Accessibility Keyboard Design For Fine Motor Disabilities

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The investigation of the efficacy of modified keyboards in enhancing accessibility for users with motor and visual impairments. Building upon existing literature, which highlights the prevalence of accessibility barriers despite the availability of adaptive technologies, this research examines subtle adjustments to keyboard layout, including key spacing and visual presentation. Through a comparative analysis involving eight participants with motor and/or visual disabilities, the study evaluates three variations of touchscreen keyboards. This study underscores the importance of ongoing efforts to develop accessible technologies and highlights the need for collaborative endeavors between researchers, educators, and technology developers to foster inclusivity in digital environments.

CCS Concepts: • **Human-centered computing** → *Accessibility design and evaluation methods*;

Additional Key Words and Phrases: Accessibility, Keyboard, Motor Disability, Visual Impairments

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1 INTRODUCTION

Ensuring equal access to technology for individuals with disabilities remains a pressing challenge, highlighting the importance of exploring different approaches to interface design. This project delves into accessibility by focusing on one of the most common input methods, the keyboard. Although there are numerous designs in software programs to aid users with disabilities, the overwhelming amount of these options has opened the challenge of finding an effective method of input design that would accommodate a wide spectrum of abilities.

Personal experiences in supporting individuals with disabilities have proven a need for such research endeavors. Within the educational setting, I engage daily with students with a range of physical and cognitive disabilities, including motor and visual impairments. Through observation, simple tasks such as typing responses to prompts, or filling out online forms, often pose significant challenges due to the lack of digital support provided by conventional devices. This project not only seeks to address these challenges but aims to shed light on how technology can be better improved to accommodate such diverse abilities.

As underscored by Keates (2019) [5]the urgency of adopting novel research methodologies to better serve individuals with disabilities. Previous experiments often relied on data collected from able-bodied users, highlighting the need for a shift towards methodologies that directly engage disabled users. This insight serves as a pivotal foundation for this study, comparing data from only individuals with motor disabilities and visual impairments will give an insight into how to better adapt technology systematically; by focusing on two subtle yet potentially impactful modifications to the standard keyboard layout, key spacing, and visual presentation. Examining how participants interact with these modified keyboard inputs compared to standard configurations, this research aims to discern the efficiency of small-scale

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modifications. Should these adjustments prove effective, these alterations could prompt significant changes in design preferences and foster a more inclusive technological environment.

2 RELATED WORKS

To gain a better insight on this research topic, peer-reviewed literature, containing valuable information on technology accessibility and interface design gave a good base understanding of where to start and continue moving towards inclusivity. One notable study by Chiou, exposed some of the challenges of adaptive technologies often utilized by individuals with disabilities. [2] Despite the availability of innovative tools such as stroke pads, eye gaze devices, and speech recognition software, a significant number of websites, as of 2019, harbored "accessibility blockers," [3] impeding crucial functionalities for disabled users. This insight assisted me decide how to implement my research, using small adjustments rather than large downloadable programs that may cause more difficulty in certain web-based settings.

To further my understanding, I examined previous research endeavors like this, focusing on enhancing accessibility for those with motor and visual impairments. In doing so I was able to gain an idea of the crucial parameters in my study such as key spacing and styling selections. For instance, A study by Rubin shed light on the impact of font size on readability, revealing that adjusting print size from 10 to 14 or 16 points significantly enhanced proficiency for a broader demographic. [8] Though this information was originally applied to reading data, this inspired considerations regarding letter size variations for the touch screen keyboard input.

Similarly, in addressing visual impairments, considerations from web design literature provided information regarding font style and color contrast. Richardson's exploration of color contrast and font selection for optimizing accessibility advocated for techniques using sans serif fonts, liberal usage of white space, and maintaining a 3:1 contrast ratio between text and background. [7] Although this information specifically relates to website design, the guidance in what has helped make websites accessible for those who are visually impaired allows for a better understanding of color and font styles to use in this research subject. With this foundational understanding, the keyboard layouts I have designed will utilize this information to enhance the potential of speed and accuracy when using this common input device.

