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Research Article

Enhancing Distance Learning For Non-Sighted and Visually Impaired Design Students: A Study on the Usability and Effectiveness of Haptic Tools

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ABSTRACT

In the realm of design education, catering to the needs of non-sighted and visually impaired students poses unique challenges, particularly in distance learning environments. This study investigates the usability and effectiveness of a specially designed haptic tool tailored to the needs of such students. The participants, comprising non-sighted and visually impaired design students enrolled in distance learning programs, were recruited through purposive sampling techniques, ensuring diverse perspectives and experiences. Data were collected through focus group discussions, in-depth interviews, and structured surveys, providing both qualitative and quantitative insights. Results indicate that the haptic tool received positive usability ratings, with participants acknowledging its effectiveness in facilitating understanding of visual concepts commonly encountered in design education. Additionally, participants reported perceived benefits including enhanced understanding of visual concepts, improved engagement in design tasks, facilitated collaboration with peers, and increased confidence in design abilities. However, challenges such as technical issues, learning curve, limited customization options, and accessibility barriers were also noted, suggesting areas for improvement in haptic tool design and implementation. Furthermore, correlations between participants' prior experience with haptic technology and usability ratings indicate the potential benefits of familiarity with tactile feedback systems in enhancing user interaction and satisfaction. Overall, this study underscores the importance of integrating haptic technology into distance learning environments to better support the learning needs of non-sighted and visually impaired design students, while also highlighting avenues for further research and development in this domain.

Keywords: Haptic tools, Distance learning, Visuallyimpaired students, Usability, Accessibility

INTRODUCTION

In the realm of design education, accessibility and inclusivity are paramount considerations, ensuring that all students, regardless of physical abilities, have equal opportunities for learning and engagement. Among the diverse student population, non-sighted and visually impaired individuals

face unique challenges in comprehending visual concepts and navigating design software. Traditional educational approaches often struggle to accommodate their needs adequately. However, advancements in technology offer promising solutions to bridge these gaps. One such innovation is haptic technology, which provides tactile feedback and sensory information to support learning and interaction in digital environments. This study aims to explore the usability and effectiveness of haptic tools in enhancing distance learning experiences for non-sighted and visually impaired design students.

The integration of haptic tools into distance learning environments holds significant potential for transforming the educational landscape for visually impaired individuals. By providing tactile feedback, haptic tools offer a means to bridge the gap between visual content and non-visual learners, facilitating the comprehension of complex design concepts. Moreover, the interactive nature of haptic interfaces fosters a more engaging and immersive learning experience, promoting active participation and collaboration among students. Despite these potential benefits, empirical research examining the usability and effectiveness of haptic tools in design education remains limited, particularly within the context of distance learning.

This study seeks to address this gap by conducting a comprehensive investigation into the experiences, perceptions, and challenges encountered by non-sighted and visually impaired design students when utilizing haptic tools in distance learning programs. By employing a mixed-methods approach encompassing qualitative and quantitative data collection and analysis techniques, the study aims to provide nuanced insights into the usability and effectiveness of haptic technology in supporting learning objectives and enhancing student outcomes. Through in-depth exploration of participant experiences, the study aims to identify key factors influencing the adoption and utilization of haptic tools in design education.

Understanding the usability and effectiveness of haptic tools in distance learning environments is crucial not only for improving accessibility and inclusivity but also for advancing the pedagogical practices within design education. By leveraging insights from this research, educators and instructional designers can better tailor learning experiences to meet the diverse needs of visually impaired students, thereby fostering a more equitable and empowering educational environment. Additionally, findings from this study may inform the development of guidelines and best practices for the design and implementation of haptic technologies in educational settings, contributing to the broader discourse on inclusive design and accessibility in higher education.

This study endeavors to shed light on the potential of haptic tools to enhance distance learning experiences for non-sighted and visually impaired design students. By examining usability, effectiveness, benefits, and challenges associated with haptic technology in the context of design education, this research aims to inform educational practices, promote inclusivity, and advance the accessibility of learning environments for all students.

RELATED LITERATURE

In their study, Josh et al. (2023) introduced a wearable haptic interface aimed at assisting blind and visually impaired students in learning algebraic equations. This initiative exemplifies the growing interest in leveraging haptic technology to enhance educational experiences for visually impaired individuals. Similarly, the work by Alexa et al. (2021) highlights the potential of haptic guidance systems in supporting design education and collaboration among visually impaired individuals. These advancements underscore the relevance of haptic tools in addressing the unique challenges faced by non-sighted and visually impaired students in educational settings.

Samuel and Teklu (2022) explored strategies for integrating visually impaired students into online learning environments, shedding light on the importance of inclusivity in distance education. This aligns with the focus of the present study on enhancing distance learning for visually impaired design students. Additionally, the research conducted by Mariacarla et al. (2021) and others showcases the efficacy of haptic interfaces in enabling tactile learning experiences, further emphasizing the potential of such tools in supporting visually impaired individuals' educational needs.

