Development of a Modular, Wheelchair-Accessible Desk Using Design Thinking and User-Centered Design (UCD).

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ABSTRACT

Conventional desks are designed around fixed dimensions and lower structural elements that can hinder frontal approach, reach, and comfortable posture for wheelchair users, limiting their participation in study and work activities. This study aimed to develop a modular and accessible desk concept for wheelchair users through Design Thinking and User-Centered Design. An applied, mixed-methods, descriptive-propositive approach was followed, structured in the five phases of Design Thinking: empathize, define, ideate, prototype, and test. In the empathize phase, a questionnaire with two five-point Likert scales (perceived difficulty and importance of desk features) was administered to ten people, six wheelchair users and four non-users, selected through non-probability sampling. Data were analyzed descriptively, and internal consistency was estimated with Cronbach's alpha. Both scales showed high internal consistency ($\alpha = 0.955$ and 0.929). The greatest difficulties were plugging in devices and maintaining posture during long periods, while height adjustment, removable storage modules, and ample work surface were the most valued features (mean = 4.20). These findings informed a design brief, a conceptual sketch, and a three-dimensional model of an L-shaped desk with adjustable height, removable storage modules, device charging, and open space for frontal approach. The project is currently at the three-dimensional modeling stage; a physical prototype has not been built, and usability, stability, and ergonomic tests with users remain pending. Because of the small sample and the preliminary nature of the instrument, the results are exploratory and support the relevance of the proposed features rather than confirming the effectiveness of the desk. Future work will build the prototype and evaluate it with a larger group of wheelchair users.

Keywords: inclusive design, wheelchair users, Design Thinking, user-centered design, modular furniture

INTRODUCTION

Inclusive design seeks to develop products and environments that cater to the diversity of people's abilities and needs. According to the National Institute of Statistics and Geography (INEGI), disability is related to difficulty performing everyday activities, such as walking, seeing, hearing, speaking, remembering, or concentrating. A person is considered to have a disability when they experience significant difficulty or are unable to perform at least one of these activities. This definition acknowledges that accessibility needs can manifest in different ways and must be considered from the very beginning of the design process for everyday products and spaces. As discussed in the literature on inclusive design, incorporating users' experiences and involving them in the design process helps identify needs and guide design decisions (Sarmiento, 2020).

According to data from the National Institute of Statistics and Geography (INEGI, 2020), there were 6,179,890 people with disabilities in Mexico, a figure that represents 4.9% of the country's total population. Likewise, the 2020 Population and Housing Census found that 47.6% of people with disabilities had difficulty walking, going up, or going downstairs, making this activity one of the main challenges reported by this population group (INEGI, 2021). These figures highlight the importance of considering mobility needs in the design of everyday products. In particular, furniture designed for study and work represents an area of opportunity for industrial design, since a desk must allow users not only to perform activities on its surface but also to approach it, maintain

proper posture, and have sufficient space for their legs and mobility aids. However, conventional desks do not always meet these requirements due to their fixed dimensions, their lower components, and the limited ability to adapt their configuration to the needs of each user.

In this context, furniture designed for study and work represents an area of opportunity for industrial design, particularly in the development of solutions for wheelchair users. Conventional desks may present limitations related to the height of the work surface, the presence of drawers and lower supports, the arrangement of objects, and the ability to approach the desk from the front. These conditions can hinder access to the work area and limit comfort during activities such as studying, using a computer, reading, or engaging in creative tasks. Therefore, it is important to explore furniture alternatives that take into account the dimensions of wheelchairs, the space required for legs and footrests, as well as the various needs for organizing and using the work surface.

User participation is a key element in the design of inclusive solutions, as it allows for the identification of needs that might go unnoticed if decisions were based exclusively on formal or technical criteria. Rojas and García (2013) highlight the importance of user participation in inclusive design processes. Similarly, Clavería Pelegrín et al. (2022) discuss experiences in social and inclusive design in which collaboration contributes to the development of proposals geared toward social needs. These approaches support the importance of considering users' experiences and preferences as a starting point for identifying design opportunities.

In response to this challenge, we propose a modular and accessible desk concept developed through a user-centered design approach. This approach holds that a product's characteristics should be determined based on the needs, activities, and contexts of the people who will use it, rather than solely on formal or aesthetic criteria. In line with this approach, the ISO 9241-210 standard emphasizes the importance of understanding users and their contexts of use, as well as evaluating and iterating design solutions to improve their usability and accessibility (Luján, n.d.).

LITERATURE REVIEW

A literature review was conducted to identify studies, projects, and methodological frameworks related to the design of accessible furniture for wheelchair users, with an emphasis on desks, workstations, and user-centered design or Design Thinking approaches. Priority was given to works published between 2015 and 2026.

