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FURNITURE DESIGN FOR THE VISUALLY IMPAIRED PEOPLE

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Abstract:
The design of furniture products should be reinterpreted, specialized and adapted to the needs of people from different backgrounds or social categories. For these reasons, it is necessary to know more about the needs or problems of the disadvantaged people. Through this work, a detailed study has been made of the categories of visually impaired people and the varying challenges that they face with the differences caused by the different eye diseases or disorders. It must be understood that blind people can be independent and by creating a new concept of furniture specialized for them will make this transition to independent living possible with fewer problems. At the same time, it is also important to study the way of life and lifestyle of these people through documentation and through direct discussions with those in this situation. For instance, through interviews with teachers and blind students from the Regina Elisabeta Special High School in Bucharest.

Based on all the information, the project has taken on new meanings and must satisfy users by solving the movement, functional, chromatic and textural difficulties they encounter. We made various sketches and 3D models for a good understanding of the problem and the relation to the future user, as well as the space where most accidents occur: the kitchen.This led to the design of the LIGHTOUCH kitchen furniture set for the visually impaired. The concept aims to experience design through touch, texture and shape and much less through colour.

Key words: *visually impaired; furniture design; kitchen furniture; concept.*

INTRODUCTION

Being aware of the diversity of problems faced by people with visual impairments and the few solutions offered in society to improve their standard of living and the environment, we considered the implementation of furniture adapted to them as a useful and topical solution for the disadvantaged people because of the medical difficulties related to vision.

The lack of research into the organization and implementation of a special furniture and living environment for visually impaired people means that they are subject to various challenges and difficulties, including in their own homes. From the variety of objects or their functions that expose them to risks of injury, due to the lack of knowledge of the place or purpose of certain household objects, these people need guidance in their use. This help does not necessarily have to come from people who constantly supervise the activities of blind people, but can directly come from the shape, functionalities, positioning and warnings specifically designed to meet the needs of users, based on other senses such as touch or hearing. By implementing private furniture dedicated to the needs of people with visual impairments, a promising way can be provided to improve the usefulness of visually impaired people's homes.

OBJECTIVE

This study aims to develop a special furniture design for the visually impaired and will focus on kitchen furniture, the area where people with visual impairments carry out their daily activities and are exposed to several hazards**.** The implementation and incorporation of special furniture for the visually impaired will reduce the problems of the visually impaired and will also create a unique design concept, poorly studied worldwide. In this way, these people will no longer need various improvisations coming to their aid, but there will be a design that is harmonious both to the eye of the able-sighted person, but also suitable for the needs of the blind people.

METHODS

The design process was focused mainly on documentation about visual impairment, brainstorming and interviews with partially and totally blind students and teachers from the Regina Elisabeta Special High School in Bucharest - the first school for the visually impaired in Romania (est.1918).

STATISTICS

Current data on the reasons for sight problems provide an important background to the research and indirectly suggest recommendations in order to make the environment as pleasant as possible for blind and sight impaired people. The centralised databases allow interpretation of data on the causes of sight loss from 1990 to 2020. The sources include estimated but important data for establishing the proportion of mild, moderate and severe visual impairment and blindness by causative disease, age, region and years of study (Flaxman et al. 2017).

According to the World Health Organization, about 1.3 billion people worldwide live with some type of vision impairment. These can be mild, moderate, severe or complete blindness (Flaxman et al. 2017).

The global population with moderate or severe vision impairment has increased since 2015 from 216.6 million by 2020 to 237.1 million. The main causes were uncorrected refractive error (from 116.3 million to 127.7 million), cataract (from 52.6 million to 57.1 million), age-related macular degeneration (from 8.4 million to 8.8 million), glaucoma (from 4.0 million to 4.5 million) and diabetic retinopathy (from 2.6 million to 3.2 million). Also, the global population that was completely blind in 2015 increased from 36.0 million to 38.5 million by 2020. The main causes were cataract (from 12.6 million to 13.4 million), uncorrected refractive error (from 7.4 million to 8.0 million) and glaucoma (from 2.9 million to 3.2 million) (Table 1) (Flaxman et al. 2017).