Güldenpfennig et al. (2020) and Chit et al. (2019) underscore the significance of interaction design and usability evaluation in the development of educational tools for visually impaired users. This resonates with the usability and effectiveness assessment conducted in the current study regarding the specially designed haptic tool. Similarly, Espinosa and Medellín (2020) and Tu et al. (2021) contribute to the discourse by highlighting the development and usability evaluation of haptic-virtual learning systems and specialized libraries, respectively, catering to the educational requirements of blind individuals.

The reviewed literature underscores the evolving landscape of haptic technology in education, particularly in catering to the needs of visually impaired individuals. By integrating insights from these studies, the current research aims to contribute to this evolving field by assessing the usability

and effectiveness of a tailored haptic tool in enhancing distance learning experiences for visually impaired design students.

RESEARCH METHODOLOGY

Research Design

The study adopted a mixed-methods research design, integrating both qualitative and quantitative approaches to comprehensively evaluate the effectiveness of a haptic tool for non-sighted and visually impaired design students engaged in distance learning. The qualitative component involved focus group discussions (FGDs) and in-depth interviews to explore the subjective experiences and perspectives of participants, while the quantitative aspect entailed collecting demographic data and quantitative feedback through structured surveys.

Participants

The participants of the study comprised non-sighted and visually impaired design students enrolled in distance learning programs. Recruitment efforts were focused on reaching out to relevant educational institutions, advocacy groups, and online communities catering to individuals with visual impairments. A purposive sampling technique was employed to ensure the inclusion of diverse perspectives and experiences. The target sample size was 98 respondents, in alignment with the scope of the study.

Measures/Materials

The primary measure utilized in the study was a specially designed haptic tool tailored to the needs of non-sighted and visually impaired design students. This tool provided tactile feedback and sensory information to facilitate the understanding of visual concepts commonly encountered in design education. Additionally, structured surveys were developed to collect quantitative data on participants' demographic information, prior experience with haptic technology, and feedback on the usability and effectiveness of the haptic tool.

Data Gathering Tools

Focus Group Discussions (FGDs) - FGDs were conducted using virtual communication platforms to accommodate the geographical dispersion of participants. Semi-structured interview guides were utilized to facilitate discussions on topics such as the usability, accessibility, and perceived benefits of the haptic tool, as well as challenges encountered during its use.

In-depth Interviews -In-depth interviews were conducted with a subset of participants to delve deeper into their individual experiences and perspectives. Open-ended questions were employed to explore nuanced aspects of their interaction with the haptic tool and its impact on their learning process.

Structured Surveys -Structured surveys were distributed electronically to all participants to gather quantitative data on demographic information, prior experience with haptic technology, and feedback on the usability and effectiveness of the haptic tool. The survey included both closed-ended questions with predefined response options and Likert-scale items to measure participants' attitudes and perceptions.

Data Analysis

Qualitative data from FGDs and in-depth interviews were analyzed using thematic analysis techniques to identify recurring patterns, themes, and categories within the data. Transcripts were coded and systematically organized to extract key insights related to participants' experiences, challenges, and perceptions of the haptic tool. Quantitative data from structured surveys were analyzed using descriptive statistics to summarize demographic information and participants' responses to survey items. Additionally, inferential statistics such as correlations and regression analysis were employed to examine relationships between variables, such as prior experience with haptic technology and perceived usability of the haptic tool. Integration of qualitative and quantitative findings provided a comprehensive understanding of the effectiveness of the haptic tool for non-sighted and visually impaired design students studying at a distance.

Table 1.Participant Demographics

Demographic Variable	Frequency (%)
Gender (Male) Table 1. Participant Demographics	45 (46%)
Gender (Female)	53 (54%)

Age (Mean ± SD)	28.5 ± 5.2
Visual Impairment Type	
Blindness	65 (66%)
Low Vision	33 (34%)
Educational Level	
Undergraduate	25 (26%)
Graduate	73 (74%)
Prior Experience with Haptic Technology	
Yes	68 (69%)
No	30 (31%)

Table 1 presents the demographic characteristics of the participants. The sample consists of 98 non-sighted and visually impaired design students, with a relatively balanced distribution of gender. The mean age of the participants is 28.5 years, with a standard deviation of 5.2 years. The majority of participants reported blindness (66%) as their type of visual impairment, while the remaining 34% reported low vision. Regarding educational level, 26% of participants were undergraduate students, while 74% were pursuing graduate studies. Furthermore, 69% of participants reported prior experience with haptic technology, indicating a substantial level of familiarity with tactile feedback systems.

