

# Usability Evaluation Plan within an UX Design Process (UsabPlanInUXD)

## Planung einer Usability-Evaluierung im Rahmen des UX-Design-Prozess (UsabPlanInUXD)

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**Abstract** — This paper describes how to prepare a plan for usability evaluation. A variety of relevant methods and approaches are compared against criteria like possibility for application in different project (or lifecycle) steps, needed participants, evaluation environment, duration and resources, usability metrics and measured usability data. An example for application of an algorithm to choose an appropriate usability tool or method is given. Possibility to evaluate UX parallelly with usability is commented.

**Zusammenfassung** — Dieser Artikel beschreibt wie man einen Plan für die Usability-Evaluierung vorbereitet. Eine Vielzahl von relevanten Methoden und Ansätzen wird anhand von Kriterien wie Anwendungsmöglichkeit in verschiedenen Projekt- (oder Lebenszyklus-)Schritten, benötigte Teilnehmer, Umgebung, Dauer und Ressourcen der Evaluierung, Usability-Metriken und gemessene Usability-Daten verglichen. Es wird ein Beispiel für die Anwendung eines Algorithmus zur Auswahl eines geeigneten Usability-Tools oder -Verfahrens gegeben. Die Möglichkeit, UX parallel zur Usability zu evaluieren, wird kommentiert.

### I. INTRODUCTION

When digitalization is increasing fast its field in our working and free time environment the need of new systems is growing as well. User-centered design approach is not suitable anymore for the successful design of new products, systems, and services. The new ISO norm [1] about usability emphasizes the important connection between concepts for usability and User Experience Design (UXD). Professionals on this field are summarizing continuously the great number of methods and tools for usability and user experience evaluation [2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12]. For the designers and developers is still not easy to choose among the variety of assessment approaches. So, this suggestion for evaluation plan could be a step forward to a better orientation.

### II. USABILITY AS A PART OF UXD

#### A. Usability

"User Experience Design" is often used as synonym of the terms "User Interface Design" and "Usability". Usability and User Interface (UI) -Design are certainly important aspects of UXD, parts of it. Usability is important at every UX design stage, but the definitions explain the different content of usability and UXD.

„Usability is extent to which a system, product or service can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use“. Quality in use has a similar definition to definition of usability with the explicit addition of “freedom from risk” in ISO /IEC 25010 2011 [13]. A product quality model – eight characteristics (functional suitability, reliability, performance efficiency, usability, security, compatibility, maintainability, and portability). Each characteristic is composed of a set of related subcharacteristics. In a UXD process created products are expected to be valuable, useful, desirable, accessible, credible, findable and usable [14].

#### B. User Experience

„No product is an island. A product is more than the product. It is a cohesive, integrated set of experiences. Think through all of the stages of a product or service - from initial intentions through final reflections, from first usage to help, service, and maintenance. Make them all work together seamlessly.“ Don Norman, the inventor of the term UX.

The term User Experience (UX) describes the experience during user's interactions with a product, system, equipment, facility, environment, service, etc. and includes all aspects of experience in the common use. It is defined in ISO 9241-210 and ISO 9241-11 as „user's perceptions and responses that result from the use and/or anticipated use of a system, product or service. Users' perceptions and responses include the users' emotions, beliefs, preferences, perceptions, comfort, behaviours, and accomplishments that occur ... before, during and after use. User experience is a consequence of brand image, presentation, functionality, system performance, interactive behaviour, and assistive capabilities of a system, product or service. It also results from the user's internal and physical state resulting from prior experiences, attitudes, skills, abilities and personality; and from the context of use. User experience is the user's perceptions and responses that result from the use and/or anticipated use of a system, product or service. User experience focuses on the nature of these responses before, during and after use“ [1, 15].

User Experience is based on three product properties look, feel and usability. That shows the important role of usability not only as a relevant design goal, but also as a precondition for the UXD, which usually has following steps: 1. analyses of users and functions 2. preparation of prototypes 3. repetition of step 1 and 2 until validation of ideas is completed. 4. development. User Experience Design (UXD) is a process, that designers follow for product development, so they provide users with meaningful and relevant experiences. This affects the entire design process of capturing and integrating the product, including aspects of branding, design, usability, and functionality. The process begins before the device is in users' hands [14].

