

Impact of web application universal design on accessibility and usability

Wpływ projektowania uniwersalnego aplikacji internetowej na jej dostępność oraz użyteczność

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Abstract

The aim of the paper is to analyze the usability of user interfaces of websites for sharing student notes from the perspective of universal design. The analysis aimed to verify the impact of applying universal design principles on the usability of these services. The study was conducted on two websites: the existing *notatki-studenckie.pl* and its counterpart created by the authors for the purpose of this study. The following research methods were used in the analysis: SUS questionnaire, an eye tracking experiment, and the WAVE validator test. The study involved two research groups, total of 34 participants. The first group, consisting of 14 computer science students, participated in the eye tracking experiment, while the second group, diverse in terms of age and technological proficiency, tested both services and completed the SUS questionnaire. The analysis of the results showed that implementing universal design principles significantly improves the accessibility and the usability of applications.

Keywords: accessibility; usability; universal design; eye tracking

Streszczenie

Celem artykułu jest analiza użyteczności interfejsów stron internetowych do udostępniania notatek dla studentów z perspektywy projektowania uniwersalnego. Analiza miała na celu zweryfikowanie wpływu zastosowania zasad projektowania uniwersalnego na użyteczność tych serwisów. Badanie przeprowadzono na dwóch stronach: istniejącym serwisie *notatki-studenckie.pl* oraz jego odpowiedniku stworzonym przez autorów artykułu. W ramach analizy wykorzystano następujące metody badawcze: ankieta SUS, eksperyment z użyciem technologii śledzenia ruchu gałek ocznych oraz test walidatorem WAVE. W badaniu wzięły udział dwie grupy badawcze, łącznie 34 osoby. Pierwsza grupa, składająca się z 14 studentów informatyki, uczestniczyła w eksperymencie z eyetrackerem, natomiast druga, zróżnicowana pod względem wieku i poziomu zaawansowania technologicznego, testowała oba serwisy oraz wypełniała ankietę SUS. Analiza wyników wykazała, że wdrożenie zasad projektowania uniwersalnego znacząco poprawia dostępność oraz użyteczność aplikacji.

Słowa kluczowe: dostępność; użyteczność; projektowanie uniwersalne; eyetracking

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1. Introduction

Designing interfaces for websites and various IT systems requires particular attention to user experience (UX). The user is the key element of any system, and their satisfaction and ease of use are crucial for the success of the project. An intuitive and user-friendly interface allows users to perform tasks quickly and efficiently, contributing to a positive perception of the application. In today's world, where access to education and online resources is increasingly important, creating accessible and useful interfaces has become a priority for the developers of various online services.

In the digital age, where most educational and professional interactions have shifted online, the quality and accessibility of websites play a key role. Students using platforms for sharing notes need to be confident that they can quickly and seamlessly find the materials they need. It is also essential to consider individuals with disabilities, who should have the same ease of accessing information from these resources. This can be achieved by adhering to the principles of universal design.

Universal design is an approach that involves creating products and environments to be usable by all people to the greatest extent possible [1]. In the context of websites, this means addressing the diverse needs of users, such as ensuring adequate color contrast, readable fonts, intuitive navigation, and support for assistive technologies like screen readers.

This study focuses on two websites. The first is an existing platform for sharing notes among students, *notatki-studenckie.pl* [2]. The second is a newly designed website, implemented by the authors, aiming to address usability and accessibility issues. The existing platform had numerous limitations negatively affecting its accessibility and usability. The newly designed website was created to eliminate these limitations by implementing universal design principles.

The aim of this article is to thoroughly analyze the usability of the interfaces of websites intended for sharing notes among students, with particular emphasis on universal design principles. Through detailed research, the authors demonstrated how universal design can improve the quality of web interfaces, thereby increasing

accessibility and user satisfaction. The aim of this study is to propose three hypotheses: H1: Users can find the information they are looking for more quickly on a website designed according to universal design principles than on the existing platform. H2: The website implemented with universal design principles is rated higher in terms of usability and intuitiveness by users, regardless of their age or level of experience. H3: A website designed with universal design principles offers better accessibility compared to the application it was evaluated against.

