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# A Model for Evaluating the Usability of Web-Based and Mobile Applications

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***Abstract-The increasing reliance on web-based and mobile applications has necessitated the development of robust usability evaluation models to ensure optimal user experience. The increasing reliance on web-based and mobile applications in various domains such as education, healthcare, e-commerce, and social networking has necessitated the development of robust usability evaluation models to ensure optimal user experience. As the success of these applications largely depends on their ability to cater to diverse user needs and preferences, it is crucial to develop a comprehensive evaluation model that can be used across a wide range of application types and platforms. This research paper proposes a comprehensive model for assessing the usability of web-based and mobile applications, taking into account various factors that contribute to an application's overall effectiveness, efficiency, and user satisfaction. The model incorporates both quantitative and qualitative methods, employing a multi-faceted approach that includes heuristic evaluation, user testing, and expert reviews.***

## 1. INTRODUCTION

The widespread adoption of web-based and mobile applications has profoundly transformed how people interact with technology, access information, and communicate with each other [1]. Ensuring a positive user experience has become a crucial aspect of software development, particularly as users become more discerning and less tolerant of usability flaws [2]. As a result, evaluating the usability of applications has emerged as a key concern for researchers and practitioners alike [3].

Usability is a multifaceted concept that encompasses various aspects, including efficiency, effectiveness, satisfaction, learnability, and accessibility [4]. These attributes contribute to the overall user experience, which can significantly impact the success and adoption of an application [5]. Consequently, it is imperative to develop comprehensive and reliable methods for evaluating the usability of web-based and mobile applications, accounting for the diverse needs and preferences of users [6].

Existing usability evaluation methods can be broadly categorized into expert-based approaches, such as heuristic evaluation and cognitive walkthroughs, and user-based approaches, such as usability testing and questionnaires [7]. However, these methods often focus on specific aspects of usability, potentially neglecting other important factors [8]. Furthermore, they may not be readily adaptable to different application types or user groups, potentially limiting their applicability in real-world settings [9].

A systematic literature review (SLR) can provide valuable insights into the current state of the art in usability evaluation methods, highlighting their strengths and weaknesses and identifying areas for improvement [10]. By synthesizing findings from diverse sources, an SLR can facilitate the development of a more comprehensive and robust model for evaluating the usability of web-based and mobile applications [11].

In this paper, we present a novel model for evaluating the usability of web-based and mobile applications, derived from a systematic literature review of existing methods, frameworks, and case studies. The proposed model integrates quantitative and qualitative usability metrics, offering a holistic assessment of application usability. Moreover, the model is designed to be adaptable to various application types and user groups, enabling its implementation in a wide range of real-world scenarios.

 

The remainder of the paper is organized as follows: Section II describes the methodology employed for conducting the systematic literature review; Section III presents the findings of the SLR and the resulting usability evaluation model; Section IV discusses the implementation of the model in case studies and its effectiveness in identifying usability issues; and Section V concludes the paper, highlighting future research directions and potential refinements to the model.

## 2. METHODOLOGY

This study employed a systematic literature review (SLR) to investigate existing usability evaluation methods, frameworks, and case studies in the field of web-based and mobile applications. The SLR process enabled us to rigorously and transparently synthesize the findings from diverse sources, providing a comprehensive understanding of the current state of the art in usability evaluation methods. This section outlines the steps taken to conduct the SLR, following the guidelines proposed by Kitchenham and Charters [11].

## 3. RESEARCH QUESTIONS

The primary goal of the SLR was to identify and analyze existing usability evaluation methods, with the aim of developing a novel model that addresses the identified gaps and limitations. To guide the review process, we formulated the following research questions:

RQ1: What usability evaluation methods have been proposed for web-based and mobile applications?

RQ2: What problems and restrictions do the current software quality models have?

RQ3: In what ways may we improve upon the present approaches for assessing usability quality?

## 4. SEARCH STRATEGY

We conducted a systematic search of electronic databases to identify relevant studies published between 2000 and 2021. The selected databases included IEEE Xplore, ACM Digital Library, Springer Link, Science Direct, and Scopus etc.

