Usability in Software for People with Disabilities: Systematic Mapping

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Abstract: This study presents a systematic mapping of usability analysis tools focused on accessibility, aiming to identify technologies, methods, and challenges related to improving inclusive interfaces. Tools such as DUXAIT-NG, Guideliner, and MUSE were analyzed, standing out for integrating automated evaluations and specific adaptations. However, they exhibited technical limitations in customization and application to different contexts and types of disabilities. The results demonstrated the positive impact of these tools on the development of accessible software while also highlighting research gaps, such as the lack of empirical studies and the absence of real-time dynamic analyses. Based on this analysis, the study contributes by organizing and systematizing knowledge on accessibility tools, identifying research gaps that emphasize the need for greater flexibility in solutions and validations, and suggesting technological and methodological advancements. It reinforces the importance of expanding research to other databases and developing more robust and dynamic tools.

1 INTRODUCTION

With the growing popularity of mobile devices, the alignment between web applications and usability guidelines has become one of the key factors for user satisfaction and the success of an application (Marenkov et al., 2018).

However, manual usability evaluation is time-consuming and resource-intensive, making automated evaluation a promising alternative to overcome these limitations (Marenkov et al., 2018). Evaluating user satisfaction with user interfaces (UIs) presents additional challenges due to the dynamic nature of UIs and the constant movement within the usage context (Yigitbas et al., 2019). These challenges are even more evident in mobile devices, where developers have focused on creating interfaces that are intuitive and easy to use (Bessghaier et al., 2021).

Achieving these qualities requires an iterative process of evaluating mobile interfaces and eliminating structural flaws that could compromise visual and functional consistency—crucial factors for the user experience.

At the same time, technological advancements have driven the development of smart cities, which demand the creation of applications that meet rigorous usability criteria, such as the ten usability heuristics and the principles of usability analysis (Adinda and Suzianti, 2018). This scenario underscores the importance of continually evaluating software usability to ensure its effectiveness and accessibility, particularly for people with disabilities.

In this context, the present study systematically maps the literature to identify and evaluate usability analysis tools focused on software accessibility. To this end, articles in the selected databases were analyzed, providing a broad understanding of the available tools and methods.

The remainder of this article is structured as follows: Section 2 provides the theoretical context, addressing concepts of usability and accessibility in

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software. Section 3 presents related work. Section 4 details the methodology used. Section 5 describes the results, while Section 6 discusses the analyzed issues. Finally, Section 7 presents the conclusions of this study.

2 THEORETICAL FRAMEWORK

Including all students in education, particularly in higher education, has become a global concern, with efforts focused on meeting the learning needs of students with disabilities (Ndlovu, 2021). In this context, assistive technologies (AT) play a crucial role in providing academic, social, and physical support to promote the well-being and independence of these students (McNicholl et al., 2021). AT encompasses devices such as iPods, iPads, computers, and software that help overcome barriers imposed by the environment or the disability itself (McNicholl et al., 2021).

Providing AT in higher education is a fundamental strategy to equalize learning opportunities for students with and without disabilities. While all students at this level meet the required academic standards, specific limitations can impact the performance of students with disabilities due to environmental or individual factors (Ndlovu, 2021). Equipping these students with appropriate devices and technologies helps eliminate barriers and create a more inclusive and accessible learning environment (Mji et al., 2009; Tony, 2019; Lyner-Cleophas, 2019; Alnahdi, 2014).

In this scenario, mobile learning emerges as an opportunity to make the educational process more flexible, allowing students to learn anytime and anywhere (Kumar and Mohite, 2018). Mobile learning provides adaptable and collaborative environments, extending teaching possibilities beyond the traditional classroom (Nedungadi and Raman, 2012). However, the design of mobile educational applications faces significant challenges, such as adapting to small screens, input method limitations, and the ever-changing context of use (Kumar and Mohite, 2018). These factors highlight the importance of usability testing to ensure that applications are practical, effective, and easy to use (Harrison et al., 2013).

The usability of mobile applications, especially those designed for learning, is an emerging and essential area in human-computer interaction (HCI). Considered a determining factor for technological success and adoption, usability is associated with ease of use, perceived utility, and a satisfying user experience (Nielsen, 1994; Cole et al., 2008). Despite its importance, few studies are systematically evaluating the usability of mobile educational applications, representing a critical gap in research and development (Zhang and Adipat, 2005).

