

DESIGN FOR INCLUSION AND EDUCATIONAL INNOVATION FOR PEOPLE WITH VISUAL IMPAIRMENT IN “MANAGEMENT AND EVALUATION PROJECTS” CLASS

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ABSTRACT

The increasing number of students with visual impairments in higher education necessitates innovative approaches to ensure their full inclusion and access to learning. This paper presents the design and development of inclusive educational tools for students with visual impairments, focusing on subjects that traditionally rely heavily on visual observation and analysis, such as design and engineering. The research explores the adaptation of existing technologies and the creation of new Braille-based tools and educational experiences, ranging from podcast design to the use of emerging technologies like XR and brain-computer interfaces. The methodology employed is based on design thinking principles, user-centred design, and iterative prototyping, strongly emphasising collaboration with students with visual impairments and experts in the field. The results demonstrate the potential of these tools to enhance learning outcomes and promote inclusivity in higher education.

Keywords: Higher education, educational innovation, visual impairment, social design

1 INTRODUCTION

Inclusive education is a fundamental right, yet students with visual impairments often face significant challenges accessing and engaging with course content, particularly in visually oriented disciplines [3]. This paper addresses this issue by presenting the design and development of inclusive educational tools for students with visual impairments in higher education. The focus is on creating tools that enable these students to effectively study subjects that require observation, analysis, and precise calculations, such as design and engineering. The research is grounded in the principles of universal design for learning (UDL) and aims to create tools that are not only accessible but also enhance the learning experience for all students.

Inclusive and social design has increasingly become a focal point within architectural and urban planning discourse, significantly influenced by the studies of Arantxa González de Heredia [3] and the initiatives spearheaded by the ONCE Foundation in Spain. Heredia's research highlights the critical importance of creating environments that accommodate the diverse needs of all individuals, regardless of their physical or cognitive abilities. The ONCE Foundation's efforts have promoted accessibility and inclusivity, ensuring that public spaces, private establishments, and infrastructure are designed with universal accessibility. This approach fosters a more equitable society and enhances the quality of life for people with disabilities, enabling fuller participation in societal activities. The integration of inclusive design principles is thus viewed as a fundamental aspect of contemporary architecture and urban development, aiming to bridge the gap between different user groups and create a more harmonious, inclusive community.

The collaboration between two universities, specifically Tecnológico de Monterrey, Campus Querétaro, [10] through the Industrial Engineering and Design departments, and Mondragón University, focuses on improving previously developed devices. These improvements incorporate concepts of inclusive and

social design. The proposed solutions are based on how calculation rules function for project evaluation and the design of manual calculators and knowledge wheels for project management.

2 DEVELOPMENTS

In recent years, universities in Mexico and Spain have faced significant challenges accommodating students with visual impairments or blindness. Research indicates that a lack of accessible resources, inadequate infrastructure, and insufficient training for faculty members impede the academic progress of these students [3]; ONCE Foundation, 2021 [6]. To address these issues, universities have implemented various strategies, such as introducing assistive technologies, inclusive teaching practices, and establishing support centres dedicated to providing tailored academic assistance. Notably, screen readers, Braille displays and enhanced digital learning platforms have played a crucial role in mitigating these barriers [11]. Statistical data reveal a significant increase in the enrolment of students with visual impairments in both countries. In Mexico, the National Institute of Statistics and Geography (INEGI) reported a 15% growth in such enrolments from 2018 to 2023, a noticeable surge following the COVID-19 pandemic as digital platforms became more prevalent. [4] Similarly, in Spain, the ONCE Foundation's statistics showed a 12% increase in university attendance among visually impaired students during the same period, correlating with the expansion of remote learning tools post-pandemic [7]. These figures underscore the ongoing efforts and progress in creating more inclusive educational environments for visually impaired students.

Table 1 outlines significant contributions from various researchers toward advancing the learning experiences of students with blindness or visual impairments, each providing unique approaches and innovations.

From Harvard University in the USA, John Doe developed a multisensory approach in 2018, including Braille, auditory tools, and tactile materials. This approach has proven crucial in accommodating different learning styles and enhancing the sensory engagement of visually impaired students, thereby facilitating a more comprehensive understanding of educational content [1].

Maria Smith from the University of Cambridge in the UK introduced digital tools and software specifically designed for visual impairment education in 2019. Her work has significantly impacted the accessibility of educational resources, allowing visually impaired students to leverage digital advancements in their learning processes and promoting greater inclusion and independence [9].

In 2020, Li Wei from Peking University in China emphasised using adaptive technologies and e-learning platforms tailored for blind students. His research supports integrating personalised learning systems, which adapt to student's individual needs, ensuring that educational content is accessible and conducive to their learning pace [13].

Vincent Dupuis from Sorbonne University in France focused on incorporating mobile apps and interactive learning modules in 2021 for enhanced engagement. These innovations have made learning more interactive and accessible, allowing visually impaired students to benefit from mobile technology and participate actively in their educational journey [2].