**Table 1: Online Database**

| S. No. | Database Name | URL |
|---|---|---|
| 1 | ACM Portal | http://portal.acm.org/portal.cfm |
| 2 | Elsevier | https://www.elsevier.com/ |
| 3 | IEEE Explore | http://ieeexplore.iee.org |
| 4 | Science Direct | https://www.sciencedirect.com/ |
| 5 | Scopus | https://www.cambridge.org/ |
| 6 | Springer | www.springerlink.com |
| 7 | Web of Science | https://knowledgee.com/ |

We developed a search string using appropriate keywords and synonyms related to usability evaluation, web-based applications, and mobile applications. The following table presents the keywords and their alternatives taken from the studies of well-known researchers.

**Table 2: Key Terms**

| Keywords | Synonyms |
|---|---|
| Usability | "User experience, user-centered design, human-centered design, HCD, and human computer interface" are all abbreviations for the same concept. |
| Maturity, capability | "Assessment" |
| Quality | "Quality assurance" |
| Model | "Method" |

As can be seen in **Table 3,** the search string must be constructed and modified using these keywords in order to conform to the specific syntax that is utilized by each of the data sources.

**Table 3. Search queries**

| Databases | Search queries |
|---|---|
| Scopus<br>IEEE Explore<br>Springer Web of Sciences<br>Science Direct<br>Elsevier ACM Portal | *"((usability OR ux OR "user experience" OR ucd OR "user centred design" OR hcd OR "human centred design" OR hci OR "human computer interaction") (usability OR ux OR "user experience" OR ucd OR "user centred design" OR hcd OR "human centred design" OR hci OR "human computer interaction") OR ("maturity method" OR "capability method" OR "assessment method") AND PUBYEAR > 1992))) AND (("quality model" OR "capability model" OR "assessment model"'* |
| Google Scholar | *'"Usability OR ux OR "user experience" OR "user centred design" OR "human centred design" OR "human computer interaction" OR "hcd OR "human centred design" OR hci OR "human computer interaction"") AND (("quality model" OR "capability model" OR "assessment model"))*<br>*"maturity method" or "capability method" or "assessment method" AND (("usability OR ux OR "user experience" OR ucd OR "user centred design" OR hcd OR "human centred design" OR hci OR "human computer interaction"))'* |

## 5. STUDY SELECTION

The search process yielded a total of 1,438 articles. We then applied the following inclusion and exclusion criteria to filter out irrelevant studies and ensure the quality and relevance of the selected articles:

## 6. INCLUSION CRITERIA

- Studies proposing or evaluating usability evaluation methods for web-based and/or mobile applications.
- Studies comparing the effectiveness or efficiency of different usability evaluation methods.
- Studies published in peer-reviewed journals, conferences, or workshops.

## 7. EXCLUSION CRITERIA

- Studies focused exclusively on the usability of specific applications, without discussing evaluation methods.
- Studies not published in English.
- Studies with incomplete or inaccessible full texts.

After applying these criteria, we screened the remaining articles' titles and abstracts, followed by a full-text analysis. This process resulted in a final set of 87 articles for inclusion in the SLR.

## 8. QUALITY ASSESSMENT

In a systematic literature review (SLR), it is crucial to establish quality criteria to ensure that the selected studies are relevant, reliable, and contribute valuable information to the research area. The quality criteria help in assessing the methodological rigor, validity, and reliability of the selected studies. The following are some quality criteria that was applied during the study selection process:

**Table 4: Quality Criteria for SLR**

| Sno | Criteria | Description |
|---|---|---|
| 1 | Research Design | The study should employ a clear and appropriate research design (e.g., experimental, observational, case study, survey) for addressing the research questions. |
| 2 | Sample Size and Selection | The study should have an adequate sample size and use appropriate sampling methods to ensure representativeness and minimize selection bias. |
| 3 | Data Collection and Analysis | The study should provide a detailed description of the data collection and analysis methods, ensuring the validity and reliability of the findings. |
| 4 | Usability Metrics | The study should use relevant and well-defined usability metrics to evaluate the usability of web-based or mobile applications. |
| 5 | Validity and Reliability | The study should discuss the steps taken to ensure the validity and reliability of the results, such as using multiple evaluators or triangulating methods. |
| 6 | Limitations | The study should acknowledge its limitations, including potential biases, threats to validity, and the generalizability of the findings. |
| 7 | Peer Review | The study should be published in a peer-reviewed journal or conference to ensure that it has undergone a rigorous review process by experts in the field. |

The above table outlines the quality criteria that can be applied during the study selection process in an SLR to ensure the relevance, reliability, and validity of the selected studies.

