

A Heuristic Usability Evaluation of Kadi4Mat

Jan Weidemüller, Patrick Niebergall, and Anton Schulze Wehninck

University of Cologne, Albertus-Magnus-Platz, 50923 Köln, Germany

Keywords: Usability Evaluation · Data Management Tools · Heuristic Analysis
· Nielsen

1 Abstract

This report conducts a usability evaluation of Kadi4Mat, a digital laboratory logbook. Various usability tasks are performed in the system and categorized into different severity levels using ten usability heuristics based on Nielsen. Overall, the usability of Kadi4Mat is satisfactory in most cases. Only in a few cases, there is a need for action to improve the system. All findings are documented and specific recommendations for patches are described. In addition, new features that could lead to a further improvement of the user experience are briefly described. All in all, it can be said that Kadi4Mat is a system suitable for laboratory work, which is particularly convincing due to its adaptability to different research purposes. We also conclude that Nielsen's heuristics are a solid framework for effectively evaluating the usability for such use cases. However, we also see weaknesses of the heuristics, which is why the applicability should be evaluated individually for each evaluation case.

2 Introduction

Within the constantly progressing field of research management, the management and analysis of research data are one of the most crucial factors for conducting successful research. Kadi4Mat¹, developed at the Karlsruhe Institute of Technology, offers a tool with innovative solutions for data management and electronic lab notebook functionalities. However, the usability of such complex applications is the core for their effectiveness and user adoption. This paper employs Nielsen’s 10 usability heuristics² [4] to conduct a heuristic evaluation of Kadi4Mat, rating usability tasks into three levels of severity and providing recommendations for enhancements. Additionally, we provide suggestions for features to extend the application with the goal to further improve the user experience. Through this analysis, we aim to improve the tool’s user experience, thereby contributing to more efficient and effective research done with Kadi4Mat.

3 Background

Before elaborating on the evaluation, we need to introduce the relevant framework and system subject to this study.

3.1 Nielsen’s 10 usability heuristics

Nielsen’s 10 usability heuristics, devised by usability expert Jakob Nielsen, form a set of guiding principles for evaluating and improving the usability of software and user interfaces [4]. These heuristics include concepts such as visibility of system status, match between system and the real world, user control and freedom, consistency and standards, error prevention, recognition rather than recall, flexibility and efficiency of use, aesthetic and minimalist design, help users recognize, diagnose, and recover from errors, and the provision of help and documentation. By adhering to these heuristics, a comprehensive evaluation of a software system’s usability can be conducted, aiding in the identification of potential areas for improvement.

3.2 Kadi4Mat

Introducing “Kadi4Mat,” an open-source software designed for the comprehensive management of research data: With a primary focus on serving as a digital collaborative lab notebook, “Kadi4Mat” is uniquely tailored to cater specifically to the field of material science. Its modular and adaptable architecture facilitates smooth collaboration among Experimenters, Theorists, and Simulators, creating a dynamic environment for interdisciplinary research. Notably, “Kadi4Mat” stands out by accommodating a variety of workflows, allowing for customization

¹ <https://kadi.iam.kit.edu>

² <https://www.nngroup.com/articles/ten-usability-heuristics/#poster>

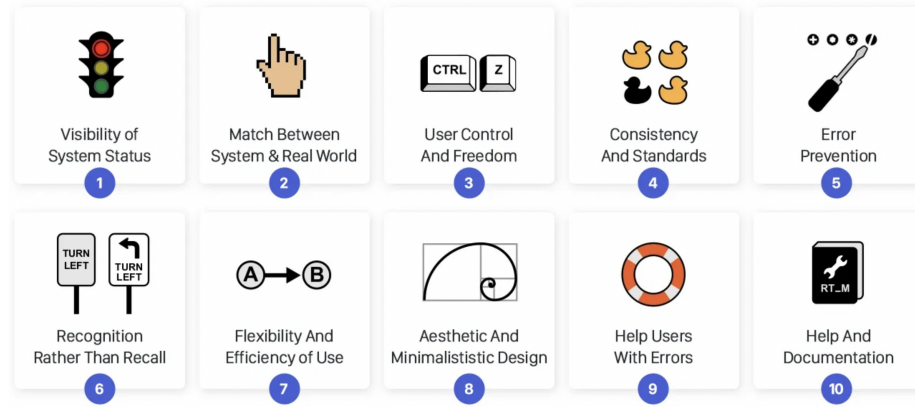


Fig.1: Overview over the Nielsen’s ten usability heuristics. Illustration taken from <https://uxdesign.cc/10-usability-heuristics-every-designer-should-know-129b9779ac53>