Table 1. Review of 20 relevant studies and projects on accessible furniture

#	Author(s) and year	Objective	Method	Results	Limitations
1	Naeini et al. (2021)	Design and evaluate a desk ergonomic for laptop Wheelchair users	Panel of experts, prototyping, evaluation with RULA and perceived discomfort	Wrist posture improvement, arm and neck; reduction significant discomfort	Small sample (14 users)
2	Quality Function Deployment study (2025)	Design Artboard for people with disabilities using QFD and anthropometry	Quizzes, House of Quality, measurement anthropometric	Average improvement of 5.93% in satisfaction; higher in Security and stability	Limited sample (15 people)
3	Rifton Adaptive Desk (commercial/academic)	Height Adjustable Desk for educational environments inclusive	Commercial design based on user needs	Wide height range, space wheelchair, tilt optional	It's not a study Peer Scientist reviewed
4	Sharifa's Workstation (2019)	Design Workstation Personalized with participation of the user	Design Thinking, prototyping iterative from low to high fidelity	Final product adapted to specific needs of the User	Individual case

5	Dynamic Worktop (DfA)	Design Work surface kitchen dynamics inclusive	Needs analysis, modular design adjustable in height and depth.	Configuration adaptable to different body types and mobility conditions	Focus on the kitchen, not the desk
6	ISO 9241-210 (2019)	Standard for Human Centered Design	Regulatory Framework for User-Centered Design Activities	Principles of User Understanding, Evaluation, and Iteration	Standard, not an empirical study
7	Ergonomic evaluation Brazilian standards (2021)	Evaluating workstation furniture according to accessibility standards	Case study, ergonomic analyss	Compliance with ABNT NBR-9050 and NR-17 standards	Brazilian context
8	Changes in musculoskeletal discomfort (2021)	Effect of Table Height on Wheelchair Users with Spinal Cord Injuries	Experimental study using different table heights	The optimal height varies depending on the level of injury (C6 vs. T6)	Small, specific sample
9	A Design of a Work Desk for Persons in a Wheelchair (2015)	Proposing ideal desk dimensions for people in wheelchairs	Anthropometric Analysis and Simulation	Dimensional Parameters for Clear Space and Reach	Thesis, not an article
10	Inclusive design furniture projects (2025)	Review of inclusive furnitue projects	Review of design case studies	Examples of modularity and user-centered design	Non-empirical
11	Seat elevating devices study (2023)	Functional Benefits of Seat Height Adjustment in Wheelchairs	Analysis of data from 1,733 users	Significant improvement in reach and transfer	Not specific to desks
12	Ergonomic study of VDT workstation (2016)	Ergonomic Study of Workstations for People with Disabilities	Anthropometric Analysis and Design	Recommendations for Height Adjustability	Previous Study
13	Cara Circular Desk (2026)	Modular Desk for People with ADHD	Design developed in collaboration with users, prototyping.	Modularity and height adjustability	Focus on neurodiversity, not mobility
14	ADA Furniture Co. (commercial)	Accessible, designer furniture for wheelchair users	Commercial design with clear front space	Desks with knee clearance and side storage	Commercial, not academic
15	Inclusive offices adaptive furniture (2025)	Guide to Adaptive Furniture for Inclusive	Offices: A Review of Universal Design Principles;	Recommendations for Height- Adjustable Desks and Modularity	Guide, not a study
16	RESNA Student Design Challenge cases	User-Centered Workstation Design Projects	Design Thinking, Co-Design	The importance of user participation in the process	Student case studies
17	Anthropometric data for wheelchair users	Anthropometric Data for Wheelchair Users	Anthropometric Measurements	Reach,elbow height,and clearance dimensions	Reference data
18	Universal Design principles (Mace)	Universal design principles applied to furniture	Conceptual framework	Equity of use, flexibility, simple and intuitive use	Theoretical framework
19	Worktable height optimization studies	Optimizing work surface height	Experimental studies on posture	Adjustable height reduces musculoskeletal discomfort	Variability by user
20	Modular furniture design studies	Adaptable modular furniture design	Review and design case studies	Modularity allows for customization based on needs	Not specifically related to accessibility

The review shows that ergonomic and workstation design studies for wheelchair users agree on the importance of adjustable height, clear front space, and consideration of anthropometric data. Projects that incorporate Design Thinking or user-centered design emphasize user participation in the process of defining requirements and evaluating prototypes. The main limitations of the existing literature are the prevalence of studies with small sample sizes, a focus on individual cases or specific contexts, and a lack of proposals that integrate modularity, removable storage, and charging solutions into a single desk concept. This justifies the development of a conceptual proposal that combines these features through a structured Design Thinking process.

Table 2. Count and analysis of methodological tools and approaches

Tool / Approach	Frequency	Main Purpose	Comments
Design Thinking / User-Centered Design	6-8	Structuring the design process with users	Recommended approach for the project
Ergonomic Evaluation (RULA, Discomfort, Posture)	5-7	Evaluate comfort and postural risk	Useful during the prototype testing phase
Anthropometry and Dimensional Analysis	6-8	Defining clearance and reach dimensions	Essential for accessibility
Iterative prototyping	5-6	Validate concepts with users	Low- to medium-fidelity
Interviews / Observation with Users	4-6	Empathize and define needs	Initial phase of Design Thinking

User-centered design and Design Thinking are the most appropriate approaches for developing accessible furniture, as they allow for the integration of the experiences of wheelchair users from the earliest stages. Ergonomic and anthropometric tools are complementary and necessary for translating user needs into dimensional specifications.

THEORETICAL FRAMEWORK

Social Conceptualization of Disability

The contemporary paradigm views disability not as a strictly medical or biological condition, but as the direct result of the interaction between an individual's functional limitations and the physical, technological, or attitudinal barriers imposed by the environment. According to data from the 2020 Population and Housing Census conducted by the National Institute of Statistics and Geography (INEGI), disability is defined as the extreme difficulty or inability to perform at least one daily activity. In Mexico, approximately 6.18 million people (4.9% of the population) live with a disability; of this total, 47.6% have mobility limitations (walking, going up or down stairs). This prevalence places mobility aids and the built environment among the top priorities for accessible design.

