Evaluating UX Factors on Mobile Devices: A Feasibility Study

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Abstract: The acceptance of consumers regarding software products determines their success of technologies, making it a crucial topic in industrial research. In this context, the evaluation of User Experience (UX) can provide benefits in understanding for practitioners and researchers before the launch of products in the market. The literature encompasses works that focus on the assessment of UX for various software products, emphasizing the importance of clearly evaluating UX characteristics for those involved in a project. This paper presents a feasibility study with the participation of 25 practitioners engaged in the evaluation of UX for mobile devices, analyzing UX problems concerning different UX factors presented in the literature. The application of these factors was deemed easy and useful in understanding the quality of mobile devices before their market release. The study aims to contribute to practitioners and researchers involved in the assessment of UX for mobile devices, addressing different perspectives on product quality.

1 INTRODUCTION

The acceptance of consumers regarding software products determines their success of technologies (Wang et al., 2013). In this context, User Experience (UX) can contribute to the acceptance of these products. Researchers and practitioners understand the importance of providing a good user experience when developing interactive software products (Kou and Gray, 2019). For example, (Lallemand et al., 2014) conducted a survey with 758 participants from different fields and 35 nationalities, revealing that 83.9% consider UX as central or very central to their practitioner work. Thus, the prior evaluation of UX products can significantly contribute to product success.

Some works present studies from different perspectives of UX evaluation (Alves et al., 2021) (Jesus et al., 2022), focusing on experiments conducted through sessions with users, providing insights for future improvements. However, UX evaluations over a longer period contribute to collecting more data about the quality of a given product. One approach that has been adopted by UX evaluation by companies is Dogfooding (Harrison, 2006). Through this approach, company employees experience their products and services before they are launched in the market. This can be a way for an organization to test its products in the real world, obtaining feedback on how end-users would use them. This approach has been used by well-known technology market players such as Apple, Facebook, and Google (Soderquist et al., 2016). For mobile devices, for example, we can understand positive and negative aspects, such as camera quality and adaptation of different used applications. In addition, equally important to conduct UX evaluation is the understanding of different UX characteristics discussed in the literature (Nakamura et al., 2022) because it helps software development team make decisions about product quality (Schrepp et al., 2023), including the practitioners' perceptions concerning such characteristics.

Our paper presents a feasibility study that aims to assess the practitioners' perceptions, that working in UX evaluation using Dogfooding approach about factors that can characterize UX through evaluations (Nakamura et al., 2022). To guide our research, we explored the following research questions: **RQ1 - Is the use of UX factors understandable for practitioners during problem analysis?** and **RQ2 - What**

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is the level of participants' acceptance for this type of analysis in mobile device development projects?

Our investigation was based on an action research methodology (Petersen et al., 2014), which combines theory and practice for the development of solutions to real problems through collaboration between researchers and practitioners. The results indicated that the analysis of UX factors is feasible, as the factors were applied coherently with the expectations of the researchers. Furthermore, this study showed a positive acceptance from practitioners involved in UX evaluation for a better understanding of the acceptance of consumers regarding mobile devices. Thus, our work can contribute to other practitioners and researchers working on UX evaluation, providing valuable insights for the continuous improvement of this user experience dimension.

2 BACKGROUND

ISO 9241-210 defines UX as "*a person's perceptions and responses that result from the use and/or anticipated use of a product, system, or service*" (de Normalisation, 2010). UX encompasses both pragmatic aspects, focusing on the traditional usability features that aid in task accomplishment and hedonic aspects, involving sentiments and emotional responses from using a product (Hassenzahl, 2018). For instance, a product may be perceived as pragmatic if it efficiently facilitates task completion, while it may be seen as hedonic if it provides stimulation, identification or evokes memories.

In terms of UX evaluation, practitioners and researchers recognize its importance as it enables an understanding of how users apply and perceive a product or service, facilitating improvements aligned with user expectations (Moreno et al., 2013). This approach allows the identification of potential problems in the applications usage, their causes and provides suggestions for improvement. While various methods exist for evaluating the UX of system products (Marques et al., 2018), many works primarily offer indications about the overall experience, necessitating a deeper understanding of issues that can lead to a negative user experience.

