Navigating the Energy Maze:
Cracking the Code of User-Friendly Solutions

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Abstract

This study investigates usability and design aspects of two interfaces provided by DAZOQ AB and Tekniska Verken i Linköping AB, focusing on the presentation of complex household energy usage data. Tekniska Verken's system has already been established for private users in Linköping while DAZOQ has previously been geared towards industries. Through user testing and heuristic evaluations using Nielsen's principles, various flaws were identified in both systems. The problems encountered during the user tests were categorized into different themes using Thematic Analysis, which served as the basis for further discussion. Some themes, such as unclear icons, were applicable on both interfaces while others were more specific to one of them. Based on identified flaws, improvement recommendations for both interfaces were developed for both interfaces, along with a new prototype for DAZOQ's system. The outcomes of this project offer insights to companies seeking to effectively present complex data to users in an understandable and usable way.

Introduction

In the early 2021, energy prices in Europe began to steadily rise due to inflation and economic sanctions on Russia following its invasion of Ukraine. However, Sweden has a low dependency on Russia, being, along with Denmark, leading countries of renewable energy in Europe (Eurostat, 2022). Because of this, Sweden faces challenges in meeting energy demand, resulting in an increase in cost of electricity (Svenska Kraftnät, 2021). One way to save money is by implementing a feedback system for energy use in households. This paper aims to evaluate and compare two different feedback systems. The systems are provided by the startup company DAZOQ and the Linköping based company Tekniska Verken. Both companies have a focus on efficiently and sustainably reducing energy usage among residents.

Theory

Nielsen & Molich presented a user analysis method in 1990 called Heuristic evaluation. This method is informal and amounts to the evaluator taking a look at the interface and intuitively deciding on what they think is good or bad about the system. Rather than following specific guidelines, the evaluator can practically base the evaluation on the following 10 basic usability principles.
1. System Status Visibility: Design should clearly communicate the system's status and provide appropriate feedback to users. **2. Match to Real-World**: Design should be intuitive and familiar, using language and interactions that users can easily understand. **3. User Control and Freedom**: Design should provide users with control and freedom to undo actions and explore the interface. **4. Consistency and Standards**: Design should follow industry standards and internal consistency, making it easy for users to understand and learn. **5. Preventing User Errors**: Minimize errors by reducing cognitive load and providing affordances for correct actions. **6. Recognition over Recall**:

Design should focus on recognition rather than recall, providing cues and easily accessible information. **7. Flexibility and Efficiency of Use**: Design should cater to both novice and expert users, offering shortcuts and accelerators for efficiency. **8. Aesthetic and Minimalist Design**: Display only relevant information and create a visually appealing interface to make a good first impression. **9. Error Recognition, Diagnose, and Recovery**: Error messages should be clear, human-readable, polite, descriptive, and provide constructive advice. **10. Help and Documentation**: Provide helpful instruction manuals and documentation for users to easily understand and use the product.

Tidwell et al. (2021) suggest six different questions that a good interactive system should offer answers to. These include organizing the data in an intuitive way, rearranging data for personalization and clear presentations of what the data represents, among more. Pierce et al. (2008) further suggests the data should be presented in an intuitive way for the user's understanding.

One tool that can enhance positive patterns and user engagement is gamification. This means incorporating game-like features for behavioral changes (Hamari et al., 2014). Another way to affect behavior in users is with the implementation of colors and animations. This has the potential to guide users while using interfaces, as the affective responses from colors and animation can shape experiences and effectively guide user behavior (Odushegun, 2023). Furthermore, to avoid information overload and direct the user, the interface should only obtain necessary data and avoid all excess information (Scammon, 1977).

Bryman (2018) cites Webb et al. (1966) for their description of reactive effects that require consideration when conducting qualitative studies involving participant observation. These effects tend to emerge when participants are aware of being observed and can influence behavior in participants when being observed.

Method

The participants for the user tests were recruited with convenience selection. 12 participants were recruited for each system. For the user tests of Tekniska Verken’s system, 4 of the participants identified as women and 8 as men, all students between the ages of 21 and 26 (M=22.5, SD=1.38). For the user tests of DAZOQ’s system, 7 of the participants identified as women and 5 participants identified as men, all between the ages of 22 and 30 (M=24.2, SD=3.16), and all students, except one.

