

## Association for Information Systems AIS Electronic Library (AISeL)

---

Wirtschaftsinformatik Proceedings 2015

Wirtschaftsinformatik

---

3-4-2015

# Towards Usability Guidelines for Mobile Websites and Applications

Maria Shitkova

Justus Holler

Tobias Heide

Nico Clever

Jörg Becker

Follow this and additional works at: <http://aisel.aisnet.org/wi2015>

---

### Recommended Citation

Shitkova, Maria; Holler, Justus; Heide, Tobias; Clever, Nico; and Becker, Jörg, "Towards Usability Guidelines for Mobile Websites and Applications" (2015). *Wirtschaftsinformatik Proceedings 2015*. 107.  
<http://aisel.aisnet.org/wi2015/107>

This material is brought to you by the Wirtschaftsinformatik at AIS Electronic Library (AISeL). It has been accepted for inclusion in Wirtschaftsinformatik Proceedings 2015 by an authorized administrator of AIS Electronic Library (AISeL). For more information, please contact [elibrary@aisnet.org](mailto:elibrary@aisnet.org).

# Towards Usability Guidelines for Mobile Websites and Applications

Maria Shitkova<sup>1</sup>, Justus Holler<sup>1</sup>, Tobias Heide<sup>1</sup>, Nico Clever<sup>1</sup>, and Jörg Becker<sup>1</sup>

<sup>1</sup> University of Muenster - ERCIS, Muenster, Germany  
{firstname.lastname}@ercis.uni-muenster.de

**Abstract.** The market for mobile devices is growing rapidly nowadays. Constant technological improvements provide great opportunities for the creation of mobile applications. For the success of a mobile application or website, one of the main concerns, besides security issues, is usability. Poor usability decreases user productivity and consequently causes loss of users. In order to avoid these problems, usability aspects have to be considered already during the design phase of the application, e.g. by following predefined usability guidelines. Although usability guidelines for web development are already in place since the 1990s, structured and evaluated usability guidelines for mobile applications can rarely be found in scientific literature. Thus, in this paper we introduce a catalogue of usability guidelines for mobile applications and websites, and subsequently demonstrate their usage by applying them in two case studies: the development of a mobile application and a mobile website.

**Keywords:** Usability, usability guidelines, mobile applications, mobile websites

## 1 Introduction

The market for mobile devices is growing rapidly nowadays. Gartner research reported that "In 2009, smartphone sales reached 172.4 million units, a 23.8% increase from 2008" [1]. Nielsen names 2010 "the year of mobile" [2]. Smartphones as a combination of a handheld computer and a mobile phone [3] became available to a broad group of people and the ground was set for the development of mobile applications and mobile websites [4]. Constant improvements of mobile devices, such as increased computing power, enhanced functionality, and larger screen size with higher resolution, provide even more opportunities for the creation of mobile applications [5].

One of the main concerns in mobile applications, next to security issues, is usability [6], which can be defined as "the degree to which specified users can achieve specified goals in a particular environment, with effectiveness, efficiency and satisfaction" [7]. Nielsen states that "usability is a necessary condition for survival on the web" [8]. Insufficient usability of e-commerce applications means inevitable loss of customers and, in case of intranet applications, the loss in employees' productivity and thus increased costs for the enterprise. The importance of usability of mobile applications is constantly growing: "Last year [2010], it might have been cool simply to have an app. Now, that

app better be good.” [2]. The current best practice is to spend about 10% of the budget on ensuring usability when developing a product [8]. Usability engineering methods have to be applied not only in the testing phase, but in the whole development process. Usability guidelines, which can be defined as “any statement ensuring some adequacy of a particular user interface [...] with respect to a particular context of use where a given user population has to fulfil interactive tasks with a given system” [9], are one of the techniques for keeping usability knowledge, which is vital for producing useful and usable software [10]. Applying usability guidelines can reduce time and effort needed for performing the iterative “implement-evaluate-improve” development steps by assuring that certain classes of errors are avoided already during the design [10].

In the development of applications for mobile devices a number of issues have to be taken into account, such as small screen size, limited processing power, data entry methods, connectivity, etc. [11]. Due to these properties and complexity of developing a mobile application, the usability guidelines and evaluation methods for mobile applications have to be studied specifically [11]. However, still no clearly formulated and properly evaluated usability guidelines can be found in the scientific literature. Thus, in this paper we address this problem by answering the following research questions:

- *RQ 1: Which usability guidelines should be considered to develop a usable mobile website or application?*
- *RQ 2: To which extent are these guidelines applicable to a real world development process of mobile websites and applications?*

The remainder of this paper is structured as follows. In the next section, related work in the field of usability guidelines is presented. In section 3, the research approach is explained, followed by a literature review on usability experiments in section 4, which results in a catalogue of mobile usability guidelines. The compiled guidelines are then utilized in two demonstration scenarios, a mobile application for a process modelling tool and a mobile website for research portals, as presented in section 5. The evaluation of the suggested guidelines is described in section 6. The paper concludes with a discussion of findings and limitations of our research, as well as an outline of the future steps.

## **2 Related Work**

The first guidelines for user interfaces (UI) of desktop applications appeared in the beginning of the 1980s and the first web-specific guidelines were formulated in the 1990s [12]. Usability guidelines together with design principles and conventions provide the foundation for a good interface design [13]. The difference in these three information structures is in the provided level of detail. Principles are the most general goals, which guide the design decision, whereas conventions are specific design decisions that are chosen for a particular organization, e.g. a convention may include certain terms or icons to be used [13]. Guidelines occupy the middle layer of this hierarchy, they are based on principles, but are specified to reflect the needs of a particular design domain [13].