Principles of Inclusive Design and Universal Design

Inclusive Design and the Universal Design framework (proposed by Ronald Mace) establish that everyday products and spaces must be conceived to accommodate human functional diversity from the design phase onward, avoiding subsequent or segregating adaptations. When applied to furniture, their fundamental pillars include:

- Equitable Use: Provide the same guarantees of interaction, accessibility, and autonomy to all users.
- Flexibility of Use: Accommodate a wide range of preferences and physical abilities through dimensional variability.
- Simple and intuitive use: Facilitate the manipulation of controls and interfaces by eliminating unnecessary complexity and excessive physical effort.

ISO 9241-210 Standard

User-Centered Design (UCD) is a design discipline that places users' needs, abilities, limitations, and real-world contexts at the center of product development. The ISO 9241-210:2019 standard establishes guidelines for human-centered activities, promoting a deep understanding of the context of use and an iterative evaluation process with participants to optimize usability and accessibility.

Iterative Design Thinking Process

The Design Thinking methodology addresses complex problems through a participatory, empathetic, and iterative approach structured in five stages:

1. Empathize: Understand the experiences, postural barriers, mobility dynamics, and requirements of wheelchair users in their study/work environment.
2. Define: Synthesize field data to identify key requirements and design criteria (clear front space, reach objects, connectivity).
3. Conceive: Generate conceptual proposals and technical innovations aimed at addressing the operational limitations of conventional furniture.
4. Prototype: Build tangible models ranging from low to high fidelity to bring spatial and mechanical solutions to life.
5. Test: Subject to the prototypes for usability, postural comfort, and accessibility tests with end users to inform the design.

Constraints of Conventional Furniture

Traditional desks are typically designed based on standardized anthropometric parameters for a population that stands or sits in a conventional manner, which creates serious accessibility barriers:

- Lack of under-desk clearance: Fixed drawers, skirting, and lower crossbars block the front entry of the legs, knees, and footrests of a wheelchair.
- Fixed Dimensions and Heights: These limit a neutral working posture, causing compensatory shoulder elevation or forced trunk tilting.
- Inefficient Reach Zones: Storage areas are located outside the functional reach of a seated person.

Modular Furniture Architecture

Modularity involves dividing a system into independent subsystems or modules that can be combined, rearranged, or disassembled according to the user's needs. In inclusive workstations, this feature allows for:

- Freely relocating storage compartments within the user's comfortable reach.
- Freeing up space underneath so as not to obstruct the path or approach of a wheelchair.

Adjustment Mechanisms and Service Integration

Modern work furniture integrates technological and mechanical solutions to increase functional autonomy:

- Adjustable height systems: These allow the work surface to be precisely adjusted to the height of the wheelchair's armrests and the user's stature.
- Connectivity and power management: The inclusion of accessible USB charging ports and cable management systems eliminates the need to lean forward or make complex movements to connect electronic devices.

METHODOLOGY

This is an applied research project on technological development, of a mixed (qualitative-quantitative) nature, with an emphasis on the design process. The primary approach is Design Thinking, structured around the phases of empathize, define, ideate, prototype, and test, complemented by principles of User-Centered Design (UCD) (ISO 9241-210) and inclusive design. This approach allows us to start with users' actual needs rather than relying solely on formal or technical criteria.

The choice of UCD responds to the need to involve users in identifying accessibility barriers and defining relevant characteristics for the furniture. In this regard, Rojas and García (2013) highlight the importance of user participation in inclusive design processes, while Clavería Pelegrín et al. (2022) present co-creation experiences in which collaboration between designers and participants contributes to the development of inclusive proposals. This background supports the relevance of considering users' experiences as a source of information to guide design decisions.

Furthermore, the ISO 9241-210:2019 standard serves as a conceptual reference, establishing principles and activities for human-centered design in the development of interactive systems. Although its scope is not limited to or specifically directed at furniture design, its principles can guide the understanding of the context of use, user participation, and the iterative evaluation of design proposals (International Organization for Standardization [ISO], 2019).

The (independent) design variables include: the height adjustment range of the work surface, the depth and width of the front clearance (wheelchair clearance), the modularity and removability of storage modules, the ability to tilt the surface, the integration of device charging solutions, and the ability to reconfigure components. These variables aim to accommodate anthropometric diversity and the different ways users' approach and use the desk.

The evaluation variables (dependent variables) include ease of frontal approach, postural comfort during study or work activities (assessed through observation or discomfort scales), perceived usability, user satisfaction, the time and effort required to adjust or reconfigure the furniture, and perception of autonomy. Control variables will include the characteristics of the user's wheelchair, the type of activity performed, and the context of use (home, study, or work).

The design process was based on a survey administered to wheelchair users and non-users, an empathy map as a synthesis tool, baseline anthropometric analysis (ADA criteria), concept generation, and three-dimensional modeling. Physical prototyping and iterative evaluation with potential users are planned as subsequent stages. Wheelchair users participated in the empathy phase, and their involvement is planned for the testing phase.