to suit the different needs of scientists across various research fields. The core components of the system include groups, collections, and records, organized hierarchically to enable structured data management. Figure 2 provides a glimpse onto the landing page of the application.

4 Methodology

In developing the methodology for the heuristic usability evaluation of Kadi4Mat using Nielsen’s heuristics, we draw upon several research papers. Our approach begins with the selection of Nielsen’s 10 usability heuristics [4], [3] as the evaluative framework, which is acknowledged for their effectiveness by e.g. [7]. An overview over all ten heuristics is shown in figure 1. Heuristic evaluation [6] with regards to usability and user interfaces has proven to be a comparatively cheap and effective method of identifying usability problems [2]. In [2] and [6], a team size between three and five persons is recommended to conduct the evaluation. We adhere to this recommendation with our team consisting of three persons. Furthermore, as suggested in [6], we evaluate the usability tasks on an individual basis which should allow for a more thorough identification of issues. The defined tasks which are investigated in Kadi4Mat are defined according to the standards set by [5].

Our team then performs a comprehensive task analysis to understand common user interactions with Kadi4Mat. Each identified issue is documented and classified based on its severity (small, medium, or severe), a method underscored in the paper by Hermawati and Lawson [1]. We then propose detailed improvements to improve these usability issues in order to enhance Kadi4Mat’s overall usability and functionality. These recommendations and suggestions are based

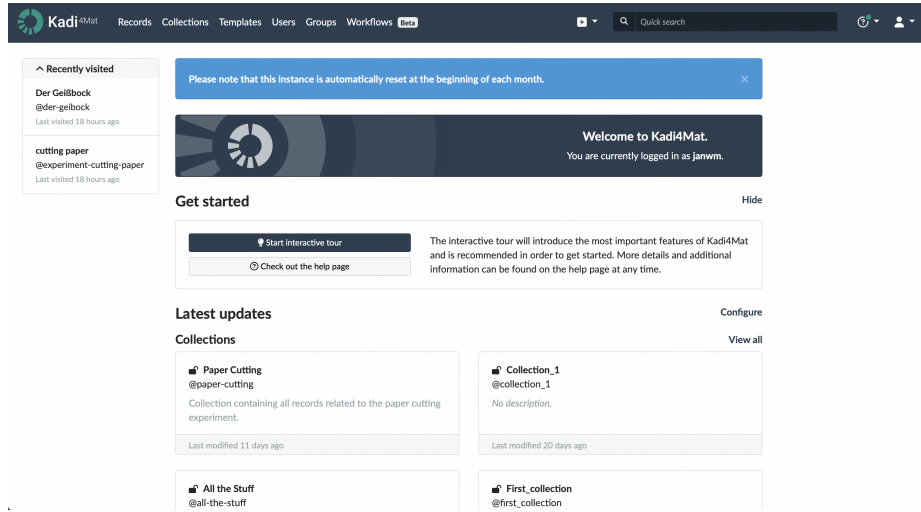


Fig. 2: Screenshot of the landing page of Kadi4Mat

on the existing literature on usability heuristics as well as our expertise in software usability. Additionally, we provide suggestions for potential features that could be added in the future to further improve Kadi4Mats usability and functionality.

In sum, the methodology provides a thorough evaluation of Kadi4Mats user interface and experience, providing actionable insights for enhancing the tool's usability as well as providing ideas for new features.

The following tasks were provided, the respective given names (e.g. "project", "experiment") were altered to reflect the language used by Kadi4Mat.