Since the beginning of the 1990s, there has been done much successful work on establishing usability guidelines for websites. For instance, the Usability.gov group has created a database of web usability guidelines [14], evaluated by experts from public and private sectors, as well as the academic community. Each guideline has a relative importance rating, strength of evidence rating and a list of supporting references. The Nielsen Norman Group [15], which is active in evidence-based user experience research, training and consulting, published a report with guidelines for web design [16].

Structured and evaluated guidelines for developing mobile applications can hardly be found in the scientific literature [17]. One of the reasons is the relative novelty of the topic. A usability model for evaluating mobile applications was introduced in [18], however, no specific guidelines were formulated. Several usability guidelines for the development of a mobile app for cultural heritage promotion were presented in [19], but neither the origin of the guidelines, nor their evaluation were specified. In [17], design guidelines for mobile web applications were derived from experiments and interviews with several users of different mobile websites. The main limitations of the study were the narrow sample of participants and only qualitative scope of the experiment and the interview results. In practice, there are more guidelines in form of books [20], reports [21], and websites [22] available. However, our study focusses on guidelines from peer-reviewed scientific literature which were mostly evaluated in controlled experiments.

### 3 Research Method

To address the research questions specified in the introduction, the Design Science Research Methodology (DSRM), introduced in [23, 24], is applied as research method. The methodology presents a procedure for creating artefacts, which may be any object designed to solve an understood research problem [23]. In our case, the catalogue of usability guidelines for mobile applications and websites is seen as the target artefact.

The methodology consists of six steps: problem identification and motivation, definition of the objectives for a solution, design and development, demonstration, evaluation and communication of the research results [23]. In Fig. 1, the steps of the DSRM methodology are presented alongside with the section of the paper, in which the research step is addressed.

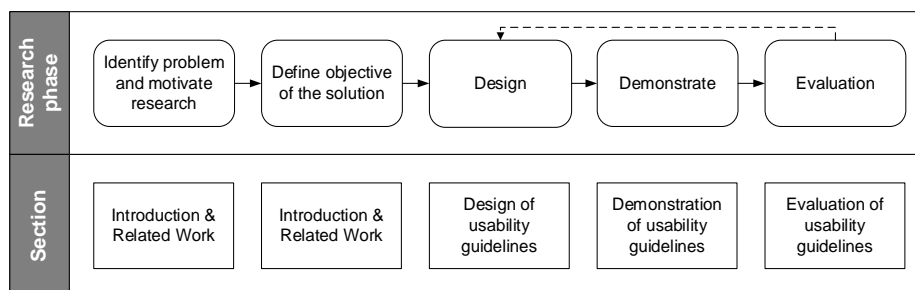


Fig. 1. Research method

The first step of the problem identification and justification is addressed in the introduction and related work sections of this paper. By performing a literature review and direct observation of the problem, the need for the development of a catalogue of usability guidelines for mobile applications is identified. The objectives of the solution are phrased in the research questions, as presented in the introduction. The third phase of the design of usability guidelines is addressed in the fourth section of the paper. We perform a systematic literature review in order to identify usability guidelines and recommendations based on the results of usability experiments with mobile applications and mobile websites.

The step of demonstration is performed by applying the guidelines within two applications scenarios: the development of a mobile application for a process modelling tool and a mobile website for a research portal. In both cases, the user-centered design approach is applied as proposed by [25]. This approach presupposes the integration of usability engineering methods already at early stages of the development process. Thus, during the design phase of both prototypes, a subset of relevant usability guidelines is identified and subsequently implemented.

Evaluation of the usability guidelines catalogue is performed by assessing general applicability and usefulness of the guidelines, as presented in the chapter six. The last communication step of the DSRM methodology is achieved by this publication.

## 4 Design of Usability Guidelines

The goal of the design phase is to identify existing usability guidelines for mobile applications. For this purpose, we conduct a literature review focusing on the results of empirical usability experiments dealing with mobile applications and mobile websites. The resulting guidelines catalogue is presented in Table 1 and is used in the implementation (see section 5: “Demonstration of Usability Guidelines”).

The literature review is structured according to the framework by vom Brocke et al. [26], which is based on the guidelines for literature reviews of Webster & Watson [27]. The approach consists of the following steps: definition of the review scope (1), conceptualization of the topic (2), literature search (3), literature analysis and synthesis (4), and deriving a research agenda (5).

The scope of the review (1) is specified by defining the purpose, subject, period covered, and degree of coverage. The scope of our research is to *identify empirical and scientifically documented usability experiments on mobile applications and mobile websites with the aim to uncover usability guidelines for mobile websites and applications*. The covered period is ten years from 2003 to 2013 and the scope is further described using Cooper’s taxonomy of literature reviews [70]:

- Focus: Research outcomes
- Goal: Integration
- Organization: Conceptual
- Perspective: Neutral representation
- Audience: Researchers, mobile web/app developers, usability specialists
- Coverage: Exhaustive with selective citation.