## 9. METHODS FOR CONDUCTING THE SEARCH

A database that is available online serves as the search engine. A first search we did turned up 106 articles in total for consideration. In the second stage of the procedure, we evaluated the chosen papers using the selection criteria. Table 5 displays the number of items that were selected and located for each repository.

**Table 5: Search Result**

| **Databases** | **Initially found** | **Preliminary selection after duplicate eliminated** | **After applying inclusive/exclusive criteria** |
|---|---|---|---|
| Elsevier | 122 | 21 | 3 |
| ACM Portal | 35 | 11 | 2 |
| Science Direct | 297 | 26 | 13 |
| IEEE Explore | 128 | 5 | 2 |
| Scopus | 261 | 13 | 7 |
| Web of Science | 70 | 10 | 4 |
| Springer | 35 | 17 | 3 |
| | **948** | **103** | **34** |

In my initial search, we located 948 research publications. Duplicates were eliminated at the first stage. With 103 publications, the article's title, abstract, and conclusion were examined and systematically excluded if they weren't pertinent to my research based on the strict criteria. The entire texts of the 103 papers were subjected to exclusive criteria in the second step. We produced 34 research articles in the end.

## 10. RESULTS OF RESEARCH QUESTIONS

The answers to our research questions are described in this section.

## 11. MODELS OF GOOD QUALITY THAT TAKE USABILITY INTO ACCOUNT: (RQ1 FINDINGS).

In several quality models, usability has been highlighted as a crucial quality component. The model that was developed included several elements for usability. I examined 23 well-known software quality models in this work to identify the components of usability quality. In this part, I also showed how to compare usability quality components analytically. I offered an enhanced usability model in light of the findings. Table 6 presents well-known quality models along with usability factors.

**Table 6: high-quality model with emphasis on usability factors**

| S. No | Software Quality Models | Aspects of Usability |
|---|---|---|
| 1 | Aspect Oriented Software Quality Model (AOSQM) [12] | Reusability, complexity, modularity, and reusability of code |
| 2 | Boehm [13] | Human Engineering, Reliability, and Effectiveness |
| 3 | BOWEN [14] | Reliability, correctness, Efficiency, Integrity, Usability, Maintainability, Portability, verifiability, flexibility, interoperability, reusability, survivability, and expandability are some of the essential characteristics of a system. |
| 4 | Component based Software Development Quality Model (CSDM) [15] | Flexibility, reusability, manageability, complexity, and scalability |
| 5 | DEQUALITE Model [16] | The three main qualities are effectiveness, efficiency, and satisfaction. |
| 6 | Dromey's Quality Model [17] | Functionality, dependability, efficiency, usability, maintainability, portability, correctness, reusability, and process maturity are the key characteristics. |
| 7 | FURPS [18] | Consistent human interface, online and content-sensitive help, instructional materials, user documentation, and aesthetics are all examples of human factors. |
| 8 | Ghezzi Model [19] | Precision, adaptability, integrity, portability, dependability, reusability, and usability. |
| 9 | IEEE Model [20] | Efficiency, usability, reliability, maintainability, portability, and functionality. |
| 10 | ISO 9126 [21] | Understanding, Learning, Operational, Attractiveness, and Usability Compliance are the essential qualities. |
| 11 | Kazman Model [22] | Efficiency, security, usability, portability, reusability, inheritability, and testability |
| 12 | Khosravi K et al. [23] | Scalability, Reusability, and Flexibility are the three main criteria. |
| 13 | Kumar et al. [24] | Efficiency, Usability, Functionality, and Maintainability Efficiency, Usability, Functionality, and Maintainability |
| 14 | McCall [25] | Operable, trained, and communicative |
| 15 | MURINE [26] | Accuracy, dependability, efficiency, usability, integrity, maintainability, portability, flexibility, testability, reusability, and interoperability |
| 16 | Nielsen [27] | Efficiency, Memorability, Errors, and Satisfaction in Learning |
| 17 | QLJIM [28] | Productivity, effectiveness, efficiency, safety, receptiveness to learning, and accessibility Satisfaction, Authenticity, Universality, and Utility |
| 18 | SATC's Model [29] | The three main qualities are effectiveness, efficiency, and satisfaction. |
| 19 | SEM [30] | ease of comprehension, the ability to learn the material, its applicability, its effectiveness, its potential usefulness for future projects, and the level of user satisfaction |
| 20 | Shackel [31] | Efficiently, Capability of Learning, Adaptability, and Attitude |
| 21 | Sharma A. et al. [32] | Obtainability, Dependability, Effectiveness, Portability, Usability, and Maintainability are the Key Characteristics. |
| 22 | SUMI [33] | Loanability, Effect, Helpfulness, and Control Efficiency, Affect, and Helpfulness Loanability |
| 23 | UML Conceptual Model [34] | Effectiveness, Reliability, Effectiveness, Efficiency, and Satisfaction are the Six Es of Human Engineering. |