1. Login

This task describes the process of logging into the application.

2. Create a group

Users can create groups of multiple collaborators in order to efficiently distribute permissions and share their records.

2.1 Edit Group

This task describes the process of editing an existing group to incorporate changes in the team structure and permissions.

2.2 Manage Members of Group

In order to reflect the dynamics of working in teams, any group's members can be managed. Users can be added, deleted or altered (in terms of permissions).

3. Create a Collection

In the process of creating a Collection within Kadi4Mat, the primary objective is to ensure that projects can be easily established while maintaining strict security and data privacy standards. The current system allows users to set various metadata such as project title, identifier, description, and visibility, along with the ability to link records to the project and assign user permissions through different roles. For identification purposes, the combination of identifier and title must be unique for every project.

4. Create Record

The creation of a Record in Kadi4Mat is designed to guide users intuitively through the process of creating an entry in the database while adhering to security standards, allowing users to set visibility and access rights. Users can input various metadata, link the record to a collection or another record, and define user permissions.

5. Create Template

In Kadi4Mat, the template creation feature is intended to offer a simplistic way for users to define templates, thereby saving time in setting up new records. Users can create two types of templates – record and extras – and set standard metadata.

6. Changes to Elements

This task describes the ability to change an existing record, collection or template. The current system allows entering an edit mode, which is similar to the process of creating new items, but with some fields already being pre-filled.

7. Find Records

With a rising number of records that any user is entering into the database, it becomes increasingly necessary to be able to search the whole personal records database for specific entries. For this, Kadi4Mat is providing search and filter options. Located over the search results section is a text input field, a sort drop-down menu and optional search extras. To the left of the results section previously saved searches can be selected and various filter options can be adjusted.

8. Free Exploration

Following task 8 we found more use cases we thought being reasonable to cover and test as well:

9. Create/Add Child Collections

The functionality for creating and adding child collections aims to facilitate the easy linkage of two existing collections and provide a clear overview of the collection hierarchy. When editing the relationship between two collections that have previously been linked, it is possible to include all the records of the child

collection into the parent collection.

10. Create Records Dashboard

A new functionality of Kadi4Mat is a tool that allows to customize dashboards in order to present laboratory data in a visual appealing way. The aim of this feature is to develop an own dashboard based on the records that were created in the previous task. It should be noted that the feature is still in the beta phase and therefore not yet fully developed.

11. Edit Profile

When editing your profile, it is possible to change basic user information that is displayed on a user's profile. Some options are disabled, based on the type of the user.

12. Interactive Tour

The interactive tour takes the user along on a guided tour that introduces the basic principles and functionalities of the application. It incorporates interactive elements which motivate the user to get directly in touch with the program.

13. Customization of Layout

Kadi4Mat allows users to customize the layout of the application in their settings to suit their needs. A user can choose to always enable the editing mode by default when using the generic record metadata editor as well as hide the "Get started" section on the home page. Additionally, they can change the number and order of shown records, collections, templates and groups and choose to filter them based on their visibility and authorship.

14. Management of Permissions in Records

Different access rights can be given to either individual users or groups for a particular record. Granting new permissions is only possible if the necessary role is owned.

15. Importing and Managing Data for a Record

Kadi4Mat allows users to append data to their records with an import function. A user can import a variety of different files or can choose to directly create files or drawings through the web interface.

5 Results

Following the methodology outlined in Chapter 4, the obtained results are presented in Table 1. To enhance result comprehension, we aggregated the data to generate two scatter plots, as illustrated in Fig 3. The scatter plots provide