**Table 1.** Usability guidelines for mobile websites and applications

<p><b>Layout:</b></p> <p>(G1) Place content in the central part of the screen [28]  (G2) Avoid horizontal scrolling [29, 30]  (G3) Arrange content vertically, avoid using tabs [28]  (G4) Locate login button on the top of the screen [31, 32]  (G5) Make the search field visible and usable [33]  (G6) Use clear linear structure and avoid table structure of input fields [34]  (G7) Use no more than three buttons in a dialogue [35, 36]  (G8) Position buttons in the middle or at the end of the dialogue [35, 36]  (G9) Position buttons on the right side of the screen [36]</p>
<p><b>Navigation:</b></p> <p>(G10) Make navigation menus as easy and as simple as possible [37]  (G11) Use one level navigation menus [38, 39]  (G12) Avoid many options [29] (max. 4-8 items) and scrolling in the navigation menu [30, 40]  (G13) Make important pages reachable from the start page [30]  (G14) Provide a possibility to quickly navigate back to the start page [30]  (G15) Minimize the number of clicks needed to reach each page [30]  (G16) Use breadcrumbs to show current location [41], quickly reach the start page [42, 43], and switch between pages [41]  (G17) Open external links in a new window, keep the current window unchanged [44]  (G18) Structure menus by topics and usage scenarios to reduce search [45–47]  (G19) Make titles, links and navigation items unambiguous [29, 30, 37, 48, 49], self-explanatory [37], and descriptive [31, 50, 51].</p>
<p><b>Design:</b></p> <p>(G20) Keep design simple [52], consistent, uniform and clear [53, 54]  (G21) Use a uniform design for different representations of the same product (e.g. website and mobile app) [55]  (G22) Emphasize important information [56, 57]  (G23) Use easy identifiable [57–59] and visible [30, 33, 60] icons  (G24) Use button size between 7mm and 10mm [35, 61]</p>
<p><b>Content:</b></p> <p>(G25) Use similar content and functionality for mobile version as for the desktop version [57]  (G26) Avoid long texts and use simple sentences [30]  (G27) Do not show much information on the start page [31]  (G28) Order content by its importance [30]  (G29) Provide automatic suggestions within the application (e.g. search autocomplete) [62]  (G30) Make user actions revertible to allow quick corrections [54, 63]  (G31) Integrate confirmation dialogues for change and edit actions [30]  (G32) Prevent data loss by reminding users of unsaved changes [64]  (G33) Save the current application state when the application is minimized and restore again when the work is continued [30]  (G34) Automatically correct typing errors [30]  (G35) Optimize interface to correct imprecise touch control [30]  (G36) Implement haptic feedback on user actions [65, 66]  (G37) Support common gestures to control apps [67]  (G38) Optimize entering passcode on mobile devices [68]</p>
<p><b>Performance:</b></p> <p>(G39) Minimize loading times [38]. Note: regular users are more tolerant to loading times than new users [69]</p>

Next, the topic is conceptualized (2) by identifying key sources as starting points for the literature search, which are the basis for setting up working definitions and search terms. The definitions for usability methods and experiments from Nielsen [71, 72] are used to conceptualize the topic of this paper.

The literature search (3) may start as soon as the preparation steps are finished. Based on the definitions and the scope presented above, the keywords are derived with the overall aim to find experiment results, targeting mobile websites and applications. Overall ten search strings are used which are the combinations of *usability experiment* on the one hand and *usability study* on the other hand with the terms *app*, *mobile*, *smartphone*, *web*, and *website*. Using the specified keywords, we perform the literature search in the following databases: IEEE, Springer Link, JSTOR, ACM, Science Direct, EBSCOhost, AIS, and Google Scholar. The search was restricted to the first 200 hits for each keyword combination per database. The initial database querying resulted in 12,934 papers. Filtering the found papers and journal articles for relevant entries was done in two phases. In the first phase, the results were reviewed by title and abstract and in the second phase by content. After reviewing title and abstract, 595 papers were identified. In this first phase, many papers could be rejected as they were either not about usability or not from the domain of information systems (e.g. medicine). In the detailed content analysis, the set was further narrowed down as only articles containing precise usability guidelines were regarded. This resulted in 127 papers which are documented in [73].

In the analysis and synthesis phase (4), the found literature is processed, e.g. using a concept matrix [74], and analysed regarding the aims of the review. Table 1 contains the identified and structured usability guidelines from the literature review. From the final set of 127 papers, some were omitted in the table, if the guidelines mentioned were too general or not suitable for applications in a mobile context.

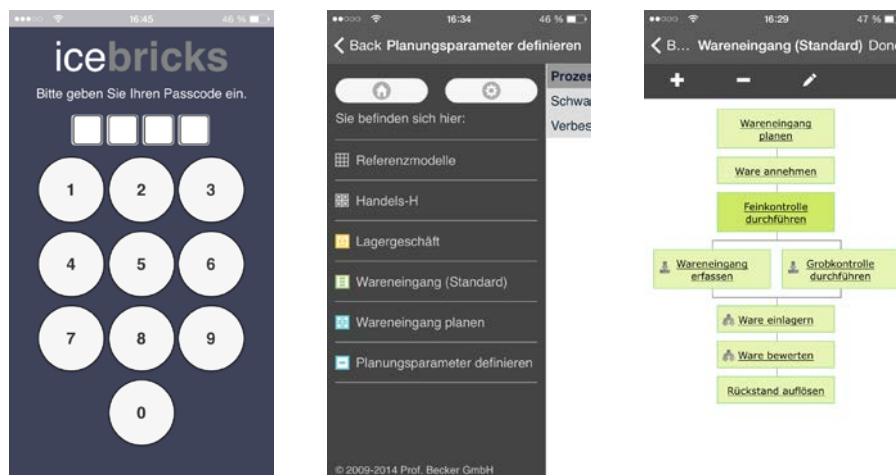
The last step of setting up a research agenda (5) is omitted in this paper, as our intention is to come up with a suitable collection of usability guidelines and to further demonstrate their applicability. Nevertheless, we identified some aspects for future research (see section 7: “Discussion”).