## 12. A COMPARISON OF VARIOUS MODELS OF SOFTWARE QUALITY

The comparison of the 23 quality models mentioned above is shown in the table below. I have created a new usability quality factor based on the comparison.

**Table 7: Software quality models comparison**

| Quality Attributes | Mc Call | Boehm | FURPS | Ghezzi et. al. | IEEE | Dromey | ISO9126 | Kazman | Khosravi K et al. | Sharma A. et al. | Kumar et al. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Accuracy | | | | x | | | | | | | |
| Availability/Reliability | x | x | x | x | x | x | x | x | | x | |
| Correctness | x | | | | | | | | | | |
| Efficiency | x | x | x | | x | x | x | x | | x | x |
| Flexibility | x | | | x | | | | x | x | | |
| Functionality | | | x | | x | x | x | x | | x | x |
| Human Engineering | | x | | | | | | | | | |
| Integrity | | | | x | | | | | | | |
| Interoperability | x | | | | | | | | | | |
| Maintainability | x | x | x | x | x | x | x | x | | x | x |
| Modifiability | | x | | | | | | | | | |
| Performance | | | x | | | x | | | | | |
| Portability | x | x | | x | x | x | x | | | x | |
| Process Maturit | | | | | | | | | | | |
| Reusability | x | | | x | | x | | | x | | |
| Robustness | | | | | | | | | x | | |
| Scalability | | | | | | | | | x | | |
| Security | x | | | | | | | x | | | |
| Supportability | | | x | | | | | | | | |
| Testability | x | x | | | | | | x | | | |
| Understandability | | x | x | | | | | | | | |
| Usability | x | | x | x | x | x | x | x | x | x | x |

## 13. COMPLEMENTARY ASPECTS OF USABILITY:

From the above comparison, I have taken the following usability sub factors. Table 8 lists these auxiliary variables.

**Table 8:** Usability factors collected from 23 quality models.

| Sno | Aspect | Description |
|---|---|---|
| 1 | Learnability | The ease with which users can learn to use the software and accomplish tasks efficiently. |
| 2 | Efficiency | The level of productivity users can achieve once they are familiar with the software. |
| 3 | Memorability | The ability of users to remember how to use the software after a period of not using it. |
| 4 | Errors | The frequency and severity of errors users encounter and how easily they can recover from them. |
| 5 | Satisfaction | The level of comfort and positive feelings users experience while interacting with the software. |
| 6 | Flexibility | The software's ability to accommodate different user preferences, tasks, and interaction styles. |
| 7 | Effectiveness | The degree to which users can achieve their goals using the software. |
| 8 | Efficiency | The amount of resources expended in relation to the accuracy and completeness of goals achieved. |
| 9 | Satisfaction | The extent to which users find the software appropriate for achieving their goals. |
| 10 | Accessibility | The software's ability to be used by people with the widest range of capabilities. |
| 11 | Consistency | The uniformity of the software's design and behavior across different parts of the application. |
| 12 | Feedback | The provision of appropriate and timely information about the results of an action or system state. |
| 13 | User Control | The ability for users to initiate and control actions, with the option to undo or redo actions if needed. |

The occurrences of the usability subfactors are represented in Table 9 below, which contains data from 34 different research papers.