Finally, the rapid technological evolution and the introduction of more sophisticated mobile devices continue to challenge developers to create interfaces that meet user expectations while overcoming technical limitations. Usability studies are an indispensable tool to ensure that mobile learning applications achieve not only a high level of user satisfaction but also contribute to a more inclusive and accessible education (Kumar and Mohite, 2016).

3 RELATED WORK

The work by Falconi et al. (Falconi et al., 2023) presents an integrated usability evaluation tool that combines heuristic evaluation methods and tree testing. The goal is to automate the usability evaluation process, allowing evaluators of different experience levels to visualize the evaluation process and its associated tasks. DUXAIT-NG was developed in response to the need for tools that support standardized usability evaluations, especially in contexts where conducting in-person tests is challenging, such as during the COVID-19 pandemic. The paper also discusses the importance of conducting case studies in different domains to validate the tool. It plans to expand its functionalities to include other types of usability evaluations.

Palternò et al. (Paternò et al., 2016) presents a system based on timelines for visualizing interactive events, which is used in a usability evaluation tool for mobile web applications. The proposal is to collect user interaction data while performing tasks in web applications, allowing usability experts to analyze this data to identify problems. The system is designed to record various interaction events, such as taps and gestures, and offers visualizations that help compare the actual user behavior with an ideal behavior. The paper concludes that improvements in future visualization and data analysis are needed to support better identification of usability issues.

Vasconcelos and Baldochi (de Vasconcelos and Baldochi Jr, 2012) discuss the USABILICS system, which aims to facilitate the usability evaluation of web applications through an automated approach. The main focus of the system is the analysis of user interactions related to defined tasks, allowing the identification of incorrect actions during task execution. The paper also reports experiments conducted with two web applications, an e-learning system, and a technology article publishing website, where several tasks were monitored. The results showed that usability scores significantly improved after implementing recommendations based on USABILICS analyses, and incorrect actions were reduced.

Zhang (Zhang et al., 2009) investigates the usability of three digital libraries: ACM Digital Library, IEEE Computer Society Digital Library, and IEEE Xplore. The research was conducted with 36 participants who performed search and navigation tasks. The results revealed several difficulties users face, especially those with less experience. The study used objective and subjective measures to assess usability, including the number of queries, search time, and user satisfaction. The authors discuss the study’s limitations and suggest that future research should include a more diverse sample and a wider range of tasks to validate the results.

Marsh (Marsh, 1999) analyzes the complexity of usability evaluation in virtual reality (VR), highlighting the inadequacy of traditional 2D interface methods for 3D environments. The author explores the definition of VR, its differences from GUIs, and the challenges in usability evaluation. He emphasizes the need to develop new methodologies adapted to the VR user experience and suggests future research directions.

Marsh proposes the need to develop new evaluation methods that consider the user experience within the virtual environment and suggests future research directions. The paper emphasizes the importance of adapting evaluation methodologies to meet the specific needs of VR to improve the user experience. These studies show how automated and innovative methods are essential for enhancing the user experience and facilitating usability evaluation, especially in specific environments such as VR and digital libraries, while promoting inclusion and accessibility.

4 METHODOLOGY

The goal of this article was to characterize, in a structured manner, an initial perspective on tools that perform usability analysis of software, with a special focus on accessibility. A systematic mapping was chosen as the research instrument to achieve this. A systematic mapping is a review of a specific topic or area, which allows the identification of various approaches and their associated challenges (Velásquez-Durán and Ramírez Montoya, 2018; Keele et al., 2007). The systematic mapping in this article follows the guidelines of Kitchenham and Charters (Petersen et al., 2008), divided into three phases: planning, execution, and communication of results. We defined the research topic, applied methodology, and selected the databases where the articles were searched. Research questions were prepared to be answered through this study, and the search string related to the theme was used using a tool called Parsifal.