Tasks	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10
1. Login	1	1	1	1	1	1	1	1	1	1
2. Create a Group	1	1	2	1	1	1	2	1	1	1
2.1 Edit Group	1	1	2	1	1	1	1	1	1	1
2.2 Manage Members of Group	1	1	1	1	2	1	1	1	1	1
3. Create a Collection	1	2	2	1	2	1	1	1	1	2
4. Create Record	1	2	2	1	2	1	1	1	1	2
5. Create Template	1	2	2	1	1	1	1	1	1	1
6. Changes to Elements	1	1	1	1	1	1	1	1	1	1
7. Find Records	1	1	1	2	3	1	1	1	1	1
Free Exploration										
9. Create/Add Child Collection	1	1	1	1	1	1	1	1	1	1
10. Create Records Dashboard	1	2	1	3	2	1	2	2	3	1
11. Edit Profile	2	1	2	1	1	1	1	1	1	1
12. Interactive Tour	1	1	1	1	1	1	1	1	1	1
13. Customization of Layout	1	1	1	2	1	1	1	1	1	1
14. Management of Permissions in Records	1	1	1	1	1	1	1	1	1	1
15. Importing and Managing Data for a Record	1	1	1	3	2	1	1	1	1	1

Table 1: Evaluation results

a comprehensive overview over the severity scores for each heuristic across all tasks, offering insights into the overall system performance. Notably, the majority of heuristics receive low severity scores, indicating a generally high level of usability within the system. However, a subset of tasks are classified with a medium severity for certain heuristics, and a limited number of tasks exhibited high severity. In the remainder of this section we will go into detail about the identified severity levels and then provide recommendations for improvement for each task.

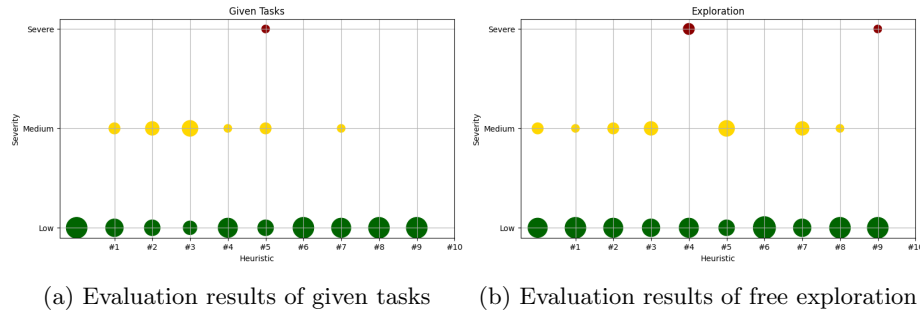


Fig. 3: Combined Evaluation Results

If not specifically pointed out, all issues mentioned below are categorized as *medium*. Usability tasks with no identified issues are not described further.

5.1 Evaluation Findings

2.x Creation and Management of Groups

Within the process of creating and managing a group, several issues were identified. During the creation of a group, the action cannot be cancelled and limits user freedom and control (H3). Furthermore, it is not possible to directly add members during creation, limiting flexibility and efficiency of use (H7). Another issue was identified when adding new users to groups. The same user can be added multiple times with different roles - however, only the last entry is executed. This provokes user-made errors (H5).

3. Create a Collection

During testing, it was noted that the "cancel" button is absent. This is usually standard in the user flow of most websites and apps and could therefore lead to confusion for users wishing to navigate backwards, limiting user control and freedom (H3). Although there are brief explanations under each field, the lack of intuitive documentation and a unclear hierarchy system might pose challenges, especially for those unfamiliar with material science and research databases. It is not obvious how a record and a collection are connected and if there are any constraints. Consequently, there is room for improvement when it comes to help and documentation (H10). Additionally, there is another issue regarding assigning roles to members of the group. The system permits the addition of users under multiple roles, but only the last entry per user is recognized. This affects the usability heuristic "help users with errors" (H9).

4. Create a Record

Similar to the collection creation process, the absence of a "cancel" button is a notable flaw concerning the user control and freedom (H3). Furthermore, the type of experiment is not predefined and can be any string, which deviates from expectations of standardized experiment types (H4).

5. Create Template

The process once again lacks a "cancel" button for easy navigation (H3). Additionally, the ability to define a unique identifier for the record in the template leads to an error message every time the template is applied. This is explained by the fact that the same identifier can not be used for every instance created from the template. Consequently, the usability heuristic concerning error prevention is affected (H5).