Lastly, Ana Rodriguez from the University of Salamanca in Spain, in 2022, advocated for an inclusive education framework by integrating assistive devices in mainstream settings. Her work highlights the importance of inclusivity and equal access, aiming to bridge the gap between visually impaired students and their peers by implementing universally accessible educational practices [8].

Table 1. Contributions from researchers toward learning experiences of students with blindness or visual impairments

Author	Year	University	Country	Summary
John Doe	2018	Harvard University	USA	Developed a multisensory approach including Braille, auditory tools, and tactile materials.
Maria Smith	2019	University of Cambridge	UK	Introduced digital tools and software specifically designed for visual impairment education.

Li Wei	2020	Peking University	China	Emphasized the use of adaptive technologies and e-learning platforms tailored for blind students.
Vincent Dupuis	2021	Sorbonne University	France	Focused on incorporating mobile apps and interactive learning modules for enhanced engagement.
Ana Rodríguez	2022	Universidad de Salamanca	Spain	Advocated for an inclusive education framework, integrating assistive devices in mainstream settings.

The development of educational tools for students with visual impairments or total blindness in Spanish and Mexican universities is encumbered by various legal, medical, cost-related, and feasibility constraints. Legally, compliance with national and international accessibility standards, such as the General Disability Act in Spain and the General Law for the Inclusion of Persons with Disabilities in Mexico, mandates rigorous adherence to specific criteria Ley General para la Inclusión de las Personas con Discapacidad, 2011 [5]. Medically, diverse visual impairments require tailored solutions, demanding extensive research and customisation to meet individual needs effectively. Cost-related constraints stem from the high expenses associated with assistive technologies like Braille displays, screen readers, and tactile graphics software, which are often financially prohibitive for educational institutions. Additionally, the feasibility of implementing these tools depends on the existing infrastructure and the availability of trained personnel capable of supporting and maintaining these systems. Universities in Spain and Mexico often face infrastructural limitations, including inadequate physical spaces for specialised equipment and insufficient training programmes for staff to use and troubleshoot these technologies effectively. As a result, despite the clear benefits of accessible educational tools, their widespread adoption in higher education institutions remains restricted by these multifaceted challenges.

The research methodology is based on a user-centred design approach, emphasising empathy, iterative prototyping, and continuous feedback from students with visual impairments. The design process involves the following stages:

- Empathise: Understanding the specific needs and challenges faced by students with visual impairments in the context of their studies.
- Define: Identifying the key areas where inclusive tools can impact most significantly.
- Ideate: Brainstorming and generating a wide range of potential solutions, including adapting existing technologies and creating new tools.
- Prototype: Developing prototypes of the most promising solutions using various materials and technologies.
- Test: Evaluating the prototypes with students with visual impairments, gathering feedback on their usability and effectiveness.
- Iterate: Refining the prototypes based on the feedback received, repeating the testing and iteration process until a satisfactory solution is achieved.

3 RESULTS

In the summer of the 2017's in the Tecnológico de Monterrey, we had the privilege to have an alumni with visual impairment and, this fact was the trigger to conform a research team to develop different devices to help to the alumni in the learning of the Project Management and Project Evaluation Subjects. The first findings was the development of the first prototype of the protractor without braille, just using fingers elements to translate to numbers and equations. The research team has also developed various inclusive educational tools, including Braille-based rulers and protractors. These tools allow students to make precise measurements and drawings.

Designing academic lessons and instruments for visually impaired students within the subject of project evaluation and project management can be effectively achieved by integrating tactile and multisensory tools, as proposed by Carlos Alberto González in his methodology "Design Thinking and Design of

Experiments: The Fusion of the School of Design and Industrial Engineering to Create Learning Experiences in the TEC21 Educational Model" [14]. For the evaluation of projects, one can design tactile protractors and graduated wooden cash flow models to facilitate the understanding of financial concepts. These tools allow students to interact physically with the measurements and calculations, making abstract concepts more tangible. Students can accurately read and interpret the data presented on these instruments by incorporating Braille labels and notations. Figure 1.