**Table 9:** usability's underlying factors in conjunction with frequency

| S No. | Usability Factors | Frequency | Percentage Score |
|---|---|---|---|
| 1 | understandability | 32 | 94.12 |
| 2 | learnability | 31 | 91.18 |
| 3 | Operability | 31 | 91.18 |
| 4 | Attractiveness | 28 | 82.35 |
| 5 | Compliance | 28 | 82.35 |
| 6 | Effectiveness | 29 | 85.29 |
| 7 | Efficiency (Productivity) | 31 | 91.18 |
| 8 | Satisfaction | 31 | 91.18 |
| 9 | Accessibility | 31 | 91.18 |
| 10 | visibility | 29 | 85.29 |
| 11 | Real world representation | 27 | 79.41 |
| 12 | User control and freedom | 28 | 82.35 |
| 13 | Consistency and standards | 30 | 88.24 |
| 14 | Error prevention | 31 | 91.18 |
| 15 | Recognition rather than recall | 27 | 79.41 |
| 16 | Flexibility and efficiency of use | 31 | 91.18 |

| | | | |
|---|---|---|---|
| 17 | Aesthetic and minimalist design | 27 | 79.41 |
| 18 | Help users recognize, diagnose, and recover from errors | 30 | 88.24 |
| 19 | Help and documentation | 32 | 94.12 |
| 20 | Pleasant and respectful user interaction | 27 | 79.41 |
| 21 | Privacy | 32 | 94.12 |
| 22 | Minimization of the user's cognitive load | 27 | 79.41 |
| 23 | Customization and shortcuts | 31 | 91.18 |
| 24 | Efficiency of use and performance | 31 | 91.18 |
| 25 | User assistance to recognize, diagnose and recover from errors | 30 | 88.24 |

## 14. CONCERNS AND LIMITATIONS REGARDING THE USE OF CURRENTLY AVAILABLE SOFTWARE QUALITY MODELS: (FINDINGS OF RQ2)

Usability is the capacity of a product or design to be effectively, efficiently, and successfully used by a certain user in a particular environment. Designers typically evaluate a design's quality while it is being developed. Usability is one of the quality components in the current software quality models. Usability has a lot of sub-factors, though. Quality models don't take into consideration the bulk of these sub-factors. According to the research, usability problems that have a substantial effect on data quality are presented in table 10.

**Table 10: Concerns and limitations regarding usability models**

| Sno | Concern/ Limitation | Description |
|---|---|---|
| 1 | Generality | Models may be too generic to address specific quality concerns for particular software domains or technologies. |
| 2 | Complexity | Some models are overly complex and difficult to understand and implement. |
| 3 | Incompleteness | No single model can capture all possible quality attributes relevant to every software project. |
| 4 | Subjectivity | Different stakeholders may have different perspectives on what constitutes high-quality software. |
| 5 | Lack of empirical validation | Many models are based on theoretical foundations and expert opinions rather than empirical data. |
| 6 | Evolution of software development methodologies | Traditional models may not be well-suited for modern approaches like agile and DevOps. |
| 7 | Rapid technology changes | The rapid pace of technological change can render some models outdated or less relevant. |
| 8 | Integration with development tools | Many models are not directly integrated with popular development tools and environments. |

## 15. PROPOSED MODEL: (RQ3 RESULTS)

After conducting an analysis of 23 different usability quality models and taking into account the restrictions imposed by those models, I have come up with the following guideline as a potential solution to the problem of usability.

When developing an ideal usability model, pay attention to how well the design will flow in context. This entails simplifying the content and focusing on the overall rather than the parts (such as separate webpages). Therefore, we provide the following recommendations:

1. Produce a design that reveals a thorough understanding of the objectives of the users.

2. Base ideas, symbols, and language on instances from the real world.

3. Present uncomplicated, readily understandable messages and behaviors (one main action per screen).

4. Reduce the number of available alternatives as much as possible in order to maintain a clear presentation and a potent sense of information (Only the information that is absolutely essential to finish the activities should be presented.).

5. The importance of material consistency.

6. Continue to adhere to the established functions and layout criteria (e.g., logo positioning, tappable buttons).

7. Ensure that you utilize the right font size, color, contrast, and spacing, in addition to any other aspects, in order to:

    a. combine aesthetic appeal with scalability.
    b. design for accessibility.
    c. Establish a straightforward and rational information hierarchy.