Table 1

Estimated number of people affected (millions) by blindness and visual impairment by region and year (Rupert 2017)

Region	Blindness		Moderate and severe vision impairment		Mild visual impairment	
	2015	2020	2015	2020	2015	2020
Pacific Asia	0,55	0,56	5,01	5,26	4,86	5,08
Australia	0,07	0,07	0,63	0,69	0,61	0,67
Central Europe	0,53	0,52	2,84	2,86	2,65	2,66
Eastern Europe	0,86	0,80	6,31	6,14	5,79	5,66
Western Europe	1,16	1,16	9,61	9,99	9,47	9,84
North America	0,98	1,03	7,46	8,13	7,25	7,90
Global level	**36,02**	**38,50**	**216,60**	**237,08**	**188,54**	**205,73**

Blindness and visual impairment at all ages in 2015 were more common among women than men according to the overall crude prevalence shown in Table 2.

Table 2

Population prevalence globally affected by blindness or visual impairment compared between both sexes (Rupert 2017)

Gender	Blindness (%)	Moderate and severe vision impairment (%)	Mild visual impairment (%)
Male	0,24	1,94	1,93
Female	0,39	2,88	2,71
Total	0,32	2,42	2,33

REQUIREMENTS FOR PEOPLE WITH VISUAL IMPAIRMENTS

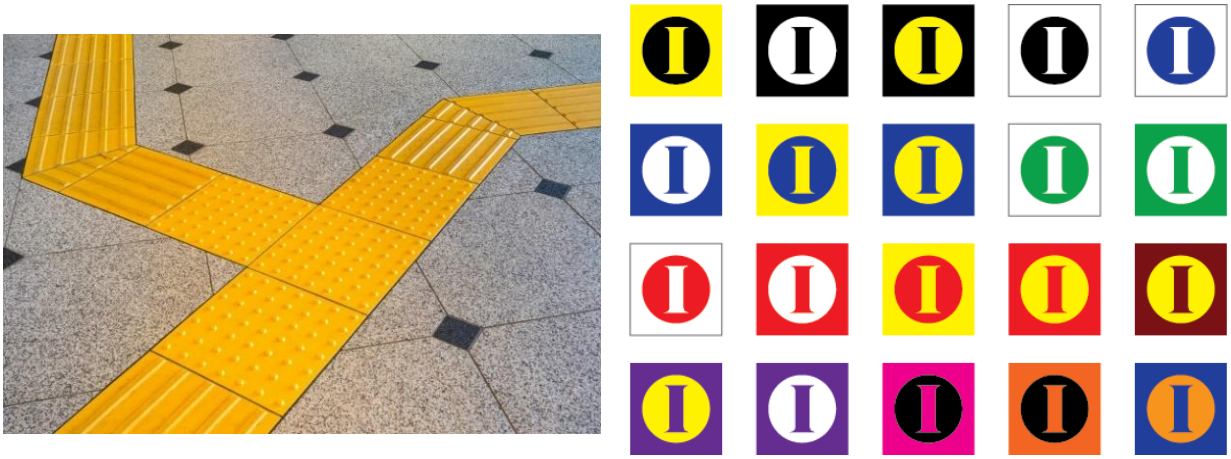
Nowadays everyone is moving towards an independent lifestyle, and this is also present in the lives of the visually impaired. They have adapted their way of coping in society with new technologies and assistive devices, often with no obvious differences from sighted people. Designers are meant to make people's lives easier by working close to their needs and making spaces usable for everyone. There are established international standards for blind-specific design that the designers should follow so that blind people can navigate easily, safely and comfortably (Daniel 2018, BigRentz 2019).

In order to design spaces and furnishings effectively for people with low vision, it is necessary to understand the adaptations of navigating in a world with limited vision. It should be noted that most people who are legally blind have some degree of vision. These people can also orient themselves by visual cues, but also rely on textures, tactile bumps and sound signals (Fig. 1a) (BigRentz 2019).

Use of recognizable textured markings, stickers with embossed letters or the Braille alphabet can help distinguish certain objects. This special alphabet is mainly used for more detailed identification of certain features. The concern with Braille is that it can be time-consuming and embossed symbols can be more useful in this regard (Daniel 2018, BigRentz 2019).

Adding tactile elements will help for ease of navigation in the home and space recognition. For example, textured upholstery can help to identify the piece of furniture in question, but also the room in which it is located (Daniel Horning 2018).