A detailed protocol for article classification was followed to ensure the study’s transparency and reproducibility. This protocol included the following steps:

- Definition of Inclusion and Exclusion Criteria
- Selection of Articles
- Classification and Analysis of Articles
- Definition of Research Questions
- Number of Publications per Year

In the definition of inclusion criteria, articles that addressed, even partially, usability tools for software and studies that included usability analysis for people with disabilities were included. As for the exclusion criteria, we removed duplicate articles, studies that did not evaluate software or assistive technologies, studies that did not focus on usability analysis, and publications that did not address accessibility or tools aimed at people with disabilities, as shown in Table 1.

Table 1: Inclusion and Exclusion Criteria.

Inclusion	Articles that address, even partially, usability tools for software
Exclusion	Duplicate articles
	Studies that do not evaluate software or assistive technology
	Studies that do not directly address usability analysis
	Publications that do not address accessibility or tools aimed at people with disabilities

We conducted the search using the terms (”usability analysis tools” OR ”usability evaluation tools” OR ”usability testing software” OR ”software usability assessment” OR ”usability metrics software”) AND (”software usability evaluation” OR ”user experience analysis” OR ”UX analysis” OR ”human-computer interaction” OR ”HCI” OR ”interface evaluation”) AND (”tools” OR ”frameworks” OR ”programs” OR ”systems”) AND (”evaluation methods” OR ”heuristic evaluation” OR ”usability metrics” OR ”task analysis” OR ”cognitive walkthrough" OR "eye-tracking" OR "heatmaps"), with no period restriction, in the ACM and IEEE databases on September 11, 2024. The selected databases are hybrid, search engines, or bibliometric databases, widely used in studies as they provide good coverage for systematic reviews (Kitchenham and Brereton, 2013). A total of 38 relevant articles were identified, which met, even partially, the inclusion criteria listed in Table 1.

We verified that there were no duplicate articles concerning the search databases used. Of 38 articles, 26 were considered relevant to the research, as their titles and abstracts addressed the inclusion criteria, while 12 met the exclusion criteria, as shown in Figure 1. As part of the study stages, we read the articles that met the inclusion and exclusion criteria to find answers to the research questions. Among them, 13 provided answers using structured questions that can assist in future research sequences and in evaluating the research process (Kitchenham and Brereton, 2013), as described in Table 2.

Figure 2 illustrates the variation in research involving the topic, showing that publications in the searched databases have experienced significant fluctuations in interest in the subject mentioned in this research, with both increases and decreases in the number of publications over time.

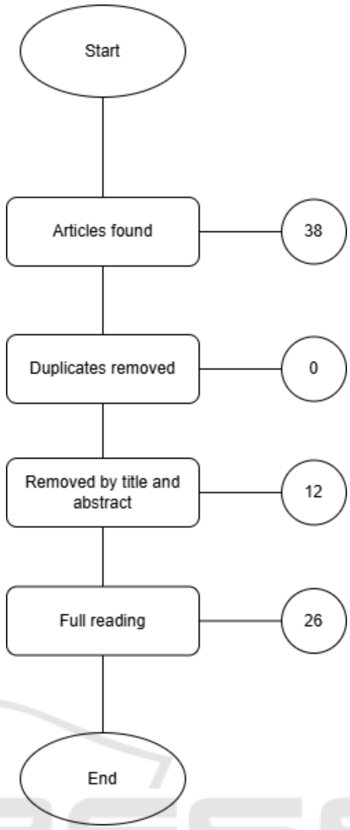

Figure 1: Selection of The Articles.

5 RESULTS

In this section, we present the results of our systematic mapping. We divided our findings into subtopics to facilitate understanding and visualization of the information. In each subtopic, we will show the answers to the specific questions.

5.1 RQ1. What Tools Are Available for Software Usability Analysis?

Several software usability analysis tools exist, such as DUXAIT-NG, MOBILICS, and Guideliner. DUXAIT-NG is a heuristic evaluation tool that inspects user interfaces, focusing on user experience (Falconi et al., 2023). MOBILICS (Gonçalves et al., 2016), which focuses on mobile interface analysis, helps evaluate software on mobile devices. At the same time, Guideliner automates the verification of UI compliance with usability guidelines, such as links, images, and buttons (Marenkov et al., 2018).