Phase 1. Empathize

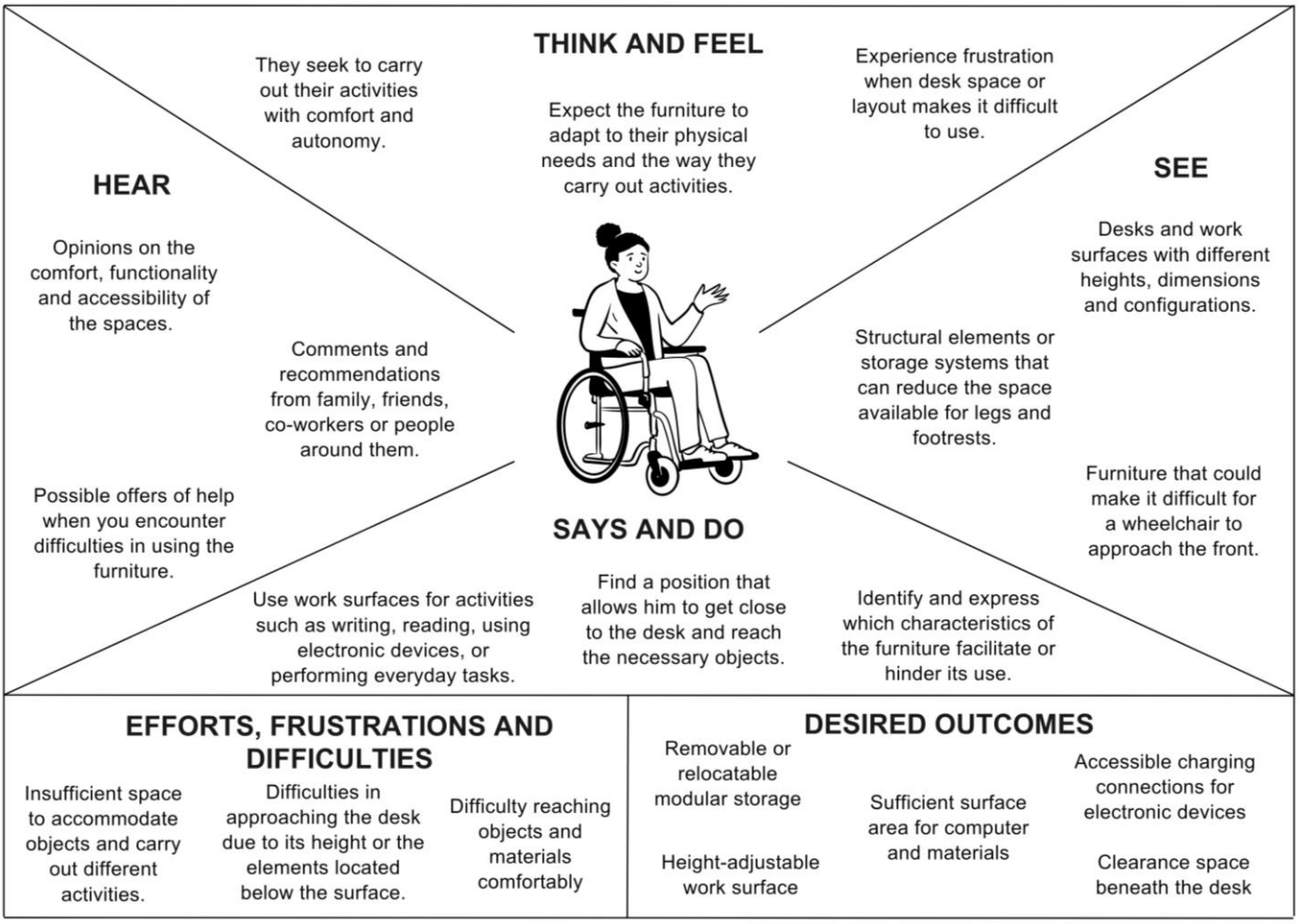
The first phase consisted of identifying the needs, challenges, and preferences of wheelchair users regarding the use of a desk. To this end, a survey was administered to ten people with the aim of gathering information about their experiences and identifying aspects of furniture that might pose challenges during study, work, or other daily activities.

Based on the information gathered, aspects related to comfort, reach to objects, organization of materials, available space for the wheelchair, and the need for adjustable and modular features were identified. The responses helped identify areas for improvement that can be considered in the development of a design proposal for an accessible desk.

An empathy map was created as a synthesis tool, organizing information on users' experiences, perceptions, actions, difficulties, and desired outcomes. This resource helps visualize the identified needs and relate them to potential design opportunities. The map is used to help synthesize the information gathered; therefore, any interpretations not directly derived from the responses should be considered hypotheses rather than confirmed findings.

The results of this phase serve as a basis for defining the desktop's key requirements and guiding the next stages of the design process.

Figure 1. Empathy map for wheelchair users, created to identify users' needs and design opportunities for a modular, accessible desk.



Source: Author's own elaboration.