2. Literature review

Issues related to website accessibility are evident in cases of public institution websites and digital services such as libraries or news platforms. The study "An Exploratory Study of Library Website Accessibility for Visually Impaired Users" [3] highlights that the lack of appropriate alternative text for images, incorrect header tagging, and complex page layouts hinder usability for visually impaired individuals. Furthermore, the article "The Accessibility of Web-Based Media Services – An Evaluation" [4] points out barriers to accessibility in online news platforms. The authors noted challenges such as difficulties with keyboard navigation, the absence of captions for video content, and issues with responsiveness. These findings emphasize the need to raise accessibility standards and educate designers on creating more universal interfaces.

The importance of well-designed user interfaces and user experience was thoroughly discussed in the articles "Development and UI/UX Usability Analysis of Pinjemobil Web-Based Application Using User Satisfaction Model" [5] and "UI/UX Prototype Usability Analysis of E-Commerce Websites" [6]. The research presented in these studies demonstrates that well-designed and intuitive interfaces significantly enhance application efficiency and user satisfaction. For instance, e-commerce platforms with clear navigation and aesthetically arranged content report higher user engagement and satisfaction levels. Moreover, the articles emphasize that investing in UI/UX improves business outcomes and fosters customer loyalty.

Similar conclusions were drawn during the study of educational and cultural websites. The article "The Effect of UI/UX Design on User Satisfaction in Online Art Gallery" [7] analyzes the impact of interface aesthetics and functionality on user satisfaction in online art galleries. It indicates that visually appealing and user-friendly websites significantly increase user engagement. On the other hand, "UI/UX Design of Educational Game for Earthquake Mitigation" [8] highlights that well-designed educational games enhance learning efficiency, which is crucial for such applications. Research findings show that educational applications with user-friendly interfaces and engaging mechanics significantly improve learning outcomes. Features such as visual appeal, smooth interactions, and well-designed educational challenges contribute to better retention of information and greater student engagement.

One of the concepts in application interface design is affordance, which refers to the potential actions perceived by individuals when interacting with objects in their environment. In the context of a website, this is the user's interaction with specific interface elements. This approach is thoroughly discussed in the article "Redesigning a Website Using Affordance-Based Design" [9]. The study results show that designing with a focus on clearly indicating the functions of an interface improves navigation efficiency and helps users better understand how to use available tools. The authors conducted research confirming that implementing changes based on this methodology led to a significant increase in user satisfaction.

The rapid development of technologies based on artificial intelligence algorithms significantly impacts modern technology development, including the ways applications are designed and implemented. The application of machine learning techniques in user interface design is increasingly common. The article "Usability Evaluation of E-Learning Platforms Using UX/UI Design and ML Technique" [10] demonstrates that integrating machine learning with UI/UX design allows content to be tailored to user needs, resulting in greater learning efficiency and higher engagement on e-learning platforms. The authors also highlight that machine learning techniques can be used to conduct more precise usability evaluations of applications, enabling designers to quickly identify areas for improvement.

Website designers use various design concepts aimed at creating clear and intuitive user interfaces. One of them is the design thinking methodology, described in the article "Revitalizing the UI/UX Design of Bromo Tengger Semeru National Park Website through Design Thinking Methodology" [11]. This technique is based on a process that includes stages such as empathizing, defining problems, generating ideas, prototyping, and testing. Applying this concept allows for the creation of clearer, more aesthetically pleasing, and functional interfaces. Research results from the authors confirm that using this methodology significantly improved user experiences and encouraged website usage.

The element of competition embedded in computer games is a significant factor in attracting users to an application or platform. Gamification can particularly engage younger users, which plays an essential role in designing modern educational platforms. This was thoroughly discussed in the article "Gamified Learning Platform Analysis for Designing a Gamification-Based UI/UX of E-learning Applications: A Systematic Literature Review" [12]. The research described in the article reveals that introducing solutions such as reward systems, leaderboards, or interactive challenges increases student engagement and improves outcomes. At the same time, the studies emphasize that the success of these platforms depends on combining gamification elements with high-quality UI/UX.