7. Find Records

During the evaluation we could not verify an error-free behavior of the search

field as not all records shown in the search results section match the entered search-string. This touches on several heuristics, most specifically on error prevention (H5). The numerous possibilities to filter entries and search for specific properties is positively noted, although we did not entirely understand the purpose of the sectioning between the search/filter options above the results and the ones to the left (H4).

9. Create/Add Child Collections

A key finding is that linking two collections is counter-intuitive and requires extensive searching. A notable limitation is the inability to view the entire collection hierarchy, restricting visibility to direct links only. The issues raised above touch on the heuristics of documentation (H10) and error-prevention (H5). We assume that the relationship functionality was made for inheriting records and permissions from one collection to another. By experimenting, we found out that it is not possible to form circular or triangle relations between collections, which is good. Relations are only allowed in a top-down hierarchy manner. Inheriting records from parent to grandchild indirectly through a parent is possible. But as of now it is only possible to see direct connections one level up or below, limiting the transparency of the system (H1). Overall the goal of the functionality is met as long as it is the intended purpose to inherit records indirectly through another collection. Otherwise this is a critical security flaw because information and permissions would be given without further authorization.

10. Create Records Dashboard

There are several findings regarding the dashboard creation process. Firstly, we note that the panel function is not working as we would have expected. It seems to be designed primarily for adding picture blocks (H2). Additionally, when inserting a path to a previously uploaded file the user is not warned when inserting flawed path. Instead, the action will be performed with no visible output. Consequently, this touches on error prevention (H5). A severe violation of a usability heuristic is concerning the redo and undo button buttons. Instead of reverting certain actions, the entire dashboard gets deleted (H4). Another finding is the absence of shortcuts within the dashboard. Basic shortcuts such as "Ctrl+C" are available, but flexibility and efficiency of use is limited nonetheless (H7). Regarding the design of the feature, there is also room for improvement. The plots added to the dashboard are displayed quite small and there are not many options for adjustment. Hence, the readability content of the plots is often bad (H8). Another severe violation of the usability heuristic H9 is identified - there are no error messages at all. Hence, if something is done wrong it simply just does not work, creating blank space instead of throwing an error. Lastly, for each panel that is created after the first one, the content will be added to the first panel automatically which does not seem to be intended.

11. Edit Profile

This feature works mostly as intended, however, two issues are identified. Firstly,

after adding a profile picture, the respective editor stays open but does not show the freshly uploaded picture. This does not reflect the system status (H1) - when closing the editor, the picture is shown. Secondly, consistent with other issues, no "Exit" button is implemented. To exit, the home button or other buttons that lead outside of the page have to be pressed (H3). Additionally, after saving, the editor stays open. This limits user control and freedom (H3).

14. Management of Permissions in Records

The usability of this task is overall well implemented, only one issue limiting the efficiency of use is identified. The application does not allow adding multiple users or groups with the same role at once. Especially for projects with a lot of collaborators, this can lead to a tedious and tiring process, impacting the flexibility and efficiency of use (H7) negatively.

15. Importing and Managing Data for a Record

Records can be enriched with uploading locally stored files. The application also allows for direct creation of files using the web interface. Overall, the upload functionality is implemented well - we only have two remarks. As of now, the existing upload limit of 25MB is only shown when exceeded, therefore not preventing user-made errors (H5). Secondly, once a file is uploaded, it cannot be deleted within the same interface, limiting user freedom (H3). When managing uploaded files, we raise a severe issue. The "Edit File" functionality does not work as expected according to usability standards. Users are merely directed to the same page that is also shown when adding new files (with no changed look or different functionality). This is confusing for users. Furthermore, if within the interface visible after pressing "Edit File" a new file is uploaded, it is added as a new file, instead of replacing the old file which one would expect.

5.2 Recommendations

2.x Creation and Management of Groups

The obvious recommendation is to add a cancellation option during group creation. Furthermore, we suggest to enable the addition of group members directly when creating a new group for efficient usage. For the sake of error prevention, adding the same user with different roles should be prohibited. One can consider to enable the assignment of multiple roles, however, as currently only three roles exist, we advise against this option.