Phase 2: Define

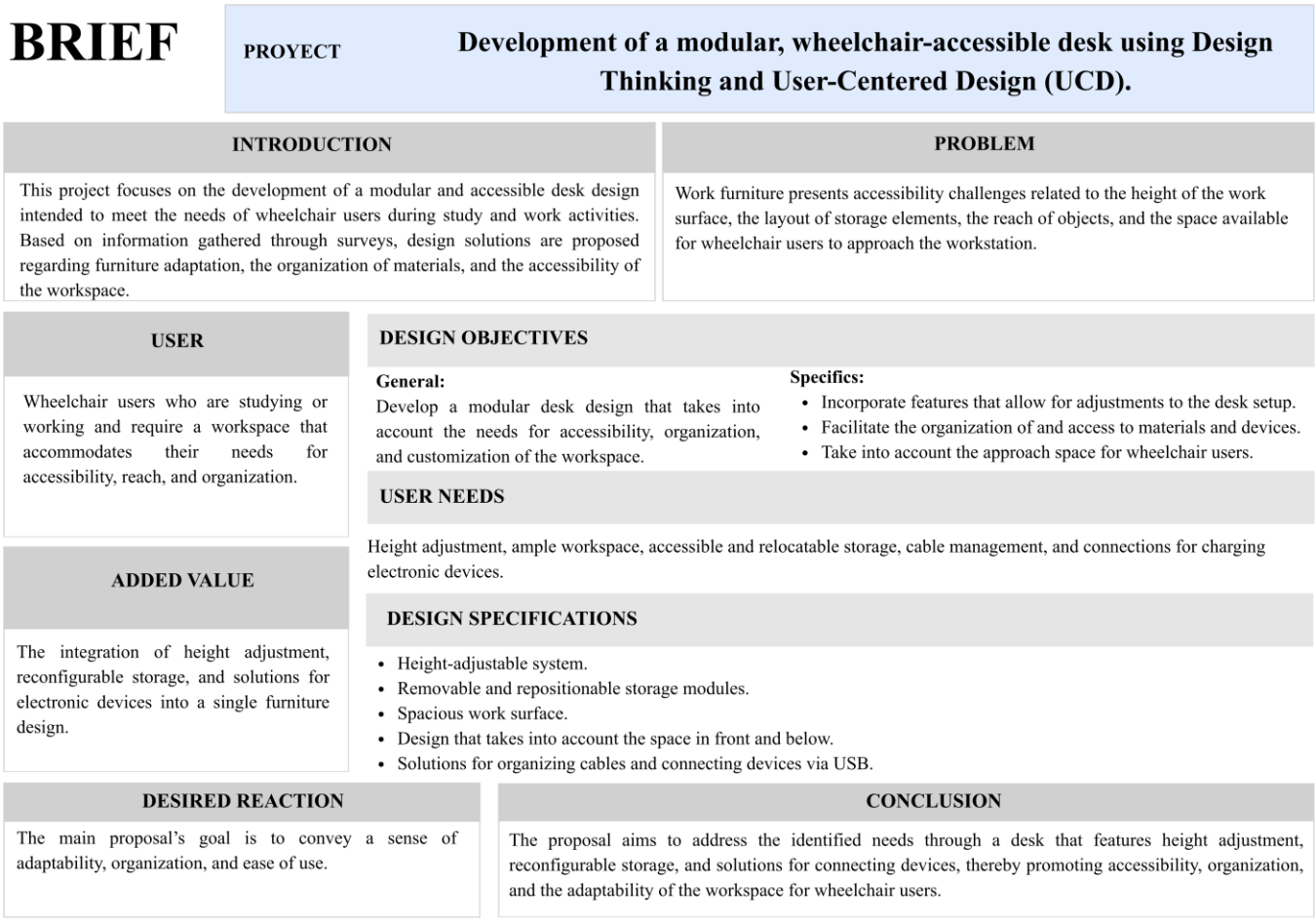
The next phase focused on synthesizing the information gathered through the surveys and the empathy map, with the goal of identifying priority needs and establishing the criteria that would guide the development of a modular, wheelchair-accessible desk.

Based on the results obtained, needs were identified related to adjusting the height of the work surface, the organization and accessibility of materials, the availability of space for various activities, the connection of electronic devices, and ensuring adequate space for wheelchair users to approach the desk. These needs served as a reference for establishing the functional requirements of the proposal.

In response to these findings, design criteria were defined to incorporate a height-adjustment system, removable and repositionable storage modules, a spacious work surface, cable management solutions, and USB ports for charging devices. Likewise, the structure configuration and the layout of the storage elements were considered to facilitate front access and, as much as possible, avoid interfering with the space designated for the legs and footrests.

The requirements were incorporated into a design brief that served as a guide for desk development.

Figure 2. Desktop design brief, based on a synthesis of findings and the definition of the product's functional needs and requirements.



Source: Author's own elaboration.

Phase 3: Concept Development

3.1 Ergonomic and Accessibility Considerations

In developing the proposal, the accessibility criteria established in the 2010 ADA Standards for Accessible Design were used as a reference to guide the dimensions and configuration of the desk, with the aim of facilitating its use by wheelchair users.

Factors such as the clear space for front access, the clearance beneath the desk for knees and feet, and the height of the work surface were considered. These criteria made it possible to establish initial parameters for the layout of structural elements and the space available to the user.

Table 3: Reference dimensions and ADA clearance criteria.

Criteria	Reference dimension	Application to design
Outer width of wheelchair	660 mm	Used to assess lateral space and access to the desk
Length of wheelchair, including footrests	1,065 mm	Designed to accommodate a wheelchair's depth
Clearance for frontal proximity	760 x 1,220 mm	Check the available space in front of the desk.

Kneeroom (high)	685 mm	Avoid interference with skirts, drawers, and crossbars
Kneeroom (width)	760 mm	Allow for frontal mounting under the cover
Turning radius	1,525 mm in diameter	For ease of use around the desk.