The literature on web accessibility and usability describes a rich set of tools that support the design process. One such solution is detailed in the article "Enhanced

Colour Scheme Assessment Tool (COSAT 2.0) for Improving Webpage Colour Selection" [13]. This tool enables designers to evaluate color schemes in terms of contrast, harmony, and psychological impact on users. By using advanced algorithms, the tool supports the analysis of text and visual element visibility on various backgrounds. This is especially important for individuals with color perception disorders or visual impairments. Such technological support contributes to creating more aesthetically pleasing, functional, and accessible websites for a wide audience.

The intuitiveness and ease of use of applications are particularly important for services related to crisis situations. This was undoubtedly the case during the COVID-19 pandemic outbreak in 2019. During this time, many applications were developed to facilitate functioning in a society under pandemic restrictions. However, many of them had significant flaws, especially related to poorly thought-out and designed interfaces. Evaluating the usability of COVID-19 contact-tracing apps, the authors of the article "Usability, Inclusivity, and Content Evaluation of COVID-19 Contact Tracing Apps in the United States" [14] point out numerous problems regarding the lack of accessibility and intuitiveness in these solutions. It was noted that these applications were often difficult for older and less tech-savvy users to operate. This was a significant issue that hindered the widespread adoption of these apps. Improving the quality of their interfaces could have significantly increased their effectiveness in managing various types of crises.

A popular topic in the study of website accessibility and performance includes research on government and educational institution websites. Articles such as "Web Accessibility Analysis on Government of India Websites Based on WCAG" [15] and "Accessibility Assessment of Selected University Websites" [16] address this issue. The studies described reveal numerous deficiencies in meeting WCAG standards. Common problems include the lack of alternative texts, inappropriate header structures, and low text readability. Similar observations are presented in the article "Evaluation of the Web Accessibility of Higher-Education Websites" [17], which found that the academic prestige of universities does not guarantee better accessibility of their websites. These findings clearly indicate the need for regular audits and a greater emphasis on educating designers about accessibility.

In conclusion, these articles collectively emphasize the critical importance of considering the needs of users with various disabilities and implementing universal design principles in creating websites and applications. Applying these principles significantly improves the accessibility of digital services, making them more attractive and user-friendly for all users. This, in turn, translates into better user experiences, increased satisfaction, and more efficient use of interfaces. Universal design is, therefore, not only an expression of care for diverse needs but also a key to creating modern, functional, and more accessible digital solutions.

3. Materials and methods

3.1. Research objects

The study focused on two websites designed for sharing notes among students. The first was the existing website notatki-studenckie.pl (Figure 1) and the second was an application designed and implemented by the authors (Figure 2). Both platforms allow students to create, edit, and share notes. The website developed by the authors was designed following the principles of universal design. This means that the interface was crafted to be accessible and useful to the widest possible group of users, regardless of their abilities or limitations.

Several improvements were introduced, such as better color contrast, larger buttons, simplified navigation, and attention to responsiveness. The design also emphasized optimizing the interface for intuitive use and accessibility for individuals with various disabilities.

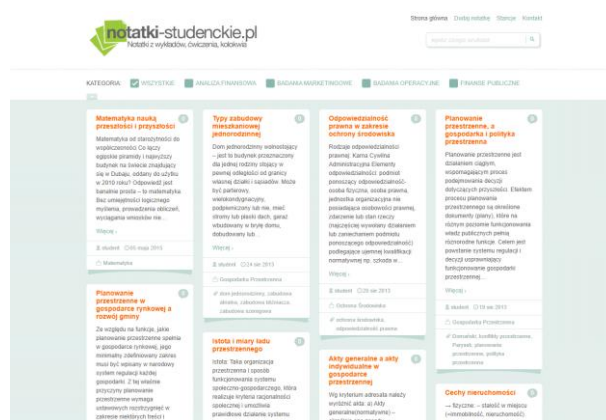


Figure 1: Home page view of notatutki-studenckie.pl [2].