## **5 Demonstration of Usability Guidelines**

### **5.1 Case 1: Mobile App for Process Modelling**

In the first demonstration case, the usability guidelines are put to effect in the development of a mobile version of a process modelling tool. To clarify the functional range of the application, the group of potential users as well as the key usage scenarios were identified in the first design step. The potential users in this case are a consultancy company’s employees and their clients using the mobile app in business process modeling (BPM) projects. Two consultants with six to seven years of BPM experience actively participated in the development project and were accompanied by three academics with three to four years of BPM and usability research experience. During this six months long project, a team of five developers collaborated with the consultants and

the academics. The joint goal was to design a mobile version of a process modelling application, which should facilitate the usage and adoption of BPM by department workers. Due to the small screen size of mobile devices and the inherent difficulty of adjusting process models, no benefits in extensive modelling functionality are seen. Hence, the main usage scenarios for the mobile version were defined as access to administrative functionality, display of model content, and a simple functionality for the creation and modification of the model content.



**Fig. 2.** Mobile process modelling application

For the development of the mobile version of the process modelling tool, a hybrid approach between a native application and a mobile website was chosen. It combines the advantages of native applications and mobile websites – simple updates, maintenance and utilization of device-specific functions like pull-to-refresh or breadcrumbs.

In the beginning of the development phase, a paper-based prototyping of the hybrid process modelling app was carried out in a design workshop together with the developers, the two consultants and the three academics. Low-fidelity prototypes were created to clarify the requirements and to draft functional and graphical design. Here, especially guideline G21 was followed to ensure the same look and feel for the desktop and mobile versions of the tool. During the whole design and development process, which was carried out in close communication and regular meetings between the developers, academics and the consultants, the previously proposed usability guidelines were considered, discussed and – where applicable – implemented. The evaluation of the usefulness of the guidelines is provided in the next section. In Fig. 2, certain aspects of the resulting mobile process modelling application, which are linked to usability guidelines, are shown as follows (left to right): login page with optimized passcode input (G38), breadcrumb navigation through hierarchical process models (G16), and display/edit mode of process models.



## 5.2 Case 2: Mobile Website for Research Portals

In the second use case, the identified usability guidelines are applied during a six months development of a mobile website for research portals. During that time, four software developers had weekly meetings with a research portal architect (four years of experience) and three power users (each two to four years of user experience). Research portals are “topic related [...] websites, designed to [...] specifically structure research information which [...] already exists elsewhere. Main goals of research portals [are] the encouragement of collaboration in the community and [...] the dissemination of research results” [75]. Research portals may be of a general nature, e.g. ResearchGate [76], with a regional focus, e.g. research portal Saxony-Anhalt [77], or topic-centric, e.g. research portal Product-Service-Systems [78]. Research portals collect information on research results, research projects, publications, people and organizations.

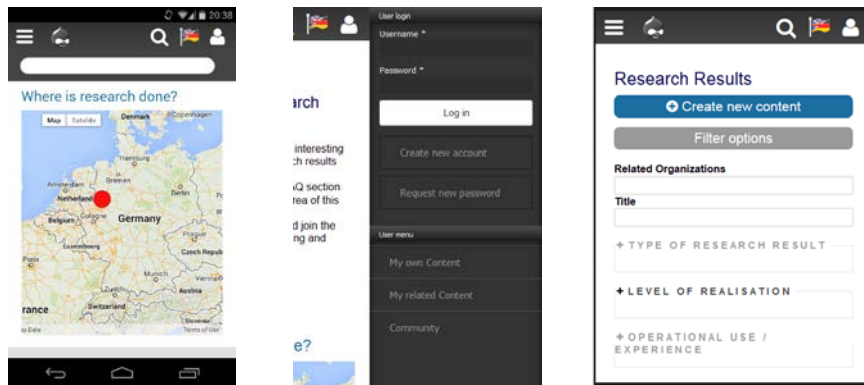


Fig. 3. Mobile website for research portal; a) start page, b) user menu, c) content filtering

The decision in favor of a mobile website is made because a desktop website for research portals already exists and only has to be adjusted to be used on a mobile device. Furthermore, the research portal does not use any specific functionality of the mobile device and, therefore, does not need to be specific for any mobile operating system. Developing a device-independent mobile website saves on resources and speeds up the development. The existing website is modified to fit usability guidelines regarding the content and functionality. The design guidelines were addressed using responsive CSS-design.

For the design of the mobile website and the selection of applicable usability guidelines, the desired focus and functionality of the mobile website needs to be considered. While the desktop website is used as a tool for creating, maintaining and viewing research data, the focus of the mobile website is mainly to conveniently display the content. Adding and modifying research information on mobile devices is too complex. Therefore, the most usability guidelines dealing with the layout, navigation, design and content presentation are implemented, and content changing optimizations (G30-G34)

are omitted for the mobile research portal website. Furthermore, some guidelines are found to not being applicable for mobile websites (e.g. G36-G38).

Some examples for mobile optimizations are the header (G4, G23-34) with integrated search field (G5; see Fig. 3a), the fading-in menu and user menu (G10-14, G18; see Fig. 3b), and the general optimization of the page layout for mobile devices (see Fig. 3c) with a vertical structure (G2-3), linear inputs (G6) and clean layout (G20-21).