3 METHODOLOGY

This research aimed to investigate the impact of slight adjustments to touchscreen keyboards on usability and interaction for individuals with disabilities. The variations introduced included changes in key spacing, size, and visual elements across three different keyboards. The usage of different keyboard variations will allow the information on spacing, font, and combinations of the two to be identified in this testing process. These insights will help gain a better understanding of accommodating users with motor and visual disabilities, thereby fostering inclusivity in technology tools.

3.1 Participants

A total of 8 participants took part in the study: 3 with motor disabilities or impairments, 4 with visual disabilities or impairments, and one with a combination of both. The definition of motor disability used in this situation is "An inability or impairment of an individual to perform tasks that require a degree of manual dexterity." [10] This included forms of cerebral palsy and muscular dystrophy. Visual disabilities encompass conditions such as cataracts, blurred vision, and varying degrees of blindness.[6]

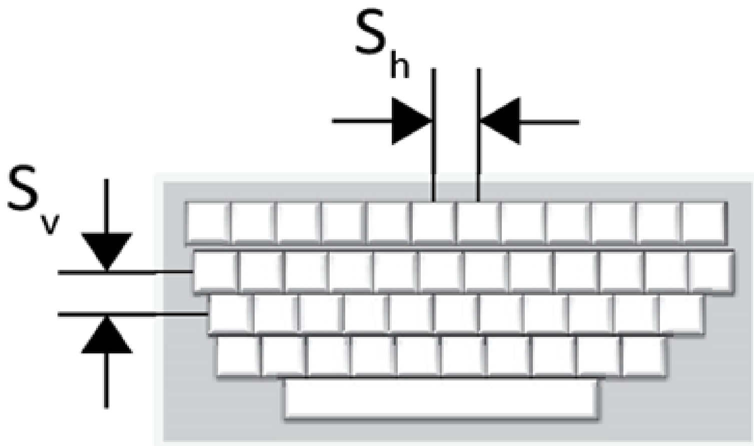

Fig. 1. Vertical Spacing - Scientific Figure on ResearchGate. (https://www.researchgate.net/figure/Horizontal-S-h-and-vertical-S-v-key-spacing-on-a-conventional-keyboard-Source_fig6_270608087).

3.2 Interface

The modified keyboards were implemented online to mitigate potential accessibility issues associated with document programs and to maintain consistency across testing environments. This decision was informed by previous research by Chiou and considerations of accessibility in different web settings. Using an online platform ensured compatibility with the participants' school district Wi-Fi and minimized external variables that could affect the data.[3]

Figure 1 represents the standard keyboard as changes are explained. On a standard on-screen keyboard, the Vertical spacing (SV) and Horizontal spacing (SH) average around 5mm depending on the computer screen. All three modified versions of the keyboard have close to 3 times the spacing horizontally (SH) averaging around 15mm depending on the screen size and an SV of 10mm. The keys on a standard on-screen keyboard average around .5cm by .375cm. On all three versions of the modified keyboards, the keys are the size of .75cm by .5cm. These size choices were formed from the reading and understanding of motor impairments from Sesto's work. [9] The differences between Keyboard 1, Keyboard 2, and Keyboard 3 are as follows:

- Keyboard 1: Slight visual differences, this keyboard combines visual and spacing aspects, only the keys "A", "B", "M", and "I" have different bolded fonts and a light blue color compared to the white keyboard. These key choices were made based on the similarity those letters share with other letters such as "L", "N" or "D" when typing. [4]
- Keyboard 2: Full visual overhaul, this keyboard has the highest contrast difference in keys and colors to see if visual aspects impact the usage of keyboards.
- Keyboard 3: No visual changes, only spacing, this keyboard is black and white and only showcases the change in SV and SH spacing between keys and size of key differences from the standard keyboard.