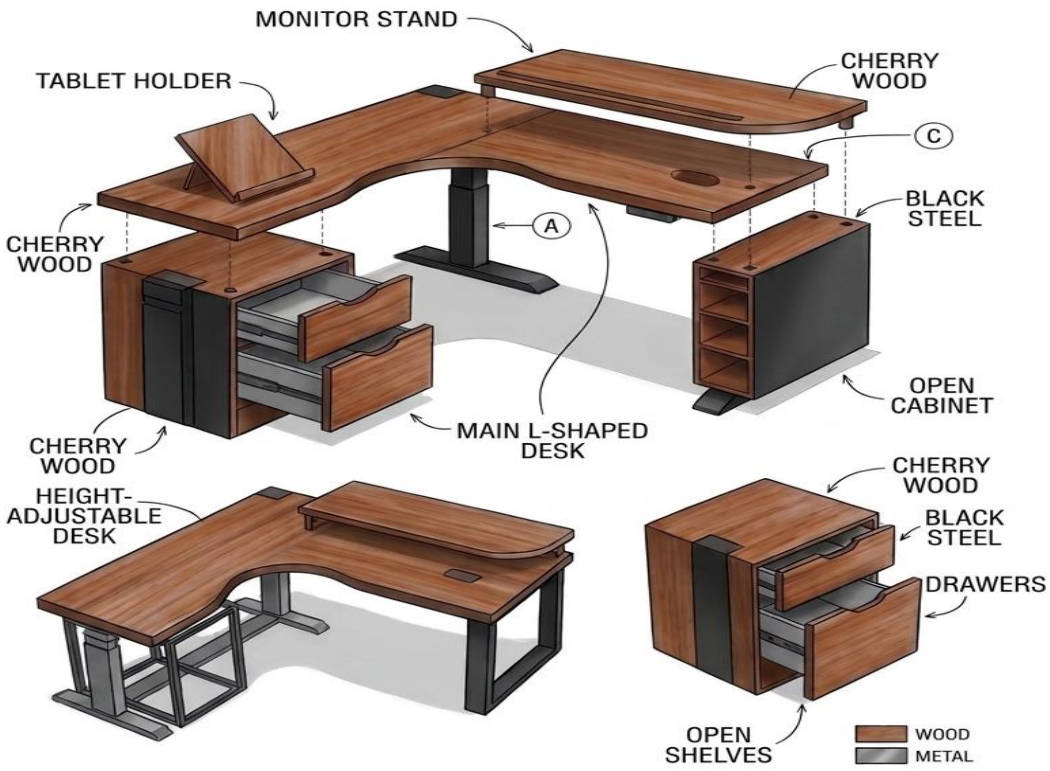
Source: Prepared by the author based on the ADA reference dimensions and clearance criteria.

3.2 Development of the Conceptual Proposal

Based on the requirements established in the definition phase and the previously identified ergonomic considerations, a conceptual sketch of the desk was developed, establishing its formal characteristics and overall configuration.

The proposal focused on integrating a functional work surface with a structure that would allow a wheelchair user to approach the desk from the front, considering the space required for the legs and the arrangement of the support elements. This sketch served as a guide for the subsequent digital rendering and the development of the design proposal.

Figure 3. Conceptual sketches of the desk developed based on functional, ergonomic, and accessibility requirements.



Source: Created by the author (digitized using AI)

3.3. Three-Dimensional Modeling and Material Selection

Subsequently, based on the conceptual sketch, a three-dimensional model of the desk was developed using SolidWorks 2025 software, with the aim of defining and visualizing its geometric configuration, proportions, and the arrangement of its structural components.

The proposal called for the use of wood for the work surface and steel for the support structure, seeking to combine a functional surface with a sturdy and stable structure. This combination of materials allows for the exploration of a solution that integrates functionality, durability, and constructability.

Digital modeling facilitated an overall visualization of the product and provided a reference representation for reviewing its dimensions and the spatial relationship between the desk and the user.

Figure 4: The three-dimensional model of the desk developed in SolidWorks 2025 based on the conceptual sketch.



Source: Author's own elaboration.

3.4. Visualization of the Proposal in Context of Use

Finally, a visual representation of the desk in interaction with the user was created to illustrate its appearance and show the relationship between the wheelchair and the furniture layout.

This representation helps convey the design intent and provides a preliminary visualization of the desk layout and use. However, the image is a conceptual representation and does not replace the verification of the product's dimensions, clearances, or accessibility.

Figure 5: Visualization of the proposed desktop in a real-world usage context with a wheelchair user.



Source: Generated using AI.

Phase 4: Prototyping

4.1. Development of the Digital Prototype

Currently, the project is in the 3D modeling phase, which is being carried out using SolidWorks 2025 software based on the previously defined conceptual sketch. This model allows us to visualize the desk's overall configuration, its proportions, and the layout of its components, as well as to establish a basis for its subsequent manufacturing.

The proposal calls for the use of wood for the work surface and steel for the support structure; the final selection of these materials and their technical specifications must be established prior to manufacturing.

To date, no physical prototype has been built; therefore, the evaluation of aspects such as structural stability, material strength, and the desk's performance during use remains pending. As a next step, the plan is to build a prototype to verify the design's characteristics and make any necessary adjustments.

Phase 5: Testing

5.1. Test Planning and Validation

The evaluation and validation phase for the desk has not yet been carried out, since so far only the 3D model developed in SolidWorks 2025 is available, and no physical prototype has been built.

Once the prototype is built, we propose conducting tests to verify compliance with the functional, ergonomic, and accessibility requirements established during the previous phases. These evaluations will help identify potential interference between the structure and the wheelchair, verify legroom, and assess the desk's stability and functionality.

In addition, we plan to evaluate user experience through user participation, with the aim of identifying opportunities for improvement in the configuration, dimensions, and interaction with the product.

The results of these tests will help determine whether the design meets the identified needs or requires modifications before a final version can be considered.