3. Create a Collection

To enhance usability, it is recommended to include a "cancel" button, provide more detailed documentation and explanations, and ensure that only one role can be assigned to each member, with an error message for any discrepancies. Overall, the goal of easy project creation with secure settings is met, but these improvements would significantly enhance the user experience.

4. Create a Record

To improve user control and freedom, implementing a "Cancel"-button is paramount. To align with scientific standards and enhance user experience, it is recommended that experiment types are predefined and presented in a drop-down menu. This would ensure consistency and prevent issues like spelling errors and mistyping, thereby facilitating better filtering and categorization.

5. Create a Template

Exclude fields that are necessary to be unique for each record, such as the name and identifier, from the template in order to prevent recurrence of error messages and enhance the practicality of using templates.

6. Changes to Elements

The recommendations for creating new items should be applied similarly to editing existing ones.

7. Find Records

The accuracy of the search functionality should be improved in an error-free manner. Additionally, we recommend to clarify the layout of the search and filter sections, either joining them or pointing out the differences more precisely.

9. Create/Add Child Collections

To improve the process of creating and adding child collections, it is recommended to include a holistic overview of the entire collection chain, enhance documentation for improved clarity, and simplify the linking process by reducing the number of steps involved. This way, error prevention is improved. It is also recommended to include an overview over the established direct and indirect relationships of a collection as a graph in order to make the user aware of indirect relationships that might be unintended. Additionally, this feature will improve the transparency of which other collections are affected of a given change. In general, a more direct guidance through the process would help users who are not familiar with the system. One could think about to incorporate this process within the guided interactive tour.

10. Create Records Dashboard

The dashboard functionality scored *medium* or *severe* in six out of the ten usability heuristics, two of them severely. As mentioned previously during task description, this feature is still in beta and therefore still under development. As one can already suspect, there is a lot of need for improvement until this feature can be released for public and can be effectively used for presenting laboratory data. We recommend to continue the work on the beta version and use our findings to eliminate errors. Nonetheless, this feature look promising and could provide a nice overview over records.

11. Edit Profile

A preview of the freshly uploaded picture should be shown in order to correctly reflect the status within the system. To address the other mentioned issues, the developers should implement a "Save & Exit" button and provide an option to cancel the process altogether with a "Cancel" button.

14. Management of Permissions in Records

The lacking functionality of allowing the addition of multiple users or groups with the same role at once should be implemented, enhancing flexibility and efficiency of use.

15. Importing and Managing Data for a Record

Firstly, the upload limit should be visible to users directly in order to prevent user-made errors. Secondly, it is strongly recommended to enable the direct deletion of files within the process of adding files. Finally, the "Edit File"-functionality should be re-worked in a way to reflect standard editing behaviour, such as to allow the direct editing of files within the application. Alternatively, the feature could be re-named and re-worked in a way to replace uploaded files.

6 Feature Suggestions

In the course of the comprehensive evaluation of Kadi4Mat using Nielsen's 10 usability heuristics, we identified noteworthy opportunities to enhance the system's usability and integration into the daily workflow of scientists. In the following, we will provide a high-level overview of each feature suggestion, highlighting their potential impact on enhancing the overall usability of the system in day-to-day operations of the scientific community.

Implement a Search Function in Help Section

Introducing a search function in the help section is important for enhancing user experience since it allows the user to navigate to relevant help sections faster. It addresses the need for quick access to information, reducing the time users will spend trying to find a given resource. Adding this feature is a quick way to improve efficiency of use and user friendliness. Furthermore it will reduce hurdles for new users who need guidance with the software.

More Detailed Layout Options

Detailed layout options are an important aspect of user-centered design. They allow users to customize their individual interface to their specific needs. Improving this functionality will enhance personalization and ease of use, catering to a broader range of user preferences. Furthermore, improved layout options will improve data readability and interaction for the respective user, leading to a more productive usage.