The user tests on Tekniska Verkens' and DAZOQ's system were conducted in controlled group rooms at the Linköping campus to minimize distractions. Three project group members were present during the tests, with one serving as test leader and recording task completion times, another taking notes, and the remaining member counting task-related clicks. Participants received project information and a consent form outlining voluntary participation, the option to discontinue at any time, and data storage and presentation protocols ensuring anonymity. Prior to the user testing, participants answered questions regarding age, field of study, and energy usage systems to ascertain suitability and identify potential performance-affecting factors. Four tasks involving information retrieval from the websites were then orally and in writing assigned to participants. Participants were instructed to verbalize their thought process during task completion, allowing the project group to transcribe their actions and assess task ease or difficulty. The project group familiarized themselves with the systems to design relevant tasks and gain insights into system functions and feasible tasks.

Following task completion, participants provided qualitative feedback on the tested system and their overall experience through follow-up questions.

To conduct a heuristic evaluation of the systems, a team of five evaluators from the project group was selected. The evaluators familiarized themselves with Nielsen's 10 principles, considering the 9 principles proposed by Nielsen & Molich (1990) and the additional modern principle that has later been added. Individually assessing the systems based on these principles, the evaluators intuitively identified system problems using a customized form. The evaluators then ranked the identified problems on a severity scale from 1 to 5, indicating the most severe issues. Additionally, the evaluators proposed solutions to address the identified problems. Subsequently, the individual lists were consolidated, and prominent problems and themes were summarized.

The two systems were empirically evaluated by combining information from the user tests. Task difficulty was determined based on participant scores, calculating the mean for each task. Similar to Iqbal et al. (2009) in their study on a support management system, success scores were assigned to tasks, with different scores for failure (3 points), difficulty (2 points), and ease (1 point). Time taken and the number of clicks were also considered, comparing them to the median. In addition to the aforementioned evaluation method, the results from user tests were analyzed using Thematic Analysis. Thematic Analysis is a systematic approach for analyzing qualitative data, aiming to develop theories or explanations based on empirical evidence. The analysis involved multiple stages of coding, starting with detailed labels and progressing towards broader themes that emerged from the data. These themes were then analyzed and discussed to provide a deeper understanding of the phenomenon under study.

Results

The user tests of the DAZOQ system found 6 main themes: **Need for clarification**: Participants experienced a lack of understanding in certain elements of the interface, such as branch-specific terminology and the meaning of certain terms like "instantaneous power" and the y-axis in diagrams. **Unclear data visualization**: The data presentation was considered confusing or non-intuitive, particularly in the detailed nature of the graphs, leading to interpretative difficulties. **Unclear icons**: Participants expressed confusion and found certain icons in the interface to be misleading or unclear in their functionality, including a gear icon and calendar functions. **Trial and error**: Participants encountered confusion in accessing functions, locating information, and understanding the purpose of different graphs. Trial and error was often necessary to navigate the system effectively. **Too simple design**: Some participants found the system design to be overly simplistic, leading to boredom and difficulty in understanding the available options and features. **Motivations for using the system**: Participants expressed motivations such as general interest, curiosity, control over energy usage, monitoring energy costs, and potential savings.

The user tests of the Tekniska Verken system found 5 main themes: **User confusion and doubt**: Participants expressed doubts about their own abilities when encountering difficulties, questioning whether they were doing something wrong. **Unclear icons**: Participants raised concerns and confusion regarding the buttons and icons on the website. Specifically, the "show" button was unclear in indicating the presence of average temperature information. **Motivations for using the system**: Participants expressed motivations for using the system, such as checking statistics and energy usage, tracking progress towards environmental goals, and monitoring consumption for cost-saving purposes. **Trial and error**: Participants found the process of using the system to be complicated, particularly due to non-intuitive ordering and unexpected outcomes when clicking different buttons. **Missing functions**: Participants expressed a desire for more information on how the system works and its various features. They also suggested adding functions to improve usability, such as clearer explanations of different options and improved pop-up boxes.

The heuristic evaluations in total found 26 problems in the DAZOQ system, and 23 problems in the Tekniska Verken system. The DAZOQ system had one problem ranked at the highest severity level (5), and had no problems connected to principle 9, but apart from that, both systems had similarly severe issues connected to all heuristic principles presented by Nielsen (2020).

Discussion

The research showed a great deal of themes and difficulties in the two systems evaluated, both similarities and differences. Similarities found in the two systems were related to the unclarity in buttons, the lack of intuition in the systems resulting in trials and errors along with the same types of motivations for using the systems. The presentation of necessary information should be captivating for the user (Pierce et al., 2008), and presented in an intuitive way (Tidwell et al., 2021). Solutions for these themes are consequently to redesign icons for more intuitive functions and implementing an "undo" or "reset" button for trials and errors. Lastly the implementation of gamification could encourage user engagement and motivation for using the system (Hamari et al., 2014).