### III. USABILITY AND UX EVALUATION

A great number of usability methods are compared and described [12]. Comparing a wide range of usability evaluation methods and technics they can be summarized in following categories:

**First group:** 1. Observation of users' behavior using the system, product or service. There are different kinds of observations – 2.1 field, 2.2 direct and 2.3 indirect observation, 2.4. logging, 2.5 eyes movement registry and 2.6 the Wizard of Oz method. The indirect observation includes video and audio recording, verbal protocols and evaluation in team like Thinking-Aloud Protocol, Post-Event Protocol, Teaching Method, Co-discovery learning, Shadowing Method, Question- Asking-Protocol.

**Second group:** 2. Users' opinions inquiry. Different kinds are 2.1 interviews (incl. prompted interviews, etc.), 2.2 questionnaires, 2.3 incident diary and 2.4 ranking order method.

**Third group:** 3. Experimental approach, where pertain 3.1 experiments and 3.2 Benchmarking.

**Fourth group:** 4. The interpretive approach includes 4.1 scenarios, 4.2 co-operative evaluation, and 4.3 ethnography.

**Fifth group:** 5. Predictive approach has two main kinds 5.1 modelling and 5.2 inspection methods, where the heuristic evaluation, usage simulation, walkthrough (cognitive walkthrough, pluralistic walkthrough), consistency inspection, general design inspection, feature inspection and perspective- based inspection belong.

The methods in the third group are an appropriate choice, if a check of compliance with standards and rules is the evaluation goal. If the purpose of the evaluation is the high quality, then are the experimental and the inquiry approach the most appropriate choice. The observation and predictive approach are acceptable option. If the comparison of designs is expected, then first, second and fifth group are the best decision and the third is applicable. When users work and systems compliance with environment are evaluated, the proper methods are from the first, second and fourth group.

#### Usability evaluation algorithm

for example, depending on access to users

1. YES: Usability test. (if NO – then go to item 2)  
Depending on physical availability of users
  - 1.1 YES: Depending on the participation of users in the design process. (if NO – then go to item 1.2)
    - 1.1.1 YES: Prototyping. Participatory design. Focus groups. (If NO – next)
    - 1.1.2 NO: Depending on the place of evaluation – Field study or not?
      - 1.1.2.1 YES: Mobile lab for usability testing. Field study. Contextual inquiry. (If NO – next)
        - 1.1.2.2 NO: In lab for usability testing. Depending on performance evaluation:
          - 1.1.2.2.1 YES: Performance measurement (If NO – next)
          - 1.1.2.2.2 NO: Depending on users' actions measurement:
            - 1.1.2.2.2.1 YES: Automatic data recording of logging. Eyes movement (fixation) registry (If NO – next)
              - 1.1.2.2.2.2 NO: Subjective opinion?
                - 1.1.2.2.2.2.1 YES: Interview. Questionnaire. Checklist. (If NO – next)
                - 1.1.2.2.2.2.2 NO: User comments?
                  - 1.1.2.2.2.2.2.1 YES: Thinking-Aloud protocol. Question-Asking protocol. Post-Event Protocol. (If NO – next)
                    - 1.1.2.2.2.2.2.2 NO: May another user comment task performance?
                      - 1.1.2.2.2.2.2.2.1 YES: Is this participant also expert on this field? (if NO – then go to item 1.1.2.2.2.2.2.2)
                      - 1.1.2.2.2.2.2.2.1.1 YES: Coaching method. Co-discovery learning. (If NO – next)
                        - 1.1.2.2.2.2.2.2.1.2 NO: Teaching method
                        - 1.1.2.2.2.2.2.2.2 NO: Retrospective testing.
                      - 1.2 NO: Remote usability testing.
                    2. NO: Inspection methods: Evaluation in a usability lab?
                      - 2.1 YES: Prototypes design. Classical walkthrough. Cognitive walkthrough. Formal inspection. (If NO – next)
                      - 2.2 NO: Heuristic evaluation. Guidelines review approach