Integration of Commonly Used Databases

Integration with commonly used databases (e.g. GitHub) will help to streamline the research process by establishing a single source of truth. This feature allows for an integrated workflow, enabling users to access external data sources from within Kadi4Mat directly. It will enhance usability by reducing the need to switch between different platforms and will therefore contribute to increasing the efficiency and ease of use.

Integrated Literature and Database Search

Complementing the feature mentioned above, an integrated literature and database search feature will address the need for comprehensive research tools within the application. It provides users with easy access to a wide range of academic resources. This integration enhances usability by offering a one-stop solution for research needs, saving time and effort in accessing external literature and data sources. If compatible with data security, AI-support could be employed to make suggestions based on the content of records.

Comment and Message Functions

Adding comment and message functionalities will foster a collaborative environment. This feature will encourage a more fruitful interaction between researchers and will facilitate a feedback culture directly within the application which is a vital part of collaborative research. Furthermore, it improves usability by enabling communication and the exchange of ideas directly on the platform, making collaborative work more efficient.

Notification/Alert System for Deadlines

A notification/alert system for deadlines is essential for effective time management. Directly integrating this feature will help users to keep track of important dates and deadlines within their research projects. One could think about a simple system sending out a message or mail to remind users of upcoming deadlines, or showing a banner when logging into Kadi4Mat. This will improve usability by providing timely reminders, ensuring that users can plan and execute their tasks more reliably, leading to better project management and possibly a faster project execution.

7 Discussion

Nielsen's 10 Usability Heuristics have been instrumental in guiding the design of user interfaces, providing a set of principles to enhance the overall usability of interactive systems. In this chapter, we are going to reflect on how we experienced the use of these heuristics as well as argue about how they could be improved and modernized.

Advantages: One of the strengths of Nielsen’s heuristics is their simplicity, making them easy to understand and apply by many user types in various design contexts. Furthermore they have proven highly effective in traditional web and software design. Their long-lasting success underscores their reliability in providing a solid foundation for creating user-friendly interfaces. Notably versatile, these heuristics can be applied across various development stages - from conceptualization to usability evaluation, making them a valuable tool throughout the product development life-cycle. Despite their age, they offer a steady framework for user interface (UI) design and usability evaluation, signifying their relevance and reliability in the field of UI design.

Disadvantages and Improvements: Nielsen’s heuristics face criticism for potential misalignment with modern design principles, especially in adaptive design for mobile, Virtual Reality, and Augmented Reality. Since they have been developed decades ago, they may not adequately address the evolving nature of technology and user interaction. Additionally, their applicability may be limited in specialized systems, e.g. medical or aviation applications, and in diverse cultural contexts.

To improve and adjust the heuristics for modern times, it would be beneficial to consider adding specific guidelines. To mention a few, we provide a list of three suggestions:

1. **Adaptability:** Evaluate how well the interface adapts to different devices and user preferences, ensuring a seamless experience across various platforms and screen sizes.
2. **Inclusive Design:** Assess the extent to which the interface considers diverse user needs, including those with disabilities, different cultural backgrounds and different use-cases to improve accessibility and inclusion.
3. **Ethical Design:** Examine the ethical implications of the interface, including data handling practices, transparency, and user consent in order to ensure a trustworthy and responsible user experience.

Nielsen’s 10 Usability Heuristics have proven highly effective in traditional web and software design, offering a reliable foundation throughout the development process. However, their generic nature poses limitations in addressing modern technologies and specific needs. Proposed adjustments include specific guidelines for emerging tech and new heuristics emphasizing adaptability, inclusive design, and ethical considerations. These enhancements aim to ensure the continued effectiveness of these heuristics in the evolving landscape of information systems and user interaction.

8 Conclusion

The Nielsen’s 10 usability heuristics are a suitable framework for the Kadi4Mat usability assessment use case. We applied the framework to the predefined tasks that were given and categorized our observations into three severity levels. We went ahead and also applied this approach to other tasks that we had chosen ourselves during exploration of Kadi4Mat. This process was not particularly intuitive in times and required knowledge of typical laboratory procedures, which is explained by the fact that the software was originally developed for experimental research in the field of materials science. We conclude, however, that the software has a sufficiently generic design so that it is also suitable for information management of other research data.