5.2 Proposed Tests

Since the tests have not yet been conducted, the following table presents the proposed evaluations to subsequently verify the desk compliance with functional, ergonomic, and accessibility requirements.

Table 4: Suggested assessment tests.

Aspect to Be Assessed	Proposed test	Objetive
Ergonomics	Review of dimensions and user posture.	Check that the height and workspace are appropriate.
Accessibility	Verification of frontal alignment and lower body measurements.	Identify any obstacles to wheelchair movement.
Stability	Evaluation of the structure's behavior under anticipated loads.	Ensure that the desk remains stable during use.
Functionality	Simulation of study or work activities.	Verify that the surface and layout allow for the intended tasks to be performed.
User Experience	Evaluation with representative users.	Identify challenges and opportunities for improvement.

Source: Author's own elaboration.

Research Design

This study is based on an applied research design focused on technological development, employing a mixed-methods (qualitative-quantitative) approach and a descriptive-propositional scope. The research adopts the Design Thinking process as its primary methodological framework, structured into five iterative phases (empathize, define, ideate, prototype, and test), aligned with the normative principles of User-Centered Design (UCD) stipulated in the ISO 9241-210:2019 standard and the guidelines for Inclusive Design.

The central goal is to address physical and ergonomic barriers faced by wheelchair users when using

conventional desks (such as height limitations, lack of clear front space, and difficulty connecting devices). The iterative model of Design Thinking allows us to move from qualitative empathy to the precise definition of technical requirements, ensuring that the proposal is not based on purely aesthetic or intuitive criteria, but rather on the needs expressed by the users themselves.

Population and Sample

The target population consisted of wheelchair users who engage in or could engage in study or work activities at a desk, as well as people who do not use wheelchairs. The latter group was included to compare perceptions and guide a design with an inclusive approach

The sample consisted of 10 participants, selected through non-probability sampling. Six participants were wheelchair users (four manual and two electric) and four were non-wheelchair users. Eight participants were men and two were women; five were between the ages of 18 and 24, and most resided in Pachuca de Soto.

The inclusion criteria were being of legal age, engaging in study or work activities at a desk, and voluntarily agreeing to participate; those who did not complete the questionnaire were excluded. Participation was voluntary.

Due to the small sample size and the type of sampling, the results are considered exploratory and cannot be generalized to the entire population of wheelchair users.

Table 5: Characteristics of the sample (n = 10*)*

Variable	Category	n
Wheelchair use	Yes, manual	4
	Yes, elecrtric	2
	No	4
Gender	Male	8
	Female	2
Age	18–24 years	5

Instruments and Data Analysis

For the Empathize phase, a questionnaire was designed using Google Forms and targeted at both wheelchair users and non-users. The instrument included a section on sociodemographic data (wheelchair use, gender, age, and place of residence) and two five-point Likert scales: 1 = No difficulty, 2 = Little difficulty, 3 = Moderate difficulty, 4 = Great difficulty, and 5 = Extreme difficulty

- Perceived Difficulty Scale (7 items): approach and positioning, leg and foot space, reaching for objects, desk height, organization of materials, posture during prolonged periods, and connecting devices.
- Scale of Feature Importance (11 items): height adjustment, under-desk clearance, materials within reach, removable storage modules, sufficient surface space, extendable auxiliary surface, cable management, USB and charging ports, easily accessible controls, rearrangement of components, and storage without reducing approach space.

Reliability Analysis (Cronbach's Alpha)

The internal consistency of the instrument's two Likert scales was assessed using Cronbach's alpha. Values of $\alpha \geq 0.70$ are considered acceptable; ≥ 0.80, good; and ≥ 0.90, excellent.

Table 6: Reliability Summary

Scale	Items (k)	Valid n	Cronbach's α
Perceived Difficulty	7	10	0.955

Importance of Characteristics	11	8	0.929
Combined Scales	18	8	0.939

Both scales show excellent reliability (α > 0.90). The Difficulty scale achieved α = 0.955 with all 10 cases completed. The Importance scale obtained α = 0.929 (n = 8 due to missing values). These results indicate high homogeneity among the items and good preliminary psychometric quality of the instrument.

Table 7: Descriptive Statistics – Difficulty Scale

Item	Average	SD	Range
Approach and position	2.50	1.08	1-4
Leg/foot space	3.00	1.25	1-4
Reaching for objects	2.90	1.37	1-5
Desk Height	2.80	1.48	1-5
Organizing materials	3.00	1.49	1-5
Posture / prolonged periods	3.60	1.43	1-5
Plugging in devices	3.80	1.69	1-5

The greatest difficulties are concentrated in “Plugging in devices” (M = 3.80) and “Posture during prolonged periods” (M = 3.60). The least difficulty is associated with “Reaching and positioning” (M = 2.50). The moderately high standard deviation reflects the diversity of the sample (wheelchair users and non-users).

Table 8: Descriptive Statistics – Scale of Importance

Item	Average	SD	Range
Height adjustment	4.20	1.14	2-5
Clearance below	3.80	1.03	2-5
Materials within reach	3.78	1.09	2-5
Removable storage modules	4.20	1.32	1-5
Ample counter space	4.20	1.03	2-5
Extendable side table	3.70	0.95	2-5
Cable management	3.33	1.50	1-5
USB ports / charging	4.00	1.33	1-5
Easily accessible controls	3.90	0.88	3-5
Reorganize components	3.80	1.14	2-5
Store items without taking up extra space	3.30	1.34	1-5

The features perceived as most important are height adjustment, removable storage modules, and sufficient countertop space (M = 4.20 in all three cases). Cable management and the ability to store items without reducing the approach space received the lowest average scores. Overall, the importance of scores is high, which validates the relevance of the proposed features for desk design.