Schrepp et al. (2023) investigated the importance of UX aspects for different product types through five independent studies, involving 361 participants. They found that the significance of UX quality aspects varies depending on the product type, offering valuable guidelines for UX developers and researchers during the design and evaluation phases of interactive products. Their conclusion emphasized that the relevance of UX factors is subjective, varying among individuals and different product categories.

Nakamura et al. (2022) conducted a systematic mapping of UX factors for mobile devices based on user reviews in app stores. The study identified 31 distinct factors, such as Compatibility, measured by issues on a specific device or operating system version and Attractiveness, defined as the user's experience and feelings towards a product in a particular situation during evaluative judgment.

Given the escalating interest in UX within the scientific community and industry, it is crucial to comprehend UX characteristics specific to certain types of products. In addition, it is important to investigate UX factors presented in the literature concerning the practitioners' perceptions.

3 RESEARCH METHOD

It is crucial to analyze the UX characteristics for different types of products to make decisions about product quality, as highlighted by (Schrepp et al., 2023). In our work, we are examining the feasibility of using a set of UX factors identified from user reviews for mobile devices in general. In other words, participants in UX evaluations use mobile devices in their daily lives and share their perceptions about aspects such as camera quality, connectivity, and available applications in the market. For this purpose, a feasibility study involving practitioners from a Brazilian company has been planned. This company is involved in both local and international projects, including the evaluation of UX for mobile devices before their market release.

3.1 UX Factors in UX Evaluation

In our previous work (Damian et al., 2023), we investigated the possibility of applying the factors identified by Nakamura et al. (2022) in the context of UX evaluation of mobile devices. Twelve researchers in three weekly meetings internally discussed this work. The factors related to UX were reviewed and problems from four mobile devices were selected to be evaluated. After applying the factors to different products, the researchers noticed that some of them were not applicable to the context of product evaluation. As a result, the factors are presented in Table 1. Nevertheless, since this was an internal effort by the involved researchers to create a new approach for enhancing UX analysis, it was decided that it would be valuable to evaluate the perception of other individuals involved in this type of evaluation.

Table 1: Adapted UX Factors for Mobile Devices UX Evaluation.

UX Factors	Description
Accuracy	Characterizes discrepancies between the proximity of aspects experienced by users and the value obtained in data measurement.
Attractiveness	Characterizes discrepancies representing positive and negative perceptions of a product. What attracts the customer to that product.
Comparison	Characterizes discrepancies with comparisons to other products or comparisons within the same product but in different software versions.
Ease of Use	Characterizes discrepancies about the effort required to use a specific functionality or feature of the product. Ease of use can also be related to tutorials with missing information. It does not characterize problems with the app/feature itself; the focus here is on the user experience.
Satisfaction	Characterizes praise and criticism regarding product features during its use.
Screen Interface	Discrepancies related to the appearance of the product (display), font and color schemes, and icons.
Performance	Discrepancies related to the product's performance, given the configuration.
Customization	Characterizes discrepancies related to screen and feature/functionality customization.
Bugs	Characterizes discrepancies about functionalities with issues during the use of the product.
Crash	Characterizes discrepancies that present constant crashes in the use of a functionality or feature.
Network Issues	Discrepancies related to telephony network problems.
Exceeded Resources	Discrepancies related to excessive consumption of product resources, such as memory and battery.
Software Update	Discrepancies related to updates, improvements, and changes to the operating system.
Hardware Component	Hardware component that was implemented in different versions of the phone hardware.

3.2 Feasibility Study Design

The feasibility study was meticulously planned to be conducted in the industry within the scope of UX evaluations for mobile devices before their market launch. This scope encompasses both new devices and operating system updates.

3.2.1 Context of UX Evaluation

Regarding UX evaluation participants, the company's own employees use these products and share their perceptions of their quality via the Dogfooding approach. The product evaluation cycle begins with an analysis of the minimum requirements to be met in mobile devices, covering both hardware and operational system version. During the evaluation cycle, which lasts an average of three to four months, various methods are employed to characterize UX, such as focus groups, weekly meetings, surveys, and the use of an application that records suggestions for improvement/problem and automatically collects device logs. Related to this last aspect, this contributes to a more in-depth analysis of problems by developers. Moreover, different roles play specific functions in this type of analysis, such as UX analysts, analysts responsible for problem screening, leaders for recruiting and engaging participants, engineers responsible for the tools used during evaluation and product managers. These practices significantly contribute to the improvement of product UX, as scenarios often not identified by the testing team are revealed in such evaluations (Silva et al., 2019). Additionally, we have observed that it is possible to obtain a preview of end-users' perceptions.