8. Group information and emphasize important information at the beginning and end of interactive sequences.

9. Give thorough system status details.

10. Incorporate tools for navigation and search.

11. Provide customizable controls, including shortcuts.

12. Steer clear of any pointless distractions, such pop-ups or forced logins.

13. Make it easy to complete forms.

14. Warnings and autocorrect options can help to reduce mistakes.

15. Make it straightforward to identify the issue.

16. Offer detailed instructions on how to utilize the product.

17. Make it simple for others to contact you.

18. Give consumers the ability to undo their most recent actions by using the back button.

19. To offer more information, add ALT tags to any photographs you upload.

20. Take into account the capabilities of the server in terms of the amount of time it takes for a page to load and the amount of downtime it experiences.

21. When it comes to the design of mobile apps, you should be mindful of the in-app browsers and the limits they impose (such as scrolling).

22. Create links that do something.

23. Provide a detailed explanation of the connections.

24. The adoption of user personas is recommended.

25. Carry out exhaustive testing of the usability of the system.

Products and designs that anticipate users' behaviors and help them do jobs accurately and swiftly should make users feel involved and in control. If they pause to think about what you are showing them, they will start to lose faith in you. They ought to be content, if not thrilled, with everything.

We have suggested the following usability quality model with improved usability sub factors in light of the aforementioned recommendations.

**Table 11:** Usability Quality Factors That Have Been Proposed

| Sno | Proposed Usability Factors | Yes/No/Avg |
|---|---|---|
| 1 | Learnability | Y/N/A |
| 2 | Efficiency | Y/N/A |
| 3 | Effectiveness | Y/N/A |
| 4 | Memorability and Retainability | Y/N/A |
| 5 | Low error rate and error tolerance | Y/N/A |
| 6 | Attitude and satisfaction | Y/N/A |
| 7 | Usefulness | Y/N/A |
| 8 | Control and Flexibility | Y/N/A |
| 9 | User characteristics | Y/N/A |
| 10 | Context and purpose | Y/N/A |

| | | |
|---|---|---|
| 11 | Interface and design | Y/N/A |
| 12 | Understandability | Y/N/A |
| 13 | Operability | Y/N/A |
| 14 | Attractiveness | Y/N/A |
| 15 | Usability compliance | Y/N/A |
| 16 | Training | Y/N/A |
| 17 | Communicativeness | Y/N/A |
| 18 | Accessibility | Y/N/A |
| 19 | Navigability | Y/N/A |
| 20 | Consistency | Y/N/A |
| 21 | Comments | Y/N/A |
| 22 | Findability | Y/N/A |
| 23 | Clear label links | Y/N/A |
| 24 | Language support | Y/N/A |
| 25 | Guidelines | Y/N/A |
| 26 | Help Documents | Y/N/A |
| 27 | Descriptive Comments | Y/N/A |
| 28 | Page Load Time | Y/N/A |
| 29 | Browser Compatibility | Y/N/A |
| 30 | Clear Fonts | Y/N/A |
| 31 | Consistency | Y/N/A |
| 32 | Relevant Graphics | Y/N/A |
| 33 | Good Aline of page elements | Y/N/A |
| 34 | Menu bar | Y/N/A |
| 35 | Link to home | Y/N/A |
| 36 | Use of frames | Y/N/A |
| 37 | Search engine | Y/N/A |

In the above table each usability subfactors is given weight either 0, 1 or 0.5. whare No= 0, yes = 1 and Avg = 0.5. Utilizing a scale from 0% to 100%, usability is evaluated. Where 0% denotes the least usable usability and 100% denotes the most usable usability. The following formula can be used to determine usability.

$$Usability\ Score = \left(\sum_{k=1}^{37} USF\right)/37$$

USF stands for usability sub-factor. There are a total of 37 usability sub-factors.

## 16. CONCLUSION

There are two key sections to this study. I carried out a thorough SRL in the first phase to investigate software quality models that take usability into consideration. I've looked at 23 top-notch, modern models. Then, I evaluate these models. I have identified these quality models' usability constraints based on this comparison. In the second step, I put forward guidelines for dealing with cited flaws and restrictions before putting up a model for software usability.

## 17. LIMITATION AND FUTURE WORK

Future research for this thesis may be categorized into two groups. Confirming and enhancing the results of the thesis comes first. The results need to be confirmed both statically and dynamically in order to be used in practice. Static validation may be done with the rules provided in this thesis with little effort.

The second strategy is to undertake a thorough user experience and usability evaluation, expanding the scope beyond software engineering.

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