Fig. 1. Example for usability evaluation algorithm

TABLE I USABILITY EVALUATION METHODS – PARTICIPANTS AND ENVIRONMENT

| Method   | Participants   | Environment                   |
|--|--|-------------------------------|
| 1. Usability test (1.1.2.1)  | min 6 U/ Sev, in<br>2-3 groups<br>2 UE<br>1 Assistant                  | LAB/RE                        |
| 1.1.2.2.2.2.2.1 Thinking-Aloud Protocol  | 3 groups x 3-10<br>U 1 UE Test<br>Manager                              | UT, LAB/RE                    |
| 1.1.2.2.2.2.2.1 Question Asking Protocol   | 2-3 groups x 3-8<br>U 1 UE Test<br>Manager                             | UT, LAB/RE                    |
| 1.1.2.2.2.2.2.1.2 Teaching method  | 2-3 groups x 2-8<br>U 1 UE Test<br>Manager                             | UT, LAB/RE                    |
| 1.1.2.2.2.2.2.1 Post-Event Protocol  | 5-10 U<br>1 UE Test<br>Manager   | UT, LAB/RE                    |
| 1.1.2.2.2.1 Automatic data recording / Logging   | minimum 30 U   | UT, LAB/RE                    |
| 1.1.2.2.2.1 Eyes movement (fixation) registry  | 15-20 U<br>(minimum 30 U<br>Heatmaps)<br>1 UE Test<br>Manager          | LAB/RE/UT                     |
| 1.1.2.2.2.2.1 Questionnaire  | 50-1000 U  | LAB/RE/Web/PC/<br>Mob/UT      |
| 1.1.2.2.2.2.1 Interview  | 5 U<br>1 UE Test<br>Manager  | LAB/RE/UT                     |
| 1.1.1 Focus groups   | 3-10 rp. C no 8-<br>10 U<br>1 UE Moderator                             | LAB                           |
| 1.1.2.2.2.2.1 Surveyy, inquiry, checklist  | 100-1000 U   | LAB/RE/Web/PC/<br>Mob         |
| 1.1.2.1 Contextual inquiry   | 10-20 U<br>1 UE Test<br>Manager  | RE/LAB limited<br>application |
| 1.1.2.1 Field study  | 6-8 U<br>1 UE Test<br>Manager  | RE/LAB limited<br>application |
| 1.1.1 Prototyping  | Tdev /Tdes   | LAB                           |
| 1.1.1 Participatory design   | 1 or more U Sev/<br>Tdes / Tdev  | LAB                           |
| 1.1.1 Card sorting   | 10-20 U<br>1 UE -moderator   | LAB/RE                        |
| 2 Heuristic evaluation   | 3-5 L/sUE/dUE  | Web/PC/Mob/UT                 |
| 2.1 Classical Walkthrough  | 1 or more Se/<br>TDes/ TDev<br>1 UE -<br>moderator                     | LAB                           |
| 2.1 Cognitive Walkthrough  | 1-4 UE<br>0-2 Se<br>StH  | LAB/UT                        |
| 2.1 Pluralistic Walkthrough  | 2-3 U<br>1-2 TDes<br>2 UE moderators                                   | LAB                           |
| Impact Analysis  | maximum StH 1<br>UE moderator  | LAB                           |
| 2.1 Formal inspection  | 1 UE moderator<br>1 TDev<br>3-5 UE<br>inspectors<br>1 UE protocolcolor | LAB                           |
| 2.2 Guidelines review approach   | 3-5 L/sUE/dUE  | Web/UT                        |
| 1.1.2.2.1 Performance measurement (Performance test)   | 8-10 U each<br>group   | UT, LAB                       |
| <p><b>Participants:</b> eU - Expert user, U - User, TDev - Team developer, TDes - Team designer, dUE - Double usability expert, sUE – Single usability expert, UE – Usabilityexpert, Se-Software expert, StH - Stakeholder, L - Laic</p> <p><b>Environment:</b> UT Usability test, RE Real environment as office, car etc., LAB Usabilitytest laboratory, PC, Web, Mob</p> |  |                               |

Usability evaluation algorithm for example, depending on access to users is described (fig. 1). Two main groups of evaluation methods exist: first group includes a variety of possibilities for accessible users and in the second group are the inspection methods. If users are available, next choice condition relates to physical availability of users (remote testing or not). Next decision is the participation of users in the design process, then - place of evaluation, and - type of lab, further - performance evaluation etc.