Figure 2: Home page view of author's application.

3.2. Research group

The study involved two research groups, comprising a total of 34 participants. The first group consisted of 14 individuals, who were final-year master's students in Computer Science at the Faculty of Computer Science, Lublin University of Technology. The average age of participants in this group was 25 years, with a standard deviation of 0.79. Each participant conducted an experiment using an eye tracker, which monitored their eye movements while completing tasks on two different applications. The participants alternated between scenarios on both applications, allowing for a comparative analysis of their interactions with the user interface. This group was

well-versed in working with computers, enabling the collection of precise results regarding the efficiency of using the applications.

The second research group consisted of 20 persons with diverse ages and varying levels of technological proficiency. Each member of this group was tasked with familiarizing themselves with both services under study and subsequently completing a SUS (System Usability Scale) questionnaire for each. The participants' ages ranged widely from 18 to 55 years, allowing for the inclusion of both younger and older individuals representing different generations. The participants in this study group had an average age of 35 years, with a standard deviation of approximately 10. This diversity was crucial for the analysis as it enabled consideration of varying perspectives and ways of using technology. The participants' technological proficiency also varied, ranging from those who frequently use modern devices and applications to those who use them sporadically or have limited experience in this field.

3.3. Research stand

The experiment was conducted in the laboratory of the Department of Computer Science at Lublin University of Technology, which was appropriately prepared for the study. The room provided optimal lighting conditions conducive to the work of participants. The participants sat on stable chairs, ensuring comfort and freedom of movement during the experiment. Each session involved the participant and a moderator who supervised the experiment and provided necessary guidance.

The research stand (Figure 3) consisted of a Gazepoint GP3 HD eye tracker [18] connected to a Acer Nitro 5 laptop.



Figure 3: Research stand during the study.

The Gazepoint GP3 HD is a small, lightweight, and portable device that can be mounted on a sled above the laptop keyboard or attached to a monitor using a VESA mount. The eye tracker operated at a sampling frequency of 150 Hz, providing eye tracking accuracy between 0.5° and 1° under ideal conditions. It tracks both eyes and uses bright-pupil tracking technology to detect fixations, saccades, pupil diameter changes, and blinks. The optimal

distance of the respondent from the eye tracker was approximately 65 cm.

The Acer Nitro 5 laptop used in the study was equipped with an AMD Ryzen 75800H processor, 32GB of RAM, an NVIDIA GeForce RTX 3060 graphics card, a 512GB SSD, and a 15.6-inch display with a resolution of 1920x1080. The laptop operated on the Windows 10 operating system. The Gazepoint Control software, required for the operation of the eye tracker, ran in the background during the experiment [19].

To ensure precise data collection and analysis, a reliable and comprehensive research tool was required. The advanced iMotions platform version 9.0 [20] was used to conduct the study. First, it was employed for designing the experiment and calibrating the system. Then, it enabled the recording of participant sessions, followed by replaying and analyzing the collected data. The iMotions software enables visualization of results in the form of heatmaps, attention maps, fixation paths, and areas of interest. It also allows data export and the generation of statistics.

3.4. Research procedure

The entire experiment was divided into three parts. The first part involved conducting an eye tracking study with students from Lublin University of Technology. The next stage was a survey study, completed by a more diverse group in terms of age and technological experience. The final part tested both websites using a validator designed to assess web accessibility.

3.4.1. Eye tracking

Initially, participants were introduced to the purpose of the experiment and informed about its non-invasive nature. Each participant gave their consent to participate. Before starting the experiment, they were briefed on the study's procedures, objectives, and expected outcomes. They were also informed about safety and data protection measures. Calibration of the eye tracker was performed to ensure the highest possible measurement accuracy. This process involved participants tracking a series of points displayed on the screen, enabling the device to adjust to the individual visual characteristics of each participant.