## 6 Evaluation of Usability Guidelines

The evaluation of the guidelines is performed in two phases. First, the guidelines are evaluated for their general applicability by checking if the guideline can be used to improve the usability of the prototypes, presented in the previous section. Second, the usefulness of the applied guidelines is evaluated by testing the prototypes with the respective stakeholders.

In both case studies, only a subset of the proposed guidelines is chosen for implementation, as guidelines are not fixed rules [14] and always have to be adapted to the specific application domain. However, by demonstrating the guidelines in two scenarios with different domains (process modelling tool and research portals) and technologies (mobile hybrid application and mobile website), most guidelines are applied at least once and it is possible to draw a conclusion about the general applicability of each guideline. The results of the evaluation (Table 2) show that 26 out of 39 guidelines are applicable in both cases, and 12 guidelines only in one case. The layout guideline G9 is not applied at all and has to be further explored in the future research.

In the first demonstration case, the two layout guidelines G4 and G5 are not applicable, because login is required right upon the execution of the application (G4) and the search functionality is not provided (G5). The design guidelines G22 and G28 are not applicable for a process modelling tool because of the absence of textual content. Guideline G34 is applied partially by correcting the typos with standard smartphone keyboard autocorrect functionality. The guidelines G29, G30 and G36 are not addressed in the prototype because of limited implementation time, but will be implemented in the next versions.

In the second demonstration case, not all navigation guidelines are fulfilled, because of their contradicting nature. There needs to be a trade-off between the depth of menus, direct accessibility of all functionality and the number of menu options (G12). The breadcrumbs functionality (G16) is not necessary for the current case. Content guidelines G30-G34 are not applicable because the focus of the mobile website is put on display and not creation of the content. G36 and G38 were not possible to implement for mobile websites. Similarly to the first demonstration case, content guideline G29 is planned to be implemented in the next version and the guideline G34 is only partially implemented as in the first case.

**Table 2.** General applicability of the usability guidelines

<b>Layout</b>	<b>G1</b>	<b>G2</b>	<b>G3</b>	<b>G4</b>	<b>G5</b>	<b>G6</b>	<b>G7</b>	<b>G8</b>	<b>G9</b>	
Case 1	x	x	x			x	x	x		
Case 2	x	x	x	x	x	x	x	x		
<b>Navigation</b>	<b>G10</b>	<b>G11</b>	<b>G12</b>	<b>G13</b>	<b>G14</b>	<b>G15</b>	<b>G16</b>	<b>G17</b>	<b>G18</b>	<b>G19</b>
Case 1	x	x	x	x	x	x	x	x	x	x
Case 2	x	x		x	x	x		x	x	x
<b>Design</b>	<b>G20</b>	<b>G21</b>	<b>G22</b>	<b>G23</b>	<b>G24</b>					
Case 1	x	x		x	x					
Case 2	x	x	x	x	x					
<b>Content</b>	<b>G25</b>	<b>G26</b>	<b>G27</b>	<b>G28</b>	<b>G29</b>	<b>G30</b>	<b>G31</b>	<b>G32</b>	<b>G33</b>	<b>G34</b>
Case 1	x	x	x		p	p	x	x	x	(x)
Case 2	x	x	x	x	p					(x)
<b>Content</b>	<b>G35</b>	<b>G36</b>	<b>G37</b>	<b>G38</b>						
Case 1	x	p	x	x						
Case 2	x		x							
<b>Perfor- mance</b>	<b>G39</b>									
Case 1	x									
Case 2	x									
<i>x – implemented, (x) – partially implemented, p – planned for future versions</i>										

In order to assess the usefulness of the applied guidelines, in the second evaluation phase we performed stakeholder testing of the created prototypes. The evaluation was performed iteratively during the implementation period. The developers were explicitly asked to apply the guidelines in the development process. In the weekly meetings with the developer team, the stakeholder group reviewed newly implemented functionality and discussed the guidelines which were already applied or were planned to be applied in the next iteration. The discussions were mainly focused on the way of specifically implementing the guidelines, for instance, which items should be included in menus or where to locate the breadcrumbs. The already implemented guidelines were in most cases well appreciated by the stakeholders. However, the developers could still argue on the applicability of each guideline in a particular situation. This led to a subset of guidelines actually being implemented (see Table 2). Some of the guidelines required time-consuming functionality implementation (e.g. G29 or G34) or could only be partially implemented respectively had to be postponed to a later stage (see Table 2). Despite this fact, the developers agreed that they are eager to apply the guidelines in future projects.

To our knowledge, compared to previous implementation projects, applying a collection of usability guidelines and involving stakeholders early in the development process helped to reduce the number of usability bugs and, thus, made the implementation

time shorter and improved the overall result. Upon completion of the prototype implementation, the stakeholders provided positive feedback regarding the implementation results and are now using the created artefacts in their daily routines.

## 7 Discussion

The growing popularity of mobile devices, together with the constant technological improvements in the field, leads to an increased number of mobile websites and applications. However, the particularities of mobile devices, such as small screen size or unstable internet connection, require special attention to be paid to usability aspects already during the application design phase. Usability is already recognized as a crucial aspect in UI and web development. However, structured and evaluated usability guidelines for mobile websites and applications can still not be found in the scientific literature. Thus, in this paper we construct and evaluate a catalogue of usability guidelines for mobile applications.