5.2 RQ2. What Usability Tools Specifically Focus on Evaluating Software Accessible to People with Disabilities?

Tools such as Google's Mobile Friendly Test Tool and Bing Mobile Friendliness Test focus on evaluating usability on mobile devices, considering access on mobile platforms (Paternò et al., 2017). Guideliner, as described in the article (Marenkov et al., 2018), includes specific accessibility guidelines, with 13 guidelines aimed at making the interface accessible, addressing issues such as contrast and navigation on mobile devices.

5.3 RQ3. How Do Usability Analysis Tools Address Different Types of Disabilities (Visual, Auditory, Motor, Cognitive)?

Usability analysis tools adapt to handle different disabilities. Guideliner, for example, includes 16 guidelines to ensure accessibility for visual

Table 2: Research Questions and Justifications.

Question Number	Question Text	Justification
Q1	What tools are available for software usability analysis?	Identify the main tools used and their features, providing a broad view of the current state of available technologies.
Q2	What usability tools specifically focus on evaluating software accessible to people with disabilities?	Investigate the tools that meet accessibility needs, promoting the development of more inclusive solutions.
Q3	How do usability analysis tools address different types of disabilities (visual, auditory, motor, cognitive)?	Understand how different needs are addressed by the tools to ensure that all disabilities are adequately considered.
Q4	What are inaccessible software's most frequently used usability evaluation methods?	Identify the most effective methods for evaluating accessibility and guiding best development practices.
Q5	How are usability tools evaluated in terms of their effectiveness in identifying accessibility barriers?	Evaluate the performance of tools in identifying barriers, ensuring they meet accessibility goals.
Q6	Is there a correlation between the type of disability and the preference for certain usability tools?	Explore user preferences to adapt tools to their specific needs and improve their acceptance.
Q7	How do usability analysis tools handle accessible mobile and web interfaces?	Verify the adequacy of the tools to modern technologies and their impact on the usability of mobile and web interfaces.
Q8	What challenges are faced when adapting usability tools for users with disabilities?	Identify the main obstacles in adapting tools to meet users' needs better.
Q9	What is the impact of usability analysis tools on developing more inclusive software?	Examine how these tools contribute to a more inclusive design aligned with accessibility needs.
Q10	What are the gaps in research on usability tools focused on accessibility?	Highlight underexplored areas to guide future research and innovations in the field.

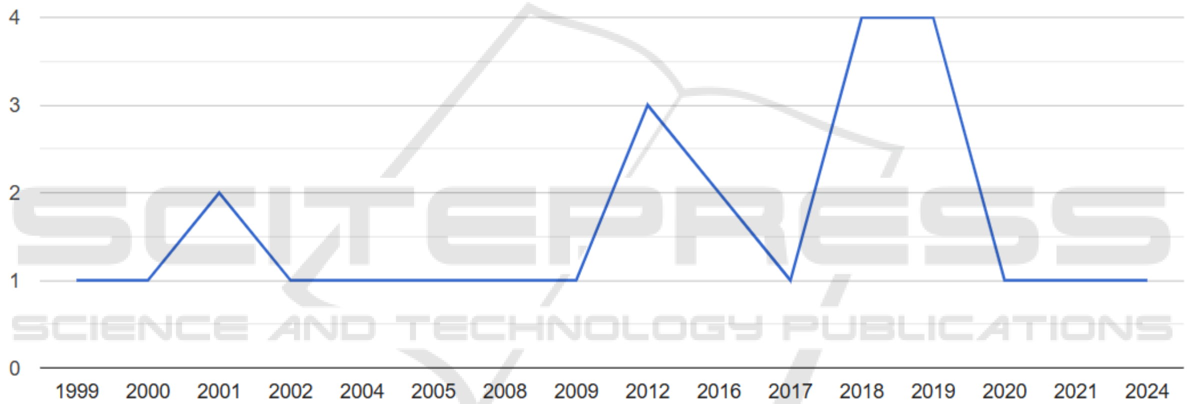

Figure 2: Articles per Year.

and auditory disabilities, as well as adjustments for mobile interfaces (Marenkov et al., 2018). DUXAIT-NG focuses on improving software interfaces to ensure inclusion (Falconi et al., 2023), and other tools like MUSE (Paternò et al., 2017) offer recommendations and perform heuristic evaluations focusing on cognitive and motor needs.