3.2.2 Problem Selection

Sixteen problems reported by different users, from eight different mobile devices and two Operating Systems, were randomly selected for analysis in the study. This amount was chosen based on the average analysis workload of a practitioner responsible for tracking issues reported by users during the review cycle, forwarding them to different development teams, such as camera experts, battery specialists, and others.

3.2.3 Participant Selection

Invitations were extended to practitioners with different roles in mobile device UX evaluation to participate in the study. Approximately 40 practitioners were contacted and, of these, 25 voluntarily agreed to participate. The study's objective was explained to the participants, emphasizing that they were to analyze problems reported in review cycles and classify the most relevant UX factor. It was clarified also that a single issue could be associated with more than one factor. The study was planned to take place over a 7-day period, during which participants would conduct the analysis and remotely submit the results. Following this phase, a post-study questionnaire, consisting of both open-ended and closed questions, was designed to collect participants' insights on the activity.

3.2.4 Questionnaire

Regarding participants' acceptance, we applied a questionnaire based on Technology Acceptance Model (TAM) (Venkatesh and Davis, 2000) adding also some open questions. This model has been applied to evaluate the acceptance of a large set of technologies about users' perceived ease of use, the degree to which a person believes that using a specific technology will be free effortless and the perceived usefulness that a person believes that using a specific technology will enhance his or her work performance (Marangunić and Granić, 2015). In addition, according to TAM, the user's behavioral intention to use a specific technology is determined by perceived usefulness and perceived ease of use. The TAM statements adapted for our study are presented below. Regarding the adapted TAM statements, participants provided their answers on a seven-point Likert scale, as follows: "Totally Agree, Strongly Agree, Partially Agree, Neutral, Partially Disagree, Strongly Disagree and Totally Disagree".

PERCEIVED EASE OF USE: E1. *My interaction (comprehension of the information) with these UX factors was clear and understandable*; **E2**. *Interacting (comprehension of the information) with these UX factors does not require a lot of mental effort*; **E3**. *I find these factors easy to understand about user experience information products*; and **E4**. *I find it easy to make these factors do what I want (user experience information product overview*).

PERCEIVED USEFULNESS: U1. *Using these factors improves my performance to better understand aspects of the product*; **U2**. *Using these factors in my work has improved my productivity in understanding aspects of the product*; **U3**. *Using these factors enhances my effectiveness in understanding aspects of the product*; **U4**. *I consider these factors useful for product analysis.*

INTENTION TO USE: I1. *Assuming I had enough time to analyze the UX of a product, I do intend to use these factors*; **I2**. *Whereas if I could choose any method to analyze the UX of a product, I predict I would use these factors*.

3.2.5 Feasibility Study Execution

For the execution of the study, a questionnaire containing the description of UX factors and the list of issues was provided to the participants. This allowed them to categorize the problems based on the most relevant factors and they also had the opportunity to review each factor. After completing this phase, a post-study questionnaire was sent to each participant.

We conducted a pilot study with four participants, according to the planned procedures. After analysing the problems and completing the questionnaires, we held a meeting with the participants to assess whether they faced any challenges with the study materials and to gather their insights on this type of research. After this meeting, we determined that there were no impediments to continuing the study with the remaining participants.

4 RESULTS

Below are the results obtained in the evaluation of the feasibility of applying UX factors. Table 2 shows the number of problems analyzed in the study and the factors applied by one of them. Regarding the description of the problems, we omitted it in Table 2 due to the confidential rules of our projects. Table 2 also highlights the factors expected to be applied by researchers. Given the qualitative nature of this analysis, it is expected that a problem may be related to more than one UX factor explored in this study. Regarding the analysis conducted, it's possible to notice that each one of the factors was utilized by the participants, although, they utilized one or more of the factors. In the case of Problem 2, for example, it can be a problem related to device functionality (Bugs) after a software update (Software Update) that impacted the Wi-Fi connection (Network Problem).