Participants then completed tasks focused on locating specific elements on the two websites being compared. Their eye movements were tracked and recorded by the eye tracker. Tasks included navigating the website, searching for specific information, adding notes, and editing existing content. The exact scenarios undertaken by the participants are presented in Table 1. Each session was recorded, and the eye tracker data were analyzed to identify interface areas that captured user attention and those that posed challenges. The distance between the user and the eye tracker was maintained at approximately 65 cm. For users wearing glasses, the distance had to be reduced to about 50 cm, with the eye height from the tracker remaining at 40 cm. In this situation, the device was adjusted at a steeper angle upwards toward the participant's face.

Table 1: Research scenarios

No.	Scenario description
1	Locate the button that redirects the user to the form for adding a new note.
2	Find the name of the note's author.
3	Locate the button that redirects the user to the application's home page.
4	Find the button on the form that adds a new note.
5	Locate the button that moves to the next note.
6	Find the date of the note titled "Typy zabudowy mieszkaniowej jednorodzinnej" (eng. Types of single-family housing developments)

3.4.2. Questionnaire

The second part of the experiment was conducted on a completely new research group and involved administering the SUS questionnaire [21]. As in the first part, participants were informed about the experiment's purpose and each provided consent to participate.

This group's task was to evaluate both applications by completing the SUS questionnaire after a brief interaction with each. Participants had a few minutes to familiarize themselves with the application, followed by filling out a questionnaire consisting of 10 questions rated on a 0–4 scale. For the purposes of the study, the questions remained unchanged from their original form. The same process was repeated for the second application.

The diversity in technological experience within this group allowed for a broad range of feedback on the usability of the applications, from more experienced users to those with limited exposure to technology.

3.4.3. Websites validating

The final stage of the experiment involved validating both websites using the WAVE validator [22]. This tool provides a detailed analysis of website accessibility in terms of compliance with WCAG (Web Content Accessibility Guidelines) standards. The WAVE validation helped identify potential accessibility barriers, such as errors in header structures, improperly described graphical elements, or text contrast issues.

The validation was conducted on two identical application views: the main pages and the detailed views of individual notes. The results obtained from the WAVE validator were used to assess the technical quality of both websites and served as a basis for further comparative analyses aimed at identifying areas requiring improvement.

4. Results

4.1. Eye tracking results

The results of the study conducted using an eyetracker are presented in terms of the average time users spent completing the research scenario and the analysis of heatmaps illustrating visual focus during task execution. In the application designed by the authors, the average time required to complete specific scenarios was significantly shorter compared to the baseline application, suggesting a higher level of intuitiveness in the custom interface (Table 2).

Table 2: Average time to first fixation of each research scenario for both applications

No.	Time to first fixation - designed application (s)	Time to first fixation - compared application (s)
1	1.262	1.390
2	0.442	2.922
3	0.552	0.987
4	0.533	1.081
5	0.507	1.068
6	1.064	2.497

A detailed analysis of the heatmaps was performed, which visualize areas of greatest visual focus, revealed differences in how users interacted with both interfaces. For the application designed by the authors, the greatest focus was recorded on interface elements directly related to completing the research scenario, indicating a better alignment of the design with user expectations (Figure 4). In contrast, the heatmap for the baseline application revealed a substantial number of focus points on elements unrelated to the task objective, which may indicate navigation difficulties and user confusion (Figure 5).



Figure 4: Heat map showing the areas of visual focus by users for the scenario 2 - an application designed by the authors.



Figure 5: Heat map showing the areas of visual focus by users for the scenario 2 – notatki-studenckie.pl site.

These conclusions are supported by the colors on the heatmaps. Warmer colors (shades of red and orange) represent greater visual focus on a given interface element. Areas marked with cooler colors (shades of blue and green) were less frequently viewed, suggesting lower interest or need for interaction with these parts of the interface.

