5.5	4.85	6.05	4.66	6.24	6.5	6.41	6.69	6.69	5.26	5.24	6.1	6.48	5.31
Customization	10	10	8	8	9	12	14	10	14	12	4	7	10	6	11
	4.92	5.33	5.13	5.45	5.24	4.68	4.07	4.81	3.19	5.08	6.18	5.59	5.21	5.52	4.81
Perspicuity	3	4	2	4	4	3	6	6	7	4	5	4	8	5	6
	5.87	6.13	6.1	5.82	5.98	6.07	5.45	6.06	5.59	6.05	6.0	5.95	5.82	5.56	5.4
Efficiency	2	2	4	9	2	4	5	2	4	3	2	3	3	7	13
	6.04	6.4	5.9	5.34	6.12	5.98	5.55	6.53	5.94	6.28	6.62	6.13	6.46	5.5	4.52
Immersion	16	15	15	12	13	15	11	16	13	11	12	13	16	8	1
	3.04	3.15	4.38	5.18	3.90	3.73	4.59	2.94	3.19	5.1	3.88	4.1	1.82	5.45	6.29
Intuitive usage	7	3	3	3	3	5	8	7	6	8	8	6	5	2	4
	5.58	6.2	6.05	5.98	6.02	5.98	5.25	6.0	5.84	5.67	5.71	5.67	6.23	6.02	5.71
Usefulness	1	1	6	14	1	6	4	4	2	2	1	1	2	12	16
	6.11	6.53	5.43	5.09	6.29	5.98	5.68	6.31	6.5	6.49	6.65	6.41	6.49	5.08	3.12
Novelty	14	14	13	16	16	14	16	15	16	14	15	14	13	14	8
	3.21	3.45	4.5	4.7	3.1	3.88	3.2	3.31	2.78	4.15	3.21	4.03	2.82	4.47	5.29
Beauty	13	12	10	11	14	10	13	11	11	13	13	11	12	13	5
	3.87	3.75	4.9	5.23	3.83	4.95	4.18	4.38	3.91	4.28	3.62	4.59	3.49	4.92	5.6
Identity	15	16	9	5	11	16	15	14	15	16	16	16	14	16	15
	3.09	2.88	4.95	5.73	4.29	3.17	3.68	3.47	3.0	3.69	3.03	3.46	2.79	3.18	3.79
Controllability	6	5	7	6	5	9	10	8	9	10	3	2	6	9	3
	5.58	6.00	5.33	5.70	5.83	5.34	4.70	5.69	4.53	5.18	6.21	6.15	6.15	5.34	5.81
Stimulation	12	13	12	10	15	13	12	13	12	9	14	12	15	3	2
	3.89	3.50	4.78	5.32	3.63	4.44	4.55	3.50	3.59	5.28	3.56	4.49	2.69	5.69	6.26
Clarity	4	6	5	7	7	8	2	5	3	6	6	5	4	4	9
	5.85	5.95	5.45	5.55	5.73	5.56	5.95	6.16	6.22	5.95	5.79	5.95	6.44	5.58	5.14
Loyalty	11	11	14	15	12	11	9	12	10	15	11	15	11	15	12
	3.98	4.03	4.43	5.00	3.95	4.76	4.98	4.31	3.94	4.00	4.12	3.82	4.97	4.11	4.60
Trust	5	7	1	1	6	2	3	1	5	7	10	10	1	10	14
	5.72	5.90	6.13	6.20	5.78	6.15	5.95	6.53	5.88	5.92	4.59	4.85	6.59	5.16	4.40
Value	8	9	16	13	8	7	7	9	8	5	7	9	9	11	10
	5.45	5.43	4.10	5.09	5.27	5.63	5.34	5.34	4.88	5.97	5.79	5.41	5.23	5.10	4.86