Overall, Nielsen’s 10 usability heuristics proved to be an effective methodology for assessing the usability of the electronic laboratory logbook Kadi4Mat. The heuristics provided a good process for testing the system in a structured and systematic manner, which was particularly helpful in evaluating the different usability tasks from different viewpoints. In this way, a few weak points were uncovered during testing. Most of the vulnerabilities discovered can be classified as *medium*, leading to the conclusion that Kadi4Mat is overall a well designed tool. However, in the course of testing, we also uncovered a few issues that can have a significant impact on the usability of Kadi4Mat. Here we see a need for action to eliminate undesirable behavior of the system. In the course of our testing activities, we also brainstormed other features that could help improve the system.

All in all it can be concluded Kadi4Mat is already an easy-to-use tool and can be used flexibly for a variety of different applications. The design is kept simplistic and straightforward, which contributes to the clarity of the system. However, the navigation is not always intuitive and sometimes deviates from the usual standards.

We also found the framework of Nielsen’s 10 usability heuristics to be a useful framework for evaluation. Nonetheless, as already mentioned before, the use case has to be evaluated as to whether the heuristics are a suitable tool for assessment. An awareness of the strengths and weaknesses of the framework are hence necessary to employ them appropriately. Using Kadi4Mat, we have also experienced that new ideas for feature spark up, which can not be exclusively be explained by the heuristics design. However, their flexibility in describing the important aspects of usability design might foster a creative process when interacting with the target software.

References

- [1] Setia Hermawati and Glyn Lawson. “Establishing usability heuristics for heuristics evaluation in a specific domain: Is there a consensus?” In: *Applied Ergonomics* 56 (Sept. 1, 2016), pp. 34–51. ISSN: 0003-6870. DOI: 10.1016/j.apergo.2015.11.016. URL: <https://www.sciencedirect.com/science/article/pii/S0003687015301162> (visited on 12/26/2023).
- [2] Jakob Nielsen. “Finding usability problems through heuristic evaluation”. In: *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*. CHI ’92. New York, NY, USA: Association for Computing Machinery, June 1, 1992, pp. 373–380. ISBN: 978-0-89791-513-7. DOI: 10.1145/142750.142834. URL: <https://dl.acm.org/doi/10.1145/142750.142834> (visited on 01/05/2024).
- [3] Jakob Nielsen. “Heuristic Evaluation”. In: *Nielsen Norman Group* (1995). URL: <https://www.ingenieriasimple.com/usabilidad/HeuristicEvaluation.pdf> (visited on 05/01/2024).
- [4] Jakob Nielsen. *Ten usability heuristics*. 2005. URL: <http://www.%20nngroup.%20com/articles/ten-usability-heuristics> (visited on 05/01/2024).
- [5] Jakob Nielsen. *Usability Engineering*. Google-Books-ID: 95As2OF67f0C. Morgan Kaufmann, Sept. 23, 1994. 382 pp. ISBN: 978-0-12-518406-9.
- [6] Jakob Nielsen and Rolf Molich. “Heuristic evaluation of user interfaces”. In: *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*. CHI ’90. New York, NY, USA: Association for Computing Machinery, Mar. 1, 1990, pp. 249–256. ISBN: 978-0-201-50932-8. DOI: 10.1145/97243.97281. URL: <https://dl.acm.org/doi/10.1145/97243.97281> (visited on 01/05/2024).
- [7] Estela Aparecida Oliveira Vieira, Aleph Campos da Silveira, and Ronei Ximenes Martins. “Heuristic Evaluation on Usability of Educational Games: A Systematic Review”. In: *Informatics in Education - An International Journal* 18.2 (2019). Publisher: Vilniaus Universiteto Leidykla, pp. 427–442. ISSN: 1648-5831. URL: <https://www.ceeol.com/search/article-detail?id=804191> (visited on 12/26/2023).