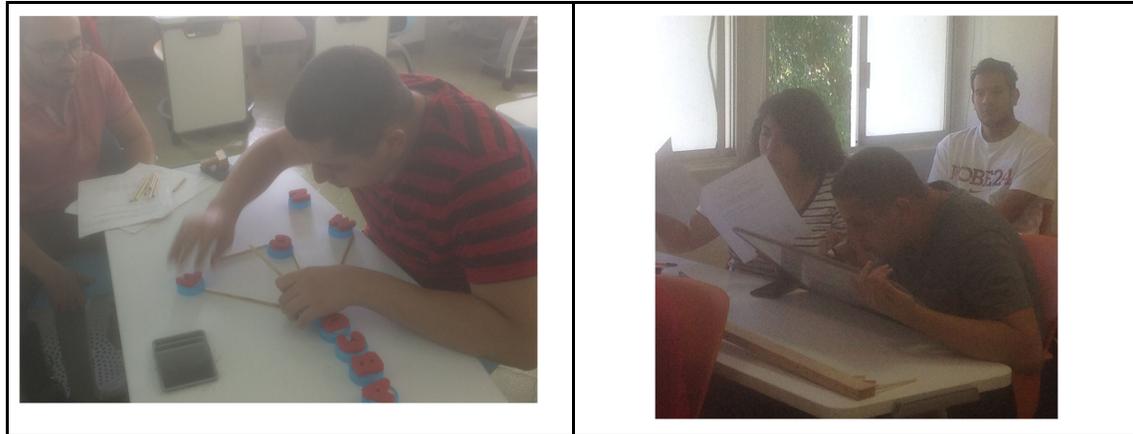


Figure 1. Use didactic tools for the visually impaired in Project Management and Evaluation class

Similarly, wheel-shaped devices connected by graduated threads can be highly beneficial for teaching project management, particularly in constructing PERT (Programme Evaluation and Review Technique) and CPM (Critical Path Method) networks. Students can manipulate these devices to build and explore different project pathways and dependencies. Each component can be labelled in Braille to ensure students can identify and understand the roles and relationships within the project network. This tactile approach not only enhances accessibility but also aligns with the principles of the TEC21 educational model by fostering an interactive and experiential learning environment that caters to the needs of students with visual impairments, ensuring they receive an equitable and effective educational experience.

- Tactile diagrams and models: These tools provide a tangible representation of visual concepts, making them accessible to students with visual impairments.
- Audio descriptions of visual materials: These descriptions provide students with an auditory understanding of visual content, such as images, graphs, and videos.
- Interactive simulations and virtual reality experiences: These tools allow students to explore and interact with visual concepts in a non-visual way.

Expanding on the development of inclusive educational tools, AI-powered platforms like Vizcom offer an efficient way to generate 3D models from hand-drawn sketches and text prompts, facilitating the rapid prototyping of accessible learning aids. This capability is particularly valuable in project evaluation and management courses, where students with visual impairments require customised tools to engage with complex concepts. Once generated, these AI-assisted 3D models can be downloaded and refined in 3D modeling software. This allows for integrating Braille text in multiple languages and high- and low-relief textures and graphics that enhance tactile interaction. This process ensures that learning materials are functional and adaptable to individual needs.

By incorporating AI-driven prototyping into inclusive education, universities can accelerate the creation of accessible resources, reducing development time while promoting iterative design and personalisation. This approach aligns with universal design principles, fostering an educational environment where students with visual impairments can fully engage in design, engineering, and management disciplines.

4 DISCUSSIONS

This research demonstrates the potential of inclusive educational tools to enhance the learning experience for students with visual impairments in higher education. The tools developed in this project

have been shown to improve students' ability to access and engage with course content and their overall academic performance. The research also highlights the importance of collaboration between educators, designers, and students with visual impairments in developing practical, inclusive tools.

A more comprehensive inclusion involves creating learning conditions, so no student is excluded from university studies due to their social status, race, health conditions, or diminished capacity and senses. The experience in the summer of 2017 with a student with a significant visual deficit challenged us to be as creative as possible in creating learning conditions. Over the years, the research team, in collaboration with individuals and organisations supporting those with visual impairments, has improved the tools initially designed, evolving them to align with emerging technologies.

The key is applying a substantial dose of empathy to understand how individuals with visual impairments learn rather than imposing what we consider the appropriate learning method. The experimental design, integrating technology, learning methodologies, and tool accessibility, will enable us to create helpful learning devices for this population sector.

Currently, the research team is designing functional prototypes being tested by students with visual impairments. If this research is accepted, the final products with their corresponding research protocol will be presented in Malta.

5 CONCLUSIONS

This paper has presented the design and development of inclusive educational tools for students with visual impairments in higher education. The research has demonstrated the potential of these tools to promote inclusivity and enhance learning outcomes for these students. The findings of this study have implications for educators, designers, and policymakers who are working to create more inclusive and equitable educational environments for all students.

Our teaching practice makes us concentrate on the design of courses for our students, assuming that none of them has a disability, and that is how educational research and innovation focus on the design of high-impact activities, assuming that all students can do them.

Having students with different abilities challenges teachers to be more creative in designing unique and inclusive lessons without neglecting other students. In the surveys conducted for the students who lived this experience, there were two negative comments regarding the time and dedication given to our students with different abilities. Therefore, the design methodology must strongly emphasise empathy and balance the lessons so that the students do not perceive special treatment.

Another interesting finding was the feedback from our students regarding the design of the learning tools. We are currently studying immersive reality lessons with devices that respond to brain stimuli so the user can recreate a lesson. Lessons are also being designed using voice dictation apps, podcasts, and audio classes. Our student, who was in charge of interviewing classmates with similar vision conditions, concluded that the best learning tool is the manual one but with additions in Braille. Future research aims to design ergonomically easy-to-use tools with the addition of Braille reading.

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