3.3 Procedure and Design

To ensure consistency and eliminate unnecessary variables, all 8 participants underwent individual examinations in identical settings, utilizing the same computer and keyboard for testing. An initial baseline study was conducted,

Standard Keyboard Tests				
Participants	Misclicks	Under 10s	Over 10s	Time
P1	4	18	4	03:17.2
P2	4	16	6	02:31.4
P3	3	19	4	06:03.3
P4	5	13	8	03:58.6
P5	18	5	3	02:50.2
P6	4	14	8	04:37.6
P7	7	15	4	02:43.5
P8	3	14	9	05:28.7

Keyboard Version 1 (Slight Color)				
Participants	Misclicks	Under 10s	Over 10s	Time
P1	4	15	7	03:05.2
P2	4	14	8	02:25.7
P3	2	18	6	06:15.2
P4	4	15	7	03:37.5
P5	17	5	4	03:12.2
P6	5	16	5	03:46.8
P7	8	12	6	02:37.3
P8	2	17	7	04:41.9

Keyboard Version 2 (Colored)				
Participants	Misclicks	Under 10s	Over 10s	Time
P1	4	14	8	02:32.2
P2	2	16	8	01:53.1
P3	5	14	7	06:38.8
P4	6	13	7	04:10.9
P5	10	7	9	03:34.6
P6	5	14	7	04:40.3
P7	8	11	5	02:49.1
P8	5	13	8	05:52.7

Keyboard Version 3 (No Color)				
Participants	Misclicks	Under 10s	Over 10s	Time
P1	5	13	8	03:50.4
P2	4	15	7	02:45.8
P3	2	20	4	05:32.6
P4	5	12	9	04:22.3
P5	18	4	4	02:47.1
P6	5	14	7	04:22.8
P7	5	14	7	02:03.4
P8	3	15	8	05:02.8

Fig. 2. Examination Tables.

allowing for a comparison of a traditional keyboard with closely spaced keys, averaging around 5mm apart. Participants were tasked with typing the sentence "The quick brown fox jumps over the lazy dog" on a blank Word document using the built-in touchscreen keyboard. This sentence was selected for the use of each English alphabet letter. Before the task, each participant was provided with a visual reference of the sentence for spelling accuracy.

Subsequently, participants were re-examined with modified keyboards, with each participant using all three keyboards presented simultaneously. This approach allowed participants to select their preferred keyboard modification and provided insights into user preferences alongside quantitative data. Recommended from Chang's work about response stimulation Typing sessions were timed, [1] and notes were taken on each letter input to assess accuracy, including successful key presses within a 10-second window and miss-clicks. Figure 2 shows the tables for each examination period.

4 RESULTS

Upon analyzing the data using statistical analysis methods, including a two-way ANOVA and post-hoc tests, it was found that there were no significant differences in the typing speed or accuracy between any custom keyboards and the standard keyboard. However, a nuanced difference in typing speed was present when comparing the modified keyboards amongst themselves.

4.1 Keyboard Variation Analysis

While there were slight differences in completion time, the ANOVA analysis Figure 3 revealed insignificant p-values, rendering comparisons to the standard keyboard statistically insignificant. The substantial sum of squares within groups indicates variability within each keyboard group, reflecting individual differences among participants. Notably,

Two-Way ANOVA Test Results						
Source of Variation	SS	df	MS	F	P-value	F crit
Sample	376.445625	3	125.481875	0.0733037	0.97418501	2.685643451
Columns	1207603.6	3	402534.532	235.15172	3.5998E-48	2.685643451
Interaction	1186.47438	9	131.830486	0.0770124	0.99986266	1.964489775
Within	191722.463	112	1711.8077			
Total	**1400888.98**	**127**				

Fig. 3. Anova Test Results

Keyboard 1 (slight visual changes in the keyboard) demonstrated the best overall performance among the modified keyboards. However, all keyboards exhibited similar miss-click rates, suggesting that increased spacing and visual adjustments did not significantly mitigate errors. Figure 4 depicts a graphical display of averages between the dependent variables and keyboards.

- Keyboard 1 (Slight Visual Changes): Average completion time of 222.725 seconds with 5.75 miss-clicks, 13.5 seconds faster than the standard keyboard.
- Keyboard 2 (Visual Overhaul): Average completion time of 241.46 seconds with 5.625 miss-clicks, 5.1 seconds longer than the standard keyboard.
- Keyboard 3 (Only Spacing): Average completion time of 230.9 seconds with 5.875 miss-clicks, 6.3 seconds shorter than the standard keyboard.