5.4 RQ4. What Are the Most Frequently Used Usability Evaluation Methods Inaccessible Software?

Traditional methods such as usability testing, interviews, and heuristic evaluations are commonly used (Falconi et al., 2023; Marsh, 1999). However, new approaches are being developed, such as automated testing with DUXAIT-NG (Falconi et al., 2023), which allows continuous and real-time usability evaluation. Other methods, such as cognitive walkthroughs and user feedback, are also essential to understanding how people with disabilities interact with software and identifying areas that need improvement (Yigitbas et al., 2019).

5.5 RQ5. How Are Usability Tools Evaluated in Terms of Their Effectiveness in Identifying Accessibility Barriers?

The effectiveness of tools is generally measured by their ability to identify accessibility flaws and the accuracy in adapting interfaces for specific disabilities. Tools like MUSE (Paternò et al., 2017) are evaluated for their ability to detect flaws during navigation and offer recommendations. Moreover, the flexibility of tools like Guideliner (Marenkov et al., 2018) and the Mobile Friendly Test Tool (Paternò et al., 2017) is crucial, as they can be applied in different accessibility contexts for users with varying needs.

5.6 RQ6. Is There a Correlation Between the Type of Disability and Preference for Specific Usability Tools?

Yes, the preference for usability tools may vary depending on the type of disability. For example, people with visual impairments may benefit from tools that adjust contrast and text readability, such as Google's Mobile Friendly Test Tool (Paternò et al., 2017). In contrast, people with motor impairments prefer tools that adapt navigation and facilitate interaction control (Yigitbas et al., 2019; Jahan et al., 2019; Bessghaier et al., 2021).

5.7 RQ7. How Do Usability Analysis Tools Handle Accessible Mobile and Web Interfaces?

Tools like Google's Mobile Friendly Test Tool and MUSE are designed to evaluate mobile interfaces and test navigability and accessibility on mobile devices. These tools use contextual and behavioral data to optimize design and ensure that interfaces are accessible and functional on different devices. Tools like Guideliner, in addition to evaluating usability guidelines, also allow customization for accessing content in an optimized way on mobile and web platforms (Lettner and Holzmann, 2012; Paternò et al., 2017; Marenkov et al., 2018; Bessghaier et al., 2021; Gonçalves et al., 2016; Zhang et al., 2009; Baguma, 2018).

5.8 RQ8. What Challenges Are Faced in Adapting Usability Tools for People with Disabilities?

The main difficulty is personalizing the tools to fit the specific needs of each type of disability. The tools need to be adaptable enough to ensure accessibility without losing effectiveness in evaluation. Additionally, integrating automated resources that provide continuous feedback tailored to different types of disabilities continues to be an essential technical challenge (Paternò et al., 2017; Bessghaier et al., 2021; Marenkov et al., 2018; Marsh, 1999; Baguma, 2018; Holmes et al., 2019).

5.9 RQ9. What Is the Impact of Usability Analysis Tools on Developing More Inclusive Software?

Usability analysis tools have a significant impact as they help identify accessibility flaws and adjust the software to serve users with disabilities better. This contributes to digital inclusion, promoting better experiences and greater functionality for all users (Falconi et al., 2023; Jahan et al., 2019; Bessghaier et al., 2021; Marsh, 1999; Baguma, 2018; Holmes et al., 2019).

5.10 RQ10. What Are the Gaps in Research on Usability Tools Focused on Accessibility?

Research still faces gaps, especially in developing tools that effectively integrate automated analysis with accessibility. For example, the article by Yigitbas (Yigitbas et al., 2019) highlights that real-time customization of interfaces is still an open area of research. Another need is empirical studies on the impact of tools on users with specific disabilities (Au et al., 2008; Paternò et al., 2017; Jahan et al., 2019; Yigitbas et al., 2019; Holmes et al., 2019).

6 DISCUSSION

The analysis of the results demonstrates significant progress in developing tools focused on software usability and accessibility, especially those that integrate automated assessments with specific guidelines, such as DUXAIT-NG, Guidelines, and MUSE. These solutions are central to identifying barriers and promoting inclusive interfaces for users with different disabilities. There are still challenges to be overcome, especially in customization to meet the specific needs of each user group, considering the technical limitations that hinder effective universal adaptation. Although there are tools focused on mobile devices and the web, such as the Mobile-Friendly Test Tool and MUSE, the restrictions of these environments, such as reduced space and interaction limitations, continue to represent substantial challenges for accessibility.