RESULTS AND DISCUSSION

The results are presented in two sections: the preliminary findings from the Empathize phase, obtained through the questionnaire and the empathy map, and the design outcomes derived from them. The project is currently in the 3D modeling stage, so no usability or user testing results are available yet.

Findings from the Empathize Phase

Internal consistency of the instrument. Both scales showed Cronbach’s alpha values greater than 0.90 (Table 7): 0.955 for perceived difficulty (n = 10) and 0.929 for importance of features (n = 8). These values indicate consistency among the items but should be interpreted with caution due to the small number of cases and items.

Perceived difficulty. The greatest difficulties were plugging in devices (M = 3.80; SD = 1.69) and maintaining posture for prolonged periods (M = 3.60; SD = 1.43). The lowest difficulties were related to reaching and positioning (M = 2.50; SD = 1.08) and desk height (M = 2.80; SD = 1.48; Table 8). The high standard deviations show that experiences varied considerably among participants.

Importance of features. The most highly rated features were height adjustment, removable storage modules, and sufficient countertop space (M = 4.20 for all three), followed by USB and charging ports (M = 4.00). The lowest-rated features were cable management (M = 3.33) and the ability to store items without reducing space (M = 3.30; Table 3). All means were above the midpoint of the scale (3.00).

Synthesis using the empathy map. The map (Figure 1) organized the users' experiences around three ideas: the difficulty of approaching the desk due to lower elements that reduce legroom and footrest space; the effort required to reach objects and connect devices; and the desire for adaptable furniture with relocatable storage.

Design Results

The findings above were translated into design criteria incorporated into a brief (Figure 2) and a desktop concept (Figures 3–5). The ADA reference dimensions (Table 3) guided the knee clearance and front approach. Table 9 shows how each finding relates to a feature of the proposal.

Table 9: Traceability between findings and design features.

Finding (Empathize phase)	Design criterion	Feature in the proposal
Height adjustment, M = 4.20	Adjustable work surface height	Height adjustment system
Removable storage modules, M = 4.20	Relocatable, removable storage	Independent storage modules
Ample counter space, M = 4.20	Wide work surface	L-shaped work surface
Plugging in devices, difficulty M = 3.80; USB ports, M = 4.00	Device charging within reach	USB charging connections
Clearance below, M = 3.80	Free frontal and lower space	Open space for knees and feet (ADA reference)

Source: Author's own elaboration.

DISCUSSION

The high rating given to height adjustment is consistent with the reviewed literature (Table 1), where adjustable height is the most frequently recommended feature in studies and guidelines on accessible desks. It also aligns with the experimental study that found that the optimal desk height varies depending on users' injury levels, which supports an adjustable system rather than a fixed height. The importance placed on removable modules aligns with research on modular and adaptable furniture, which presents them as a means of customization according to individual needs.

A striking finding is that plugging in devices was the greatest difficulty, while cable management ranked among the least valued features. One possible explanation is that participants perceive the problem of connecting devices—due to reach or trunk tilt—but do not associate it with cable management as a solution. This is a hypothesis that would require interviews or usability testing. If so, it has a design implication: it is advisable to address device connectivity based on their location, rather than simply organizing the cables.

It was also unexpected about that approach and positioning—which the literature identifies as the central barrier—were rated as the least difficult. Given that 4 of the 10 participants do not use wheelchairs, it is possible that their responses lowered the average. This reinforces the need to analyze wheelchair users separately in later stages, using a larger sample.

Overall, the results do not confirm the desk's effectiveness but do provide preliminary support for the relevance of the defined features. The reviewed literature shows that few proposals integrate modularity, removable storage, and device charging into a single concept, and this study represents a step in that direction. It's true validation will depend on the fabrication of the prototype and the user testing described in Table 4.

CONCLUSION

This study provides preliminary evidence of the value of integrating participatory methodologies such as Design Thinking and User-Centered Design (UCD) with anthropometric and ergonomic criteria in the development of accessible workstations for wheelchair users. Based on a review of the literature and participants' responses, the research identified potential operational barriers associated with conventional furniture: fixed dimensions, lack of under-desk clearance for limbs and footrests, difficulties connecting devices, and limited access to storage modules. Based on an exploratory survey—whose scales showed high internal consistency ($\alpha > 0.90$)—the conceptual design of a modular desk was developed, incorporating height adjustment, unobstructed front space, reconfigurable storage, and accessible charging ports.

From a theoretical perspective, this study proposes a way to link the anthropometric dimensions of motor disabilities and accessibility standards (such as the ADA and ISO 9241-210) with iterative ideation and prototyping processes. On a practical level, the proposal presents a conceptual solution for the furniture design industry that aims to promote proper posture, reduce postural discomfort, and foster the autonomy and inclusion of users in academic and workplace settings—aspects that will need to be verified through the prototype.

Among the project's main limitations are the small sample size in the initial phases of user research, as well as the conceptual nature of the proposal, which does not yet include a physical prototype or user testing. Additionally, the diversity in wheelchair models and in users' levels of disability or mobility introduces individual variations that require ongoing analysis of customization. Future work will involve manufacturing the prototype and evaluating it with a larger group of wheelchair users, analyzing the results separately.

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