We have approached this problem by conducting a literature review and proposing a scientifically founded catalogue of usability guidelines. In the literature review, we identified research publications presenting mobile usability experiment results. By analyzing and synthesizing the results of the literature review, we derived a catalogue of usability guidelines for mobile websites and applications. The presented guidelines were then applied in two demonstration cases: the development of a mobile application for a process modelling tool and a mobile website for research portals. The subsequent evaluation of the general applicability and usefulness of the guidelines has shown that most of the guidelines are applicable for both demonstration scenarios. Moreover, the positive feedback of the stakeholders regarding the usability of both prototypes shows that applying usability guidelines early in the design phase helps to eliminate a number of usability issues and, thus, reduces the costs for implementation and improvement.

As a limitation of our study, no controlled benchmarking of the guidelines was conducted. However, because of the nature of the research method applied to create the guidelines catalogue, most of the guidelines were already evaluated in the original studies. Moreover, the application of the guidelines in two demonstration cases merely provides an evidence that the guidelines are applicable, but it is not implied that this result is generally transferrable to other cases. For this sake, further evaluation of the guidelines should be conducted in future research in which the guidelines should be evaluated by different stakeholder groups in different development projects for their helpfulness, sufficiency and comprehensiveness.

Moreover, future research should also cover expert interviews to rank the guidelines by importance as well as to get rid of least-relevant guidelines. The guideline G9, which was not applied in both cases, specifically needs further investigation.

Furthermore, because of the growing popularity of mobile development and technological improvements, the guidelines catalogue should constantly be updated and extended in the future.

## Acknowledgement

This paper has been written in the context of the research project Cooperation Experience. The project is funded by the German Federal Ministry of Education and Research (BMBF), promotion sign 01XZ13013. We thank the project management agency German Aerospace Center (PT-DLR).

## References

1. Gartner: Press Release, [www.gartner.com/newsroom/id/1306513](http://www.gartner.com/newsroom/id/1306513) (Accessed: 14.11.2014)
2. Nielsen, J.: Mobile Usability Update, [www.nngroup.com/articles/mobile-usability-update/](http://www.nngroup.com/articles/mobile-usability-update/) (Accessed: 14.11.2014)
3. Verkasalo, H., López-Nicolás, C., Molina-Castillo, F.J., Bouwman, H.: Analysis of users and non-users of smartphone applications. *Telemat. Informatics*. 27, 242–255 (2010)
4. Charland, A., Leroux, B.: Mobile application development: web vs. native. *Commun. ACM*. 54, 49–53 (2011)
5. Burguera, I., Zurutuza, U., Nadjm-Tehrani, S.: Crowdroid: behavior-based malware detection system for android. *Proceedings of the 1st ACM workshop on Security and privacy in smartphones and mobile devices*. pp. 15–26 (2011)
6. Buranatrived, J., Vickers, P.: An investigation of the impact of mobile phone and PDA interfaces on the usability of mobile-commerce applications. *IEEE 5th International Workshop on Networked Appliances*. pp. 90–95. Liverpool (2002).
7. ISO: International Standard Ergonomic requirements for office work with visual display terminals (VDTs)-Part 11: Guidance on Usability, (1998).
8. Nielsen, J.: Usability 101: Introduction to Usability, [www.nngroup.com/articles/usability-101-introduction-to-usability/](http://www.nngroup.com/articles/usability-101-introduction-to-usability/) (Accessed: 14.11.2014)
9. Scapin, D., Leulier, C., Vanderdonck, J., Mariage, C., Bastien, C., Palanque, C.F.P., Bastide, R.: A framework for organizing web usability guidelines. *Proceedings of the 6th Conference on Human Factors & the Web* (2000).
10. Henninger, S.: An organizational learning method for applying usability guidelines and patterns. *Engineering for Human-Computer Interaction*. pp. 141–155. Springer (2001).
11. Nielsen, J., Budiu, R.: *Mobile Usability*. New Riders (2013).
12. Mariage, C., Vanderdonck, J., Pribeanu, C.: State of the Art of Web Usability Guidelines. *The handbook of human factors in web design*. pp. 688–700 (2005).
13. Ohnemus, K.R.: Web style guides: who, what, where. *Proceedings of the 15th annual international conference on Computer documentation*. pp. 189–197. ACM (1997).
14. U.S. Dept. of Health and Human Services: *The Research-Based Web Design & Usability Guidelines, Enlarged/Expanded edition*, (2006).
15. Nielsen Norman Group, [www.nngroup.com/](http://www.nngroup.com/) (Accessed: 14.11.2014)
16. Pernice, K., Nielsen, J.: *Usability Guidelines for Accessible Web Design*. (2001).
17. Hong, S., Kim, S.: *Mobile web usability: developing guidelines for mobile web via smart phones. Design, User Experience, and Usability. Theory, Methods, Tools and Practice*. pp. 564–572. Springer (2011).
18. Harrison, R., Flood, D., Duce, D.: Usability of mobile applications: Literature review and rationale for a new usability model. *J. Interact. Sci.* 1, 1 (2013).