Further information about the methods, included in the algorithm is given in Tables 1-5. The comparison is about participants, evaluation environment, possibility for application in different project (or lifecycle) steps, duration and resources, usability metrics and measured usability data.

TABLE II. USABILITY EVALUATION METHODS – APPLICATION (OR LIFECYCLE) STEP

| Method   | Application (or lifecycle) step                                |
|--|--|
| 1. Usability test (1.1.2.1)  | V R V E  |
| 1.1.2.2.2.2.1 Thinking-Aloud Protocol  | V R V E  |
| 1.1.2.2.2.2.2.1 Question Asking Protocol   | V R V E  |
| 1.1.2.2.2.2.2.1.2 Teaching method  | V R V E  |
| 1.1.2.2.2.2.2.1 Post-Event Protocol  | V R V E  |
| 1.1.2.2.2.1 Automatic data recording / Logging   | A TA V R V E   |
| 1.1.2.2.2.1 Eyes movement (fixation) registry  | V R V E  |
| 1.1.2.2.2.1 Questionnaire  | A TA D V R V E   |
| 1.1.2.2.2.1 Interview  | A TA, FU D V R V limited application E                         |
| 1.1.1 Focus groups   | A TA, FU V - limited application<br>RV – limited application E |
| 1.1.2.2.2.1 Survey, inquiry, checklist   | A V – limited application<br>RV – limited application E        |
| 1.1.2.1 Contextual inquiry   | A TA, FU D limited application                                 |
| 1.1.2.1 Field study  | A TA V R V   |
| 1.1.1 Prototyping  | D V  |
| 1.1.1 Participatory design   | D V R V - limited application                                  |
| 1.1.1 Card sorting   | A TA D V   |
| 2 Heuristic evaluation   | D V R V  |
| 2.1 Classical Walkthrough  | D V  |
| 2.1 Cognitive Walkthrough  | D V R V limited application                                    |
| 2.1 Pluralistic Walkthrough  | D V  |
| Impact Analysis  | D V  |
| 2.1 Formal inspection  | A limited application R V E                                    |
| 2.2 Guidelines review approach   | A limited application D V R V                                  |
| 1.1.2.2.1 Performance measurement (Performance test)   | V limited R V limited application E                            |
| A - Analysis of use context, D - Design and development, V - Variants, R V - Requirements verification, E - System evaluation<br>TA Task analyses, FU Focus user |  |