Regarding the TAM indicators, participants provided their answers regarding the level of acceptance of the statements of each indicator using a seven-point scale, with response options ranging from Strongly Agree to Strongly Disagree. Figure 1 shows the participants' level of acceptance for the indicator Ease of Use (P1 to P4), Usefulness (U1 to U4) and Intention

Table 2: UX problems concerning UX factors.

UX Problem	Ac.	At.	Co.	E.U.	Sa.	S.I.	Pe.	Cu.	Bu.	Cr.	N.I.	E.R.	S.U	H.C.
Problem 1	5		1	2		1			6	1		1	25	
Problem 2				1		3	1		17	7	11		12	
Problem 3	1						10		6	22		5		
Problem 4						13	6		19	5		3		
Problem 5							8	6	10	21		2		
Problem 6				2	5		24		3	2		3		
Problem 7							3	10		25				
Problem 8	13			15	8	5		6						
Problem 9		8			7	8		21						
Problem 10		6			12									21
Problem 11	14		8	13	9		6							
Problem 12			23		14				3					
Problem 13							5		9	24				
Problem 14				9	8									22
Problem 15				15	12	17								
Problem 16				3					8		24			

Ac. - Accuracy; At. - Attractiveness; Co. -Comparison; E.U. - Ease of Use; Sa. - Satisfaction; S.I. - Screen Interface; Pe. - Performance; Cu. - Customization; Bu. - Bugs; Cr. - Crash, N.I. - Network Issues, E.R. - Exceeded Resources, S.U. - Software Update, and H.C. - Hardware Component.

to Use (I1 and I2), where the vertical axis of the graph refers to the statements of each of the indicators and the horizontal axis refers to the participants' level of acceptance. The bars represent the participant codes (P1, P2, and so on).

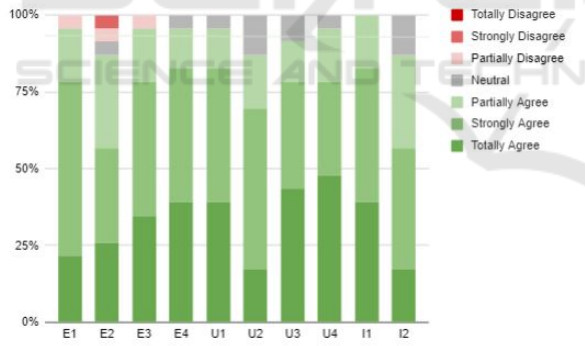

Figure 1: Participants' acceptance of UX factors.

The majority of responses were positive, indicating a positive acceptance of the UX problem analysis process. We organized the participant's answers into different categories, which represent the participants' perceptions. In terms of the Ease of Use construct, P6 and P9 state that **they did not encounter difficulties** applying this type of analysis: '*It was smooth; the description of the factors was very helpful*' and '*The description of the factors was clear and for most cases, the application was intuitive*.' Although the majority stated that this is an **ease-to-implement analytical process**, it was noticed in the feedback the difficulty in understanding some factors: '*In my opinion, some factors do not have a very clear description; more examples could be given to facilitate its application*' (P3) and '*I had doubts in some answers, especially between Bug, Crash and Accuracy; they seemed like the same response*' (P15). To enhance the understanding of each factor, some participants suggested the **inclusion of more examples for a better comprehension** of a UX factor based on the problems, as mentioned by P8: '*User reports do not always directly indicate all the UX factors that could be linked to that problem.*' We agreed that providing more examples could reduce uncertainty for some participants during the analysis, as observed in the report from P2: '*In some cases where I couldn't fit the problem into the available options, I used the Bug option.*' Another aspect noticed by the participants was the **lack of clarity in the problem reports** from UX evaluation participants, which is a limitation in this type of evaluation, as reported by P20: '*Most of the factors seemed clear and sufficient to categorize user issues. However, I think that a few pieces of feedback don't fit completely*,' and P10: '*The majority of feedback were easy to understand, but there are always cases that require a bit more attention to be comprehended.*'