The impact of usability analysis tools on digital inclusion is evident, promoting continuous interface improvements and strengthening accessible design practices. There are still gaps to be filled, such as the lack of empirical studies validating these tools' application in diverse contexts and in real-time. The need for technological advances becomes crucial to enable dynamic and continuous adaptations, ensuring that tools not only identify problems but also assist in implementing practical solutions for software accessibility.

7 FINAL CONSIDERATIONS

The study provides a comprehensive overview of how different technologies and methods have been applied to identify and address accessibility barriers in software. Tools such as DUXAIT-NG, Guideliner, and MUSE demonstrate advances in integrating automated assessments and specific adaptations for different disabilities but still have limitations in universally meeting user needs. This systematic mapping highlights the importance of documenting the state of the art in usability and accessibility, providing a basis for future research and improving practices in developing inclusive software. We emphasize that accessibility is not just a technical issue but an ethical and social commitment, requiring collaborative efforts between researchers, developers, and stakeholders.

For future work, we intend to expand the research to include databases such as IEEE Xplore, Web of Science, and Scopus, broadening the scope of the studies analyzed. This approach will allow for the identification of new methodologies and the validation of the results obtained. Empirical studies will be conducted to evaluate the effectiveness of the tools analyzed in different scenarios and with various audiences, deepening the understanding of their limitations and potential in creating accessible and inclusive software.

REFERENCES

Adinda, P. P. and Suzianti, A. (2018). Redesign of user interface for e-government application using usability testing method. In *Proceedings of the 4th International Conference on Communication and Information Processing*, pages 145–149.

Alnahdi, G. (2014). Assistive technology in special education and the universal design for learning. *Turkish Online Journal of Educational Technology-TOJET*, 13(2):18–23.

Au, F. T., Baker, S., Warren, I., and Dobbie, G. (2008). Automated usability testing framework. In *Proceedings of the ninth conference on Australasian user interface-Volume 76*, pages 55–64.

Baguma, R. (2018). Usability evaluation of the etax portal for uganda. In *Proceedings of the 11th International Conference on Theory and Practice of Electronic Governance*, pages 449–458.

Bessghaier, N., Soui, M., Kolski, C., and Chouchane, M. (2021). On the detection of structural aesthetic defects of android mobile user interfaces with a metrics-based tool. *ACM Transactions on Interactive Intelligent Systems (TiiS)*, 11(1):1–27.

Cole, J. S., Bergin, D. A., and Whittaker, T. A. (2008). Predicting student achievement for low stakes tests with effort and task value. *Contemporary Educational Psychology*, 33(4):609–624.

de Vasconcelos, L. G. and Baldochi Jr, L. A. (2012). Towards an automatic evaluation of web applications. In *Proceedings of the 27th Annual ACM Symposium on Applied Computing*, pages 709–716.

Falconi, F., Moquillaza, A., Lecaros, A., Aguirre, J., Ramos, C., and Paz, F. (2023). Planning and conducting heuristic evaluations with duxait-ng. In *Proceedings of the XI Latin American Conference on Human Computer Interaction*, pages 1–2.

Gonçalves, L. F., Vasconcelos, L. G., Munson, E. V., and Baldochi, L. A. (2016). Supporting adaptation of web applications to the mobile environment with automated usability evaluation. In *Proceedings of the 31st Annual ACM Symposium on Applied Computing*, pages 787–794.

Harrison, R., Flood, D., and Duce, D. (2013). Usability of mobile applications: literature review and rationale for a new usability model. *Journal of Interaction Science*, 1:1–16.

Holmes, S., Moorhead, A., Bond, R., Zheng, H., Coates, V., and McTear, M. (2019). Usability testing of a healthcare chatbot: Can we use conventional methods to assess conversational user interfaces? In *Proceedings of the 31st European Conference on Cognitive Ergonomics*, pages 207–214.