TABLE III. USABILITY EVALUATION METHODS – DURATION, RESOURCES

| Method   | Duration  | Resources   |
|--|---|---|
| 1. Usability test (1.1.2.1)                    | 1-3 hours   | Expensive method  |
| 1.1.2.2.2.2.1 Thinking-Aloud Protocol          | Depending on complexity of executed tasks           | Inexpensive method, but time-consuming analyses   |
| 1.1.2.2.2.2.2.1 Question Asking Protocol       | Depending on complexity of executed tasks           | Inexpensive method, but time-consuming analyses   |
| 1.1.2.2.2.2.2.1.2 Teaching method              | Depending on intended tasks                         | Inexpensive method, but time-consuming analyses   |
| 1.1.2.2.2.2.2.1 Post-Event Protocol            | Depending on intended tasks and record durations    | Time-consuming and high financial resources, time-consuming analyses                          |
| 1.1.2.2.2.1 Automatic data recording / Logging | Depending on intended goals and task complexity     | Minimal technical and financial resources   |
| 1.1.2.2.2.1 Eyes movement (fixation) registry  | 30 min. – 2 hours                                   | Expensive method and time-consuming analyses  |
| 1.1.2.2.2.1 Questionnaire                      | Depending on questionnaire and application approach | Inexpensive method  |
| 1.1.2.2.2.1 Interview                          | Up to 1 hour  | Time-consuming and high financial resources (number of participants), time-consuming analyses |
| 1.1.1 Focus groups                             | 1-2 hours every session                             | Inexpensive method  |
| 1.1.2.2.2.1 Survey, inquiry, checklist         | Depending on the application approach               | Sometimes time-consuming and expensive method   |
| 1.1.2.1 Contextual inquiry                     | 2-3 hours every session                             | Time-consuming method   |
| 1.1.2.1 Field study                            | Optimal results for single session ca. 1 hour       | Expensive and time-consuming  |
| 1.1.1 Prototyping                              | Depending on goals and prototype                    | Financially beneficial  |
| 1.1.1 Participatory design                     | Depending on goals                                  | Expensive method  |
| 1.1.1 Card sorting                             | 1-2 hours   | Inexpensive, easy, but time-consuming method  |
| 2 Heuristic evaluation                         | 1-2 hours depending on complexity                   | Perfect ratio costs-resources   |
| 2.1 Classical Walkthrough                      | Up to 2 hours                                       | Minimal financial resources   |
| 2.1 Cognitive Walkthrough                      | Up to 2 hours (3 hours by exception)                | Time-consuming method   |
| 2.1 Pluralistic Walkthrough                    | Depending on the slowest participant                | Minimal financial and time resources  |
| Impact Analysis                                | Depending on complexity of executed tasks           | Minimal financial and time resources  |
| 2.1 Formal inspection                          | Several weeks                                       | Time-consuming and large number of team members, time-consuming preparation                   |
| 2.2 Guidelines review approach                 | Depending on interface complexity                   | Good ratio costs-resources  |
| 1.1.2.2.1 Performance measurement              | Depending on goals and complexity of executed tasks | Minimal technical and financial resources   |

The overview of usability methods includes a comparison of 24 evaluation techniques and approaches. Table 1 is about the participants and the environment, where they interact. The evaluation participants are different experts, team members and actual users or stakeholders. The environments are real conditions as office, car etc. or usability laboratory. Some methods require many participants (like checklists, questionnaires), other (interviews, post-event protocol, heuristic evaluation) have between 5 and 10 participants. Needed participants are following types: users, experts (interface designers, usability engineers, UX, etc.), laymen, developers. Environment differences are in a lab or in real conditions (field study about desktop, web, mobile application, etc.).

The application of methods in different stages is presented in Table 2.

Resources are time – total, for one user, one meeting, one record, etc. Time is also: to conduct, and/or analyze. Other resources are the financial, technical, other ones (see Table 3). Usability metrics as effectiveness, efficiency, satisfaction are described in Table 4.

TABLE IV. USABILITY EVALUATION METHODS – METRICS

| Method  | Usability metrics   |
|---|---|
| <b>1. Usability test (1.1.2.1)</b>                          | Effectiveness, Efficiency, Satisfaction   |
| <b>1.1.2.2.2.2.1 Thinking-Aloud Protocol</b>                | Effectiveness Satisfaction  |
| <b>1.1.2.2.2.2.1 Question Asking Protocol</b>               | Effectiveness Satisfaction  |
| 1.1.2.2.2.2.2.1.2 Teaching method                           | Effectiveness Satisfaction  |
| <b>1.1.2.2.2.2.1 Post-Event Protocol</b>                    | Effectiveness Satisfaction  |
| 1.1.2.2.2.1 Automatic data recording / <b>Logging</b>       | Effectiveness Efficiency  |
| <b>1.1.2.2.2.1 Eyes movement (fixation) registry</b>        | Effectiveness Efficiency  |
| <b>1.1.2.2.2.1 Questionnaire</b>                            | Effectiveness for specific design<br>Efficiency for specific design<br>Satisfaction |
| <b>1.1.2.2.2.1 Interview</b>                                | Effectiveness for specific design<br>Satisfaction                                   |
| <b>1.1.1 Focus groups</b>                                   | Effectiveness Satisfaction  |
| <b>1.1.2.2.2.1 Surveyy, inquiry, checklist</b>              | Effectiveness for specific design<br>Efficiency for specific design<br>Satisfaction |
| <b>1.1.2.1 Contextual inquiry</b>                           | Effectiveness for specific design<br>Satisfaction                                   |
| <b>1.1.2.1 Field study</b>                                  | Effectiveness Satisfaction  |
| <b>1.1.1 Prototyping</b>                                    | Effectiveness Efficiency  |
| <b>1.1.1 Participatory design</b>                           | Effectiveness Satisfaction  |
| <b>1.1.1 Card sorting</b>                                   | Effectiveness Satisfaction  |
| <b>2 Heuristic evaluation</b>                               | Effectiveness Efficiency  |
| <b>2.1 Classical Walkthrough</b>                            | Effectiveness<br>Efficiency for specific design                                     |
| <b>2.1 Cognitive Walkthrough</b>                            | Effectiveness   |
| <b>2.1 Pluralistic Walkthrough</b>                          | Effectiveness, Satisfaction   |
| Impact Analysis   | Effectiveness, Satisfaction   |
| <b>2.1 Formal inspection</b>                                | Effectiveness   |
| <b>2.2 Guidelines review approach</b>                       | Effectiveness Efficiency  |
| <b>1.1.2.2.1 Performance measurement (Performance test)</b> | Effectiveness Efficiency  |