Regarding the usefulness of this type of analysis, different participants affirm that this analysis supports the **understanding of the device features that are affected** and the **development of quality metrics during the project and after the products are launched in the market**, as seen in the following quotes: '*I think these factors are highly useful; they serve as a comprehensive classifier and filter for*

problems and device features...' (P4); '*The utility of the factors could collaborate with metrics during the project development and after its launch*' (P5); '*... serve as a well-elaborated foundation for analyzing CRs and user feedback*' (P8); '*I believe it is useful during the evaluation cycle to map the most affected areas and, overall, what the user is reporting*' (P13); '*The factors are extremely useful, whether in the implementation phase, pre-launch maintenance or post-launch in the market*' (P16). Additionally, a better understanding of the affected areas of the products and the problems fix, which are included in weekly releases, contributes to the engagement of users participating in the UX evaluation, as perceived by P14: '*I agree because the improvement of the UX always leads to their loyalty to the brand, caused by the feeling of being heard and having their problems solved*'.

The participants' responses also indicate that through the '**analysis of UX factors, a better understanding for those involved in product quality can be achieved**: '*I agree that the analysis of each of the factors shown in the research can help improve the quality of the product*' (P15); '*The user responses, whether from end consumers or participants in the evaluation, actively shape the actions, improvements and corrections of the product. Therefore, understanding this information is a crucial step in decision-making in the process for product improvement*' (P16); '*UX factors play a fundamental role in product quality analysis, being extremely useful in all stages of development*' (P17). Consequently, different stakeholders in project management, such as managers, developers, testers and UX specialists, can prioritize issue resolutions and product improvements.

Regarding the intention to use, we're aware that a new activity in an ongoing process may not be accepted by all those involved. However, the responses to most open-ended questions from participants suggest a positive predisposition for the adoption of this type of analysis. P5 and P17 state that such analysis would support a **better understanding of a problem before forwarding it to the development team**: '*I would apply it in my daily activities; I believe it would help in a better understanding of the problems*' (P5) and '*The application of these factors is crucial to ensure that products meet user expectations, are intuitive to use, and offer a pleasant experience. Therefore, the application of these factors through a system would be a highly recommended choice to improve the quality and success of new products*' (P17).

Still, when applying these factors in practice, it is beneficial to **adapt the process of evaluating problems reported during UX analyses**. This allows for a deeper understanding of the key roles involved in this analysis, such as UX analysts and developers. P11 and P22, for example, provided such insights: '*If we raise awareness and discuss new good practices for factors, it would be a viable option to adopt similar practices globally*' (P11) and '*As a developer, it is unclear to me how and when these factors will be assigned to a CR* (Change Request). *During triage? In this case, would the factors already be applied when I receive the CR?*' (P22). Thus, the factors can be widely adopted and viewed by all those involved in the project. Consequently, it is possible to observe that incorporating these factors into problem analysis can positively contribute to product development projects that will be launched in the market.

5 DISCUSSION

5.1 Findings

In reference to our findings regarding to **RQ1** (*Is the use of UX factors comprehensible by practitioners during problem analysis?*), the results presented in Table 2 indicated that the majority of the employed factors are related to the analysis expected by the main researchers. Since this is a qualitative analysis, we understand that the use of most factors for a specific problem may indicate that the participants understood them. However, some aspects were observed that could affect this analysis, such as the lack of information from users who submit their evaluations of the products. As the problem sample was randomly selected, there were some reports with limited information. Additionally, some participants had difficulties with the factors' description, indicating the need for more examples in this context to minimize uncertainties in the use of factors during problem analysis. Therefore, we plan to include more examples in the description of the factors and also incorporate this activity into our analysis process, indicating the key roles involved in this analysis and the stage at which such problems can be evaluated regarding UX aspects. Thus, the results of the feasibility study indicate that the description of the factors is feasible and it was possible to understand the main limitations for the use of these factors during evaluation.

For **RQ2** (*What is the level of participants' acceptance for this type of analysis in mobile device development projects?*), utilizing the TAM revealed participants' acceptance of this analysis type. The quantitative results demonstrated predominantly positive responses, as depicted in Figure 1. Regarding user perceptions, while some indicated difficulties in understanding factor descriptions and others felt a lack

of examples, the majority of participants highlighted the importance of this type of analysis. They emphasized the ability to comprehend the affected characteristics of the device and the potential to formulate metrics to evaluate product quality. Based on the participants' responses, it became apparent that the aspect that most influences the intention to use the factors is their utility in analyzing product quality.