19. Boiano, S., Bowen, J., Gaia, G.: Usability, design and content issues of mobile apps for cultural heritage promotion: The Malta Culture Guide experience. arXiv preprint arXiv:1207.3422 (2012).
20. Ballard, B.: *Designing the Mobile User Experience*. Wiley, Chichester, UK (2007).
21. Mobile Website and Application Usability, [www.nngroup.com/reports/mobile-website-and-application-usability/](http://www.nngroup.com/reports/mobile-website-and-application-usability/) (Accessed: 14.11.2014)
22. Shebley, M.: Mobile Patterns, [www.mobile-patterns.com/](http://www.mobile-patterns.com/) (Accessed: 14.11.2014)
23. Peffers, K., Tuunanen, T., Rothenberger, M.A., Chatterjee, S.: A Design Science Research Methodology for Information Systems Research. *J. Manag. Inf. Syst.* 24, 45–77 (2007).
24. Hevner, A., March, S., Park, J., Ram, S.: Design science in information systems research. *Mis Q.* 28, 75–105 (2004).
25. Bevan, N., Bogomolni, I.: Incorporating user quality requirements in the software development process. *Proc. 4th Int. Software Qual. Week Eu.* pp. 1192–1204 (2000).
26. Vom Brocke, J., Simons, A., Niehaves, B., Riemer, K., Plattfaut, R., Clevén, A.: Reconstructing the Giant: On the Importance of Rigour in Documenting the Literature Search Process. 17th ECIS. pp. 3226–3238 (2009).
27. Webster, J., Watson, R.T.: Analyzing the Past to Prepare for the Future: Writing a Literature Review. *MIS Q.* 26, xiii – xxiii (2002).
28. Raneburger, D., Alonso-Ríos, D., Popp, R., Kaindl, H., Falb, J.: A User Study with GUIs Tailored for Smartphones. *INTERACT 2013*. pp. 505–512 (2013).
29. Fuglerud, K.S., Røssvoll, T.H.: An evaluation of web-based voting usability and accessibility. *Univers. Access Inf. Soc.* 11, 359–373 (2011).
30. Holzinger, A., Errath, M.: Mobile computer Web-application design in medicine: some research based guidelines. *Univers. Access Inf. Soc.* 6, 31–41 (2007).
31. Halpert, B.: Authentication interface evaluation and design for mobile devices. *Proc. of the InfoSecCD '05*. p. 112 (2005).
32. Llanos, C.I., Muñoz, M.N.: Design guidelines for web applications based on local patterns. *Proc. of the EATIS '07*. p. 1 (2007).
33. Freeman, M.: The Current State of Online Supermarket Usability in Australia. *ACIS Proceedings* (2003).
34. Weir, C.S., Anderson, J.N., Jack, M.A.: On the role of metaphor and language in design of third party payments in eBanking: Usability and quality. *Int. J. Hum. Comput. Stud.* 64, 770–784 (2006).
35. Park, Y.S., Han, S.H.: Touch key design for one-handed thumb interaction with a mobile phone: Effects of touch key size and touch key location. *Int. J. Ind. Ergon.* 40, 68–76 (2010).
36. Seipp, K., Devlin, K.: Landscape vs portrait mode. *Proc. of the 15th MobileHCI '13*. p. 534. ACM Press, New York, NY, USA (2013).
37. Han, M., Park, P.: A study of interface design for widgets in web services through usability evaluation. *Proceedings of the 2nd International Conference on Interaction Sciences Information Technology, Culture and Human - ICIS '09*. pp. 1013–1018 (2009).
38. Galletta, D.F., Henry, R.M., McCoy, S., Polak, P.: When the Wait Isn't So Bad: The Interacting Effects of Website Delay, Familiarity, and Breadth. *Inf. Syst. Res.* 17, 20–37 (2006).
39. Parush, A., Yuviler-Gavish, N.: Web navigation structures in cellular phones: the depth/breadth trade-off issue. *Int. J. Human-Computer Stud.* 60, 753–770 (2004).
40. Geven, A., Sefelin, R., Tscheligi, M.: Depth and breadth away from the desktop. *Proc. of the MobileHCI '06*. p. 157 (2006).

41. Dias, A.L., Fortes, R.P. de M., Masiero, P.C., Watanabe, W.M., Ramos, M.E.: An approach to improve the accessibility and usability of existing web system. *Proc. SIGDOC '13*. p. 39 (2013).
42. Nivala, A.-M., Brewster, S., Sarjakoski, T.L.: Usability Evaluation of Web Mapping Sites. *Cartogr. Journal*, 45, 129–138 (2008).
43. VandeCreek, L.M.: Usability analysis of Northern Illinois University Libraries' website: a case study. *OCLC Syst. Serv.* 21, 181–192 (2005).
44. Tirapat, T., Achalakul, T.: Usability Assessment for Hyperlink Methods. 2006 International Conference on Hybrid Information Technology. pp. 252–256 (2006).
45. Fang, X., Holsapple, C.W.: Impacts of navigation structure, task complexity, and users' domain knowledge on Web site usability—an empirical study. *Inf. Syst. Front.* 13, 453–469 (2010).
46. Karreman, J., Arendsen, R., van der Geest, T.: Navigating on web sites: Exploring the life events approach. *IEEE Int. Professional Communication Conference*. pp. 339–343 (2010).
47. Zainudin, N.M., Ahmad, W.F.W., Nee, G.K.: Evaluating C2C e-commerce website usability in Malaysia from users' perspective: A case study. 2010 International Symposium on Information Technology. pp. 151–156 (2010).
48. Fitzmaurice, G., Khan, A., Pieké, R., Buxton, B., Kurtenbach, G.: Tracking menus. *Proceedings of the 16th annual ACM symposium on User interface software and technology - UIST '03*. pp. 71–79 (2003).
49. Seva, R., Wu, J., Li Yi, X.: Evaluation of Cinema Website. *IEEE International Conference on Systems, Man and Cybernetics*. pp. 712–717 (2006).
50. Chadwick-Dias, A., McNulty, M., Tullis, T.: Web usability and age. *ACM SIGCAPH Comput. Phys. Handicap*. 30–37 (2002).
51. Crystal, A., Kalyanaraman, S.: Usability, cognition, and affect in web interfaces: The role of informative feedback and descriptive labeling. 54th annual conference of the International Communication Association. , New Orleans, LA (2004).
52. Wilson, R., Shortreed, J., Landoni, M.: A study into the usability of E-encyclopaedias. *Proceedings of the 2004 ACM symposium on Applied computing - SAC '04*. p. 1688. ACM Press, New York, NY, USA (2004).
53. Nathan, R.J., Yeow, P.H.P.: Crucial web usability factors of 36 industries for students: a large-scale empirical study. *Electron. Commer. Res.* 11, 151–180 (2010).
54. Zollet, R., Back, A.: Website Usability for Internet Banking. 23rd Bled eConference eTrust: Implications for the Individual, Enterprises and Society. pp. 166–180 (2010).
55. Cooharajanone, N., Kongnim, P., Mongkolnut, A., Hitoshi, O.: Evaluation Study of Usability Factors on Mobile Payment Application on Two Different Service Providers in Thailand. *IEEE/IPSJ* pp. 233–238 (2012).
56. Adipat, B., Zhang, D., Zhou, L.: The effects of tree-view based presentation adaptation on mobile web browsing. *MIS Q.* 35, 99–122 (2011).
57. Gunduz, F., Pathan, A.-S.K.: Usability Improvements for Touch-Screen Mobile Flight Booking Application: A Case Study. *Int. Conf. on ACSAT, IEEE*. pp. 49–54 (2012).
58. Cheng, H.-I., Patterson, P.E.: Iconic hyperlinks on e-commerce websites. *Appl. Ergon.* 38, 65–69 (2007).
59. Huang, C., Tsai, C.-M.: The Effect of Morphological Elements on the Icon Recognition in Smart Phones. *Second International Conference on Usability and Internationalization*. pp. 513–522 (2007).
60. Gatsou, C., Politis, A., Zevgolits, D.: Exploring inexperienced user performance of a mobile tablet application through usability testing. *Federated Conference on Computer Science and Information Systems*. pp. 557–564 (2013).