Table 2.Usability Ratings of the Haptic Tool

Usability Aspect	**Mean Rating (1-5)**
Ease of Navigation	4.2
Clarity of Tactile Feedback	4.4
Compatibility with Design Software	4.1
Overall Satisfaction	4.3

Table 2 presents the usability ratings of the haptic tool as reported by participants. Overall, participants rated the haptic tool positively across various usability aspects. The tool received high mean ratings for ease of navigation (M = 4.2), clarity of tactile feedback (M = 4.4), compatibility with design software (M = 4.1), and overall satisfaction (M = 4.3). These findings suggest that the haptic tool effectively supports non-sighted and visually impaired design students in their learning endeavors, offering intuitive navigation, clear tactile feedback, and seamless integration with design software.

Table 3.Benefits Perceived by Participants

Perceived Benefits	**Frequency (%)**
Enhanced Understanding of Visual Concepts	87 (89%)
Improved Engagement in Design Tasks	79 (81%)
Facilitated Collaboration with Peers	64 (65%)
Increased Confidence in Design Abilities	72 (74%)

Table 3 outlines the perceived benefits reported by participants regarding the use of the haptic tool. The majority of participants acknowledged experiencing enhanced understanding of visual concepts (89%) and improved engagement in design tasks (81%) with the support of the haptic tool. Additionally, a considerable portion of participants reported facilitated collaboration with peers (65%) and increased confidence in their design abilities (74%). These findings underscore the multifaceted advantages of incorporating haptic technology into distance learning environments for non-sighted and visually impaired design students.

Table 4.Challenges Encountered in Using the Haptic Tool

Challenges	**Frequency (%)**
Technical Issues	42 (43%)
Learning Curve	28 (29%)
Limited Customization Options	19 (19%)
Accessibility Barriers	15 (15%)

Table 4 highlights the challenges reported by participants in using the haptic tool. The most frequently cited challenge was technical issues (43%), indicating occasional disruptions or malfunctions in the functionality of the tool. Other challenges included the learning curve associated with mastering the

tool's features (29%), limited customization options to tailor the tool to individual preferences (19%), and accessibility barriers that hindered seamless interaction with the tool (15%). These findings suggest areas for improvement in the design and implementation of haptic tools to address the specific needs and preferences of non-sighted and visually impaired users.

Table 5.Correlations between Prior Experience with Haptic Technology and Usability Ratings

	Prior Experience with Haptic Technology
Ease of Navigation	.523*
Clarity of Tactile Feedback	.461*
Compatibility with Design Software	.387*
Overall Satisfaction	.576*

Table 5 presents correlations between participants' prior experience with haptic technology and usability ratings of the haptic tool. The results indicate significant positive correlations between prior experience with haptic technology and usability ratings across all aspects evaluated, including ease of navigation ($r = .523$, $p < .05$), clarity of tactile feedback ($r = .461$, $p < .05$), compatibility with design software ($r = .387$, $p < .05$), and overall satisfaction ($r = .576$, $p < .05$). These findings suggest that participants with prior experience with haptic technology tend to perceive the haptic tool as more usable and satisfactory, underscoring the potential benefits of familiarity with tactile feedback systems in enhancing user interaction and satisfaction.

CONCLUSION

In conclusion, this study provides valuable insights into the effectiveness of a haptic tool for non-sighted and visually impaired design students engaged in distance learning. The findings indicate that the haptic tool offers significant benefits, including enhanced understanding of visual concepts, improved engagement in design tasks, facilitated collaboration with peers, and increased confidence in design abilities. While participants reported high levels of satisfaction with the usability of the haptic tool, several challenges were identified, such as technical issues, learning curve, limited customization options, and accessibility barriers. Nevertheless, the correlations between participants' prior experience with haptic technology and usability ratings suggest the importance of familiarity with tactile feedback systems in enhancing user interaction and satisfaction. Overall, the results underscore the potential of haptic technology to support inclusive design education for non-sighted and visually impaired students studying at a distance.

Recommendation

Based on the findings of this study, several recommendations are proposed to enhance the effectiveness and usability of haptic tools for non-sighted and visually impaired design students in distance learning environments. Firstly, efforts should be made to address technical issues and improve the reliability and stability of haptic systems to minimize disruptions in user experience. Secondly, providing comprehensive training and support resources can help mitigate the learning curve associated with using haptic tools, empowering users to maximize the benefits of tactile feedback. Additionally, incorporating customizable features and ensuring compatibility with a variety of design software platforms can enhance the flexibility and usability of haptic tools to suit individual preferences and needs. Moreover, prioritizing accessibility considerations in the design and development of haptic tools is essential to ensure equitable access and usability for all users, regardless of their level of visual impairment. Overall, by implementing these recommendations, educators and developers can create more inclusive and effective learning environments for non-sighted and visually impaired design students studying at a distance.

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