4.2. SUS questionnaire results

The results of the study obtained using the SUS survey allow for an assessment of the usability of both applications based on user experiences. The survey questions followed the standard set of SUS questions. The average usability score for the application designed by the authors was 79, indicating a good level of usability according to SUS standards. In contrast, the application notatki-studenckie.pl scored 62, which signifies acceptable usability but falls below the "good" threshold defined as scores above 68 points.

These results demonstrate that the application developed for the study was rated higher in terms of ease of use and intuitiveness (Figure 6). Respondents emphasized that the interface was more comprehensible and logically designed, positively impacting the overall user experience. For the notatki-studenckie.pl portal, although the basic functions were understandable, users reported difficulties in finding certain options and expressed the need for navigation improvements.

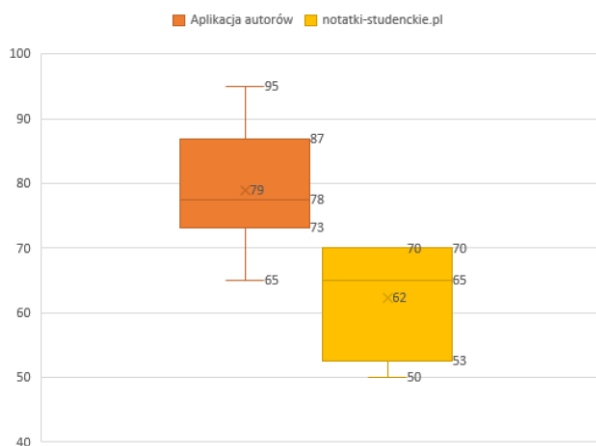


Figure 6: SUS indicators for both applications.

4.3. WAVE validator results

The results of the analysis obtained using the WAVE tool allow for an assessment of the accessibility of both applications in accordance with accessibility guidelines. The WAVE validator can be used in various ways: through the website, where a URL is entered for analysis, or as a browser extension, enabling the evaluation of accessibility for local and dynamic pages in real-time. In this study, the authors used the WAVE browser extension. This allowed for a detailed analysis of the accessibility of both applications directly in their operating environments.

The tool generates a summary report that presents the number of errors divided into specific categories. Examples of reports for both applications, generated based on their main pages, are shown in Figure 7 and Figure 8. The application designed by the authors did not show any alerts or warnings regarding contrast on its main page. In contrast, the report generated for the application notatki-studenckie.pl revealed 27 alerts and 184 contrast-related errors. These results clearly indicate that the service created by the authors has a higher level of compliance with accessibility guidelines. This means that the application developed for the study is more user-friendly for individuals with various perceptual limitations, which can positively influence its reach and usability.



Figure 7: A report showing the results of the WAVE validator test - an application designed by the authors.



Figure 8: A report presenting the results of the WAVE validator test – notatki-studenckie.pl site.

5. Discussion

The results of the conducted research confirm the significant impact of applying universal design principles on the usability and accessibility of the analyzed websites. A comparative analysis of the existing website notatki-studenckie.pl and the authors' proprietary solution demonstrated that the platform designed according to universal design principles achieved higher ratings in terms of intuitiveness and user satisfaction. These

findings align with other studies in the literature, which emphasize the critical role of universal design in improving accessibility and user satisfaction. Similar conclusions were drawn in the articles "The Impact of Applying Universal Design Principles on User Experience in Online Accommodation Booking Websites" [23] and "Analysis of the Usability and Accessibility of Online Travel Agencies in View of Their Universal Design Principles" [24], where researchers demonstrated that universal design principles enhance both user engagement and overall website performance, particularly in platforms requiring structured interactions.