The themes exclusively found in DAZOQ were the need for clarification of, for example, branch-specific terminology. One solution would be a simple question mark with a popup unit of information, explaining the different terminology. Following this theme was the unclear visualization of data where participants expressed confusion about the different graphs and symbols displayed. To improve structure and align with Nielsen's (2020) principles of real world matching, one suggestion is to display the months from left to right and 11 months prior, instead of only being able to compare two months at a time. Another suggestion is to make the graph more colorful with descriptive labels for understanding as this helps with quicker processing (Odushegun, 2023). The third theme presented is the simplicity of the design in the system, as this was stated as a hindrance making it hard to understand all functions In order to enhance the overall structure, applying different colors and animations when hovering, as well as different colors in the graph, could help users understand and utilize the system.

There were two themes identified that only applied to the system of Tekniska Verken. The first one was missing functions as participants expressed the need for functions such as seeing the price. Tidwell et al. (2021) describe how drill down functions include the opportunity to get additional information in a separate view. The solutions for the missing functions therefore include a separate window for personalization of functions, such as saving filters and settings, along with seeing the average price and prediction of cost. The second theme focuses on confusion and uncertainty, highlighting the system's lack of intuitive information retrieval. An interface should offer enough information to direct the behavior of the user, without excessive data (Scammon, 1977) , as well as the ability to personalize data (Tidwell et al., 2021). To alleviate this issue, personalized data presentation is once more needed to reduce confusion.

The improvements suggestions for DAZOQ involve more intuitive and descriptive representation of information, along with color to differentiate between information. For Tekniska Verken on the other hand, more options and functions for personalization of data is required for the user. The heuristic evaluation found similar issues in both systems, with comparable severity levels and no significant variations. These similarities indicate that the systems share common core principles that might be manifested differently through differences in design. For a visualization of the suggested enhancements, prototypes for both systems were developed, shown below.

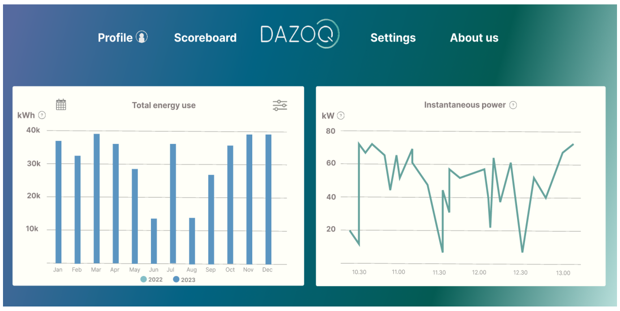

Fig 1: Prototype for DAZOQ

Fig 2: Prototype for Tekniska Verken

When conducting user tests to collect data for this project, observational methods were used which may increase the risk of reactive effects described by Bryman (2018). These effects can lead to distorted findings because of behavioral differences that occur when people are observed. To try and minimize this effect and ensure comfort and reduce nervousness, participants were made aware that the system, not themselves, was being tested. During the user tests, all 12 participants failed to complete the third task on DAZOQ's system. This might be due to unclear instructions and being influenced from the previous tasks. Moreover, the interpretation of task completion may vary, as some participants used another function than what was intended instead of what the task stated. For consistency the intended function had to be used for the task to be considered complete, however it is worth noting that some participants did a similar task related to the question. Another part of the methodology that might affect the outcome is the convenience sample used for recruiting participants. This approach compromises representativeness, generalizability and validity of the finding. The method of combining user testing with heuristic evaluation was done because Nielsen & Molich (1990) noted that heuristic evaluation is biased and insufficient for finding all problems. To broaden the study's coverage of user interface issues, and make sure that the study was less biased, an empirical evaluation method was implemented in the form of user testing.

Conclusion

In conclusion, based on the findings of the study comparing the interfaces of DAZOQ and Teknsika Verken's systems, several flaws were detected, highlighting the need for improvements. The user tests and heuristic evaluation identified similar problems in the systems such as including unclear icons, trial and error processing and similar motivations in using the systems. DAZOQ's system revealed additional issues related to the need for clarification, unclear data visualization and a too simple design. Tekniska Verken showed problems related to missing functions as well as user confusion. Several opportunities for improvements were suggested including redesigning of buttons, adding undo buttons, simplifying vocabulary, improving data visualization along with enhancing color distinctions. Along with this, a prototype of DAZOQ's system was created with improvements to give a visual representation of the suggestions.

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