Jahan, M. R., Aziz, F. I., Ema, M. B. I., Islam, A. B., and Islam, M. N. (2019). A wearable system for path finding to assist elderly people in an indoor environment. In *Proceedings of the XX International Conference on Human Computer Interaction*, pages 1–7.

Keele, S. et al. (2007). Guidelines for performing systematic literature reviews in software engineering. Technical report, Technical report, ver. 2.3 ebse technical report. ebse.

Kitchenham, B. and Brereton, P. (2013). A systematic review of systematic review process research in software engineering. *Information and software technology*, 55(12):2049–2075.

Kumar, B. A. and Mohite, P. (2016). Usability guideline for mobile learning apps: An empirical study. *International Journal of Mobile Learning and Organisation*, 10(4):223–237.

Kumar, B. A. and Mohite, P. (2018). Usability of mobile learning applications: a systematic literature review. *Journal of Computers in Education*, 5:1–17.

Lettner, F. and Holzmann, C. (2012). Automated and unsupervised user interaction logging as basis for usability evaluation of mobile applications. In *Proceedings of the 10th International Conference on Advances in Mobile Computing & Multimedia*, pages 118–127.

Lyner-Cleophas, M. (2019). Assistive technology enables inclusion in higher education: The role of higher and further education disability services association. *African Journal of Disability*, 8(1):1–6.

Marenkov, J., Robal, T., and Kalja, A. (2018). Guideliner: A tool to improve web ui development for better usability. In *Proceedings of the 8th International Conference on Web Intelligence, Mining and Semantics*, pages 1–9.

Marsh, T. (1999). Evaluation of virtual reality systems for usability. In *CHI'99 extended abstracts on Human factors in computing systems*, pages 61–62.

McNicholl, A., Casey, H., Desmond, D., and Gallagher, P. (2021). The impact of assistive technology use for students with disabilities in higher education: a systematic review. *Disability and rehabilitation: assistive Technology*, 16(2):130–143.

Mji, G., MacLachlan, M., Melling-Williams, N., and Gcaza, S. (2009). Realising the rights of disabled people in africa: An introduction to the special issue. *Disability and Rehabilitation*, 31(1):1–6.

Ndlovu, S. (2021). Provision of assistive technology for students with disabilities in south african higher education. *International Journal of Environmental Research and Public Health*, 18(8):3892.

Nedungadi, P. and Raman, R. (2012). A new approach to personalization: integrating e-learning and m-learning. *Educational Technology Research and Development*, 60:659–678.

Nielsen, J. (1994). *Usability engineering*. Morgan Kaufmann.

Paternò, F., Schiavone, A. G., and Conti, A. (2017). Customizable automatic detection of bad usability smells in mobile accessed web applications. In *Proceedings of the 19th international conference on human-computer interaction with mobile devices and services*, pages 1–11.

Paternò, F., Schiavone, A. G., and Pitardi, P. (2016). Timelines for mobile web usability evaluation. In *Proceedings of the International Working Conference on Advanced Visual Interfaces*, pages 88–91.

Petersen, K., Feldt, R., Mujtaba, S., and Mattsson, M. (2008). Systematic mapping studies in software engineering. In *12th international conference on evaluation and assessment in software engineering (EASE)*. BCS Learning & Development.

Tony, M. P. (2019). The effectiveness of assistive technology to support children with specific learning disabilities: Teacher perspectives.

Velásquez-Durán, A. and Ramírez Montoya, M. S. (2018). Research management systems: Systematic mapping of literature (2007-2017).

Yigitbas, E., Hottung, A., Rojas, S. M., Anjorin, A., Sauer, S., and Engels, G. (2019). Context-and data-driven satisfaction analysis of user interface adaptations based on instant user feedback. *Proceedings of the ACM on human-computer interaction*, 3(EICS):1–20.

Zhang, D. and Adipat, B. (2005). Challenges, methodologies, and issues in the usability testing of mobile applications. *International journal of human-computer interaction*, 18(3):293–308.

Zhang, X., Liu, J., Li, Y., and Zhang, Y. (2009). How usable are operational digital libraries: a usability evaluation of system interactions. In *Proceedings of the 1st ACM SIGCHI symposium on Engineering interactive computing systems*, pages 177–186.