5 DISCUSSION

These findings indicate that while individual preferences and needs may influence typing performance, the overall effectiveness of custom keyboards did not significantly improve typing speed or accuracy compared to the standard keyboard among participants with motor and visual disabilities. Further analysis revealed significant variability in typing performance among individual participants, emphasizing the importance of considering individual differences when assessing keyboard efficacy.

It's worth noting that the experiment was conducted with middle school students, who may be relatively inexperienced typists compared to adults. Despite this, students expressed enjoyment of keyboards with the most visual modifications based solely on aesthetics, 6 out of the 8 students picked the keyboard with the most color difference. In summary, while custom keyboards may offer aesthetic appeal, their effectiveness in improving typing performance among individuals with disabilities remains inconclusive.

6 CONCLUSION AND FUTURE WORKS

In conclusion, this experiment aimed to explore the potential benefits of keyboards with visual and spacing modifications for students with diverse disabilities, focusing on motor and visual impairments. However, as indicated in the results section, these modifications did not yield a significant improvement over the standard built-in computer touchscreen

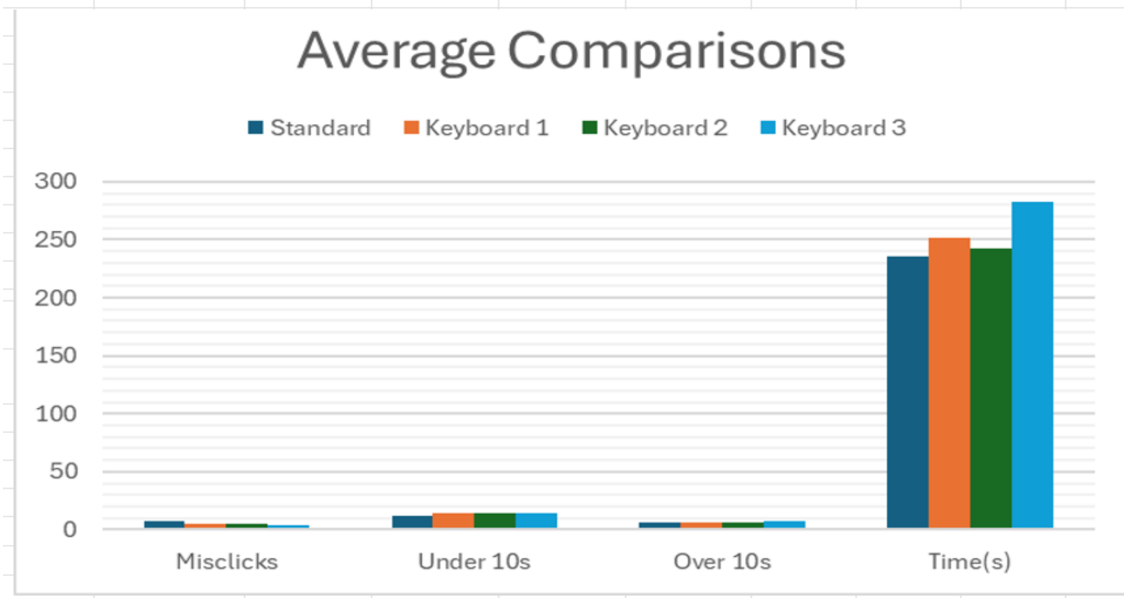

Fig. 4. Keyboard Averages

keyboard for the group. While some individuals may have exhibited better performance with modified keyboards, the overall impact was not statistically significant.

Future research endeavors could involve a larger and more diverse group of participants to gain a deeper understanding of the potential impact of these modifications. Additionally, focusing on more refined groups of disabled participants, such as solely motor disabilities or visual impairments, may provide valuable insights into how individuals with specific impairments could benefit from modified keyboards. Furthermore, investigating why Keyboard 1, with its slight visual color adjustment, demonstrated faster completion times compared to the other two keyboards could uncover valuable insights into design considerations for inclusive technology tools.

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