The eye tracking study revealed that users spent significantly less time completing tasks on the authors' application, with their gaze focusing primarily on key interface elements. These findings are consistent with conclusions presented in the articles "Enhanced Colour Scheme Assessment Tool (COSAT 2.0) for Improving Webpage Colour Selection" [13] and "Evaluation of the Web Accessibility of Higher-Education Websites" [17], whose authors highlighted that appropriate color and contrast choices enhance interface intuitiveness and direct users' attention to key elements, thus facilitating navigation. The eye tracking study comparing *notatki-studenckie.pl* with the authors' application confirmed that applying universal design principles significantly improves interface intuitiveness. The time required to locate specific elements in the authors' application was noticeably shorter than in the reference application. An analysis of scenario completion times showed that the average scenario completion time in the authors' application was slightly less than 50% shorter (Table 2).

The results of the SUS survey showed that the authors' application achieved an average score of 79, significantly outperforming the score of 62 obtained by the *notatki-studenckie.pl* website. This indicates that the authors' application scored approximately 27% higher on the usability scale compared to the benchmark website. The higher score reflects greater user-friendliness, ease of use, and logical structure in the authors' application. The literature also highlights the importance of applying universal design principles to enhance user satisfaction. For example, in the article "Usability Evaluation of E-Learning Platforms Using UX/UI Design and ML Technique" [10], the authors note that improving accessibility and site structure results in higher user satisfaction and easier access to resources.

Validation tests conducted using the WAVE tool confirmed a higher level of compliance of the authors' application with WCAG guidelines compared to the *notatki-studenckie.pl* website. The study conducted on the authors' application revealed fewer errors, indicating better adaptation to the needs of users with diverse perceptual abilities. As noted by the authors of the articles "Web Accessibility Analysis on Government of India Websites based on WCAG" [15] and "Accessibility Assessment of Selected University Websites" [16], such accessibility analysis is crucial for evaluating the quality of websites. Their studies confirm that compliance with WCAG guidelines and reducing readability-related errors

significantly enhance the perception of websites by a wide user audience, which is also reflected in the analyzed results.

All research hypotheses were confirmed based on the analysis of data collected during the conducted studies. The hypothesis H1, stating that "a website designed with universal design principles is rated higher in terms of user intuitiveness than the existing website," was confirmed, as evidenced by the SUS survey results presented in Figure 6. These results clearly indicate the significant superiority of the new solution in terms of usability. The hypothesis H2, assuming that "users find sought information faster on a website designed according to universal design principles than on the existing website," was also confirmed by the study results. The scenario completion times presented in Table 2 clearly show that users of the new service found the desired information more quickly. The hypothesis H3, stating that "A website designed with universal design principles offers better accessibility compared to the application it was evaluated against" was also confirmed, as evidenced by the WAVE reports presented in Figure 7 and Figure 8. The provided reports clearly show that the validation of the application designed by the authors returned significantly fewer errors, which in turn translates to significantly greater accessibility of the service. Each of the three conducted stages clearly showed the superiority of the application proposed by the authors. The results conclusively prove that implementing universal design principles significantly improves the quality of user experiences, providing better access, convenience, and greater comfort in using the website.

6. Conclusions

As part of the conducted research, a comparative analysis of the interfaces of note-sharing services was carried out. Both the existing service and a proprietary solution, designed in accordance with universal design principles, were evaluated. The study employed techniques such as eye tracking, questionnaire analysis, and validation testing. The results clearly indicated that the service designed according to universal design principles was characterized by greater intuitiveness, shorter task completion times, and higher user satisfaction.

However, the research had certain limitations. First, the number of participants may have been insufficient to fully reflect the diverse needs of users, including those with various types of disabilities. Additionally, the analysis was limited to two services, which may not be representative of all platforms of this type. Another limitation was that the tests focused on the basic functions of the services, potentially overlooking more advanced usage scenarios.

Future research should focus on expanding the study group to include more participants, particularly those with diverse accessibility needs. It would also be valuable to conduct an analysis of a larger number of services to identify universal patterns and challenges in design. Further studies could explore the impact of various interface elements, such as animations or advanced features,

on the intuitiveness and accessibility of services. Considering the use of new technologies, such as artificial intelligence to support interface personalization, could also contribute to advancing knowledge in the field of universal design.

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