61. Komine, S., Nakanishi, M.: Optimization of GUI on Touchscreen Smartphones Based on Physiological Evaluation – Feasibility of Small Button Size and Spacing for Graphical Objects. 15th International Conference, HCI International 2013. pp. 80–88 (2013).
62. Schreiber, D., Hartmann, M., Flentge, F., Mühlhäuser, M., Görtz, M., Ziegert, T.: Web based evaluation of proactive user interfaces. *J. Multimodal User Interfaces*. 2, 61–72 (2008).
63. Tsai, C.C., Lee, G., Raab, F., Norman, G.J., Sohn, T., Griswold, W.G.: Usability and Feasibility of PmEB: A Mobile Phone Application for Monitoring Real Time Caloric Balance. *Mob. Networks Appl.* 12, 173–184 (2007).
64. Mansar, S.L., Jariwala, S., Shahzad, M., Anggraini, A., Behih, N., AlZeyara, A.: A Usability Testing Experiment For A Localized Weight Loss Mobile Application. *Procedia Technol.* 5, 839–848 (2012).
65. Koskinen, E., Kaaresoja, T., Laitinen, P.: Feel-good touch. *Proc. of the IMCI '08*. p. 297 (2008).
66. Parikh, S.P., Esposito, J.M.: Negative Feedback for Small Capacitive Touchscreen Interfaces: A Usability Study for Data Entry Tasks. *IEEE Trans. Haptics*. 5, 39–47 (2012).
67. Tokárová, L., Weideman, M.: Understanding the process of learning touch-screen mobile applications. *Proc. of the SIGDOC '13*. p. 157. ACM Press, New York, NY, USA (2013).
68. Bao, P., Pierce, J., Whittaker, S., Zhai, S.: Smart phone use by non-mobile business users. *Proc. MobileHCI '11*. p. 445. ACM Press, New York, New York, USA (2011).
69. Tsiaousis, A.S., Giaglis, G.M.: Evaluating the Effects of the Environmental Context-of-Use on Mobile Website Usability. 7th International Conference on Mobile Business. pp. 314–322 (2008).
70. Cooper, H.M.: Organizing knowledge synthesis: a taxonomy of literature reviews. *Knowl. Soc.* 1, 104–126 (1988).
71. Nielsen, J.: *Usability Engineering*. Morgan Kaufmann (1994).
72. Mack, R., Nielsen, J.: *Usability inspection methods*, (1993).
73. Web Usability, [webusability.yourresearchportal.com/resresults](http://webusability.yourresearchportal.com/resresults). (Accessed: 14.11.2014)
74. Salipante, P., Notz, W., Bigelow, J.: A Matrix Approach to Literature Reviews. *Res. Organ. Behav.* 4, 321–348 (1982).
75. Becker, J., Knackstedt, R., Lis, L., Stein, A., Steinhorst, M.: Research Portal. Status Quo and Improvement Perspectives. *Int. J. Knowl. Manag.* 8, 27–46 (2012).
76. ResearchGate, [www.researchgate.net](http://www.researchgate.net). (Accessed: 14.11.2014)
77. Research portal Saxony-Anhalt, [www.forschung-sachsen-anhalt.de/?&lang=1](http://www.forschung-sachsen-anhalt.de/?&lang=1). (Accessed: 14.11.2014)
78. Hybride Wertschöpfung 3.0, [www.forschungslandkarte-hybridewertschoepfung.de/en](http://www.forschungslandkarte-hybridewertschoepfung.de/en). (Accessed: 14.11.2014)