5.2 Threats to Validity

The threats that may affect the validity of our study results (Falessi et al., 2018) are described below, along with the treatment for each of them.

Internal Validity. An identified threat is the sharing of information between participants during the study. To address this threat, the study's selection and materials were individually sent to participants, as participants don't need to be close. This minimizes the identification of other participants, thus reducing the possibility of communication between them. Limited information regarding problems can also affect the interpretation of UX factors.

External Validity. Validity of the assessed problems as a representative sample. To mitigate this threat, 16 problems were randomly selected from different projects. Additionally, this number is related to the average number of problems analyzed by a triage analyst, reflecting a real activity in this company.

Construct Validity. Regarding UX factors, as these are qualitative data, they were discussed in various meetings by the researchers beforehand to mitigate misunderstanding about the problems. About the adoption of TAM, it has been employed and adapted for the evaluation of different technologies (Marangunić and Granić, 2015).

Conclusion Validity. The short period of use of UX factors in problem analysis. However, this is an initial result and the findings cannot be generalized.

6 RELATED WORKS

Soleimani and Law (2017) present an empirical study and highlight the importance of using a methodological approach to measure UX. The main objective of this study was to recognize emotions via the Think-Aloud technique. The empirical study was carried out with 46 participants using an online shopping platform to evaluate each person's emotional experiences in different sessions. As the study was exploratory in nature, the main intention was to develop a practical approach to explore momentary perceptions and user interactions regarding the qualities of a product/service. The techniques applied do not require any additional expense or equipment and they can be implemented in any work environment.

Fernandez et al. (2013) present the results of a family of empirical experiments executed to compare the proposed inspection method WUEP (Web Usability Evaluation Process) with a well-known inspection method - HE (Heuristic Evaluation) regarding its Effectiveness, Efficiency, Perceived ease of use and Perceived satisfaction of use. To evaluate the results, the authors did a quantitative analysis of the results and tested all the null hypotheses. The statistical analysis and meta-analysis of the data obtained separately from each experiment indicated that WUEP is more effective and efficient than HE in the detection of usability problems. The evaluators were also more satisfied when applying WUEP and found it easier to use than HE. The experiment concluded that the WUEP method performed better for all the 4 points analyzed.

Regarding the works above, we notice the importance of evaluating the UX of a system and show a specific approach to supporting the collection of user feedback through evaluation sessions (Soleimani and Law, 2017). Our work, on the other hand, evaluates UX during a period of 3 to 4 months, including the methods to support it, which allows us to figure out the users' perceptions. While the paper from (Fernandez et al., 2013) evaluated usability for web applications during the development process considering Effectiveness, Efficiency, Perceived ease of use and Perceived satisfaction, our work evaluated the application of 14 factors in different types of real issues reported by users of your daily life. Our work focuses on UX factors, that can help to figure out pragmatic or hedonic aspects of mobile devices, contributing to the quality of these products.

7 CONCLUSIONS

This paper presented a feasibility study on the application of UX factors in the analysis of real problems in mobile devices' UX evaluations. Considering the action research methodology, we systematically evaluated UX factors for mobile devices, identifying key elements for use in projects focusing on UX evaluation. This kind of analysis can contribute to understating the main problems, both pragmatic and hedonic, that may impact the end user's perception of mobile devices before their market launch. Based on the results obtained, the consensus among practitioners is that this form of analysis is valuable for comprehending the fundamental factors of UX. While the majority agreed that it is easy to implement this type of anal-

ysis, we observed the need for improvements in describing the factors to be implemented in the daily activities of the practitioners dealing with the UX evaluation. Our perspective is that these factors can highlight the hedonic aspects related to the UX in evaluations, once the predominant focus of developers lies in fixing and enhancing the pragmatic aspects.

For future work, we intend to incorporate examples of problems related to the factors to facilitate the UX problem analysis. Additionally, we intend to refine the problem analysis process to incorporate UX factors, covering the necessary activities and metrics that can assist this type of evaluation in future projects. Moreover, it will also be possible to analyze the contributions of UX factors toward a deeper software quality comprehension in this aspect.

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