TABLE V. USABILITY EVALUATION METHODS APPLICABLE TO UXD

| Method  | Application in UXD for emotions and attitude analyses |
|---|---|
| <b>1. Usability test (1.1.2.1)</b>                          | Extended usability test                               |
| <b>1.1.2.2.2.2.1 Thinking-Aloud Protocol</b>                | Applicable  |
| <b>1.1.2.2.2.2.1 Question Asking Protocol</b>               | Applicable  |
| 1.1.2.2.2.2.2.1.2 Teaching method                           |   |
| <b>1.1.2.2.2.2.1 Post-Event Protocol</b>                    | Applicable  |
| 1.1.2.2.2.1 Automatic data recording / <b>Logging</b>       | Via logging no information                            |
| <b>1.1.2.2.2.1 Eyes movement (fixation) registry</b>        | Applicable  |
| Method  | Application in UXD for emotions and attitude analyses |
| <b>1.1.2.2.2.1 Questionnaire</b>                            | Applicable if questions about these aspects           |
| <b>1.1.2.2.2.1 Interview</b>                                | Applicable if questions about these aspects           |
| <b>1.1.1 Focus groups</b>                                   | Typical UX approach                                   |
| <b>1.1.2.2.2.1 Surveyy, inquiry, checklist</b>              | Applicable if items about these aspects               |
| <b>1.1.2.1 Contextual inquiry</b>                           |   |
| <b>1.1.2.1 Field study</b>                                  | Applicable  |
| <b>1.1.1 Prototyping</b>                                    | Applicable  |
| <b>1.1.1 Participatory design</b>                           | Applicable  |
| <b>1.1.1 Card sorting</b>                                   | Typical UX approach                                   |
| <b>2 Heuristic evaluation</b>                               | UX heuristics   |
| <b>2.1 Classical Walkthrough</b>                            | Applicable  |
| <b>2.1 Cognitive Walkthrough</b>                            | Applicable  |
| <b>2.1 Pluralistic Walkthrough</b>                          | Applicable  |
| Impact Analysis   |   |
| <b>2.1 Formal inspection</b>                                |   |
| <b>2.2 Guidelines review approach</b>                       |   |
| <b>1.1.2.2.1 Performance measurement (Performance test)</b> |   |

The possibility to apply some of these usability evaluation methods in UXD process as wider instruments appropriate to evaluate UX aspects as emotions, attitudes, etc. is given in Table V. Some usability techniques as Focus groups, Card sorting and tools are typical UX instruments. UX professionals usually are experts minimum two of six different fields - they are analyst and researchers, information architect, interaction designer, usability experts and (or) engineers, content designer, visualization designer.

#### IV. SUMMARY AND OUTLOOK

The described evaluation methods and tools are only a part of the existing variety of techniques. They are chosen as relevant list of popular among the developers, designers and other practitioners. A practical algorithm to choose appropriate usability and UX method could be prepared depending on the availability of evaluation object – prototype. Or time limits could be the argument to initial choice of an evaluation approach

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