It is important to use contrasting colors (Fig. 1b) for everything that is a barrier for the visually impaired. Marking strips have contrasting colors and are used to mark the edges of objects (BigRentz 2019). Contrasting colors also serve to visually mark certain objects or changes in a surface, indicating edges of objects. Bright colors such as orange, yellow or red are easy to see and dark colors are used to mark the outlines of objects (Daniel 2018, BigRentz 2019).



a. **b.**

Fig. 1.
Contrast forms:
a-texture contrast; b-chromatic contrast.

Illumination or bright contrasts can help visually impaired people see areas of interest, or have the function of marking places that may put people at risk. The light should always be uniform, directed towards the focal point and not towards the eye. Ground lighting can help to form a stronger chromatic contrast for distinguishing the area of movement (Daniel 2018, BigRentz 2019).

Light can be used to mark directions of movement, barriers created, workspaces, interiors of storage spaces or spaces under furniture (Fig. 2). Artificial lights added in areas of chromatic contrast help people to perceive differences even after sunset or lack of natural light. The area of change of a level should be clearly indicated by implementing contrasts and the necessary lighting. Work areas have a visual advantage if placed close to natural light sources (Daniel 2018, BigRentz 2019).

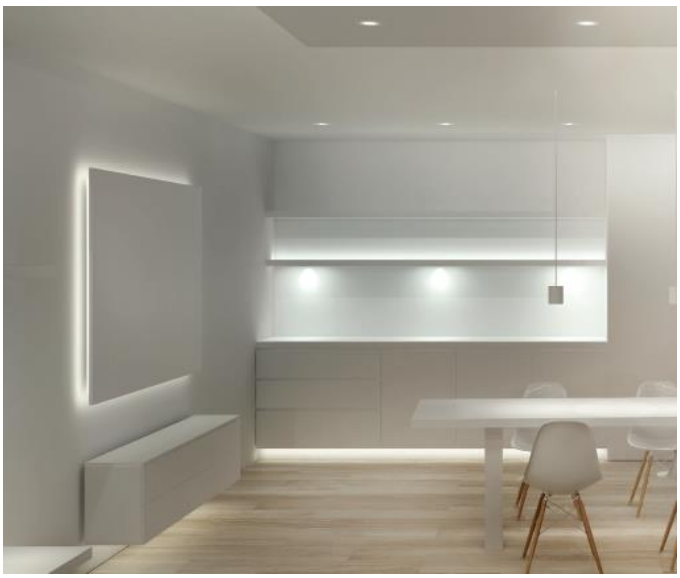


Fig. 2.
Furniture illumination.

To ensure correct movement, clear barriers must be created to prevent movement in certain undesirable directions. Limiters should be at a favorable height so that they do not represent a risk of obstruction if they are too low or an obstacle if they are too high. Any short object is dangerous and should be avoided, as should hanging objects (Daniel 2018, BigRentz 2019).

Balustrades are necessary as they have a guiding role (Fig. 3a). They should also be placed at an optimal height, easily accessible so that the route is easy to follow. Support and guide rails are recommended in areas at risk of slipping (Daniel 2018, BigRentz 2019).

Dot or stripe stickers are recommended on the glass to improve its visibility (Fig. 3b). Clear glass is difficult to see. Even mirrors should be strategically placed to avoid light reflection or glare (Daniel 2018, BigRentz 2019).

a. **b.**

Fig. 3.
Guidance and alerting: a- guide balustrades; b-alerting stickers on glass.

Warning signs for potential hazards such as doors or drawers left open should be present. Door frames should be chromatically marked to prevent accidents. Self-opening doors or sliding doors that move outward from the point of interest or away from the direction of travel are favorable (Fig. 2.1.6) (Daniel 2018, BigRentz 2019, Duffy 2019).

In the kitchen, there are multiple problems in adapting furniture and objects used in the premises. Flat-top hobs need to be replaced by those with well-defined, raised burner areas. A tray specifically designed for preparation in the kitchen will help to avoid a messy environment and maintain organized (Daniel 2018).

Any object should be kept in its well-defined place. Knives or other dangerous items should be kept in places that prevent injury. Labels can mark different items and their uses, and dividers in storage areas can help with internal organization (Daniel 2018, BigRentz 2019).

Hearing is a sense that blind people use to navigate the world. Some textured surfaces can emit different sounds and perform audible warning functions. Spaces favorable for sound detection are those where echoes are minimized, providing additional information about surroundings (Fig. 4). Auditory signals such as alarms or countdown rhythms are needed in areas with low or no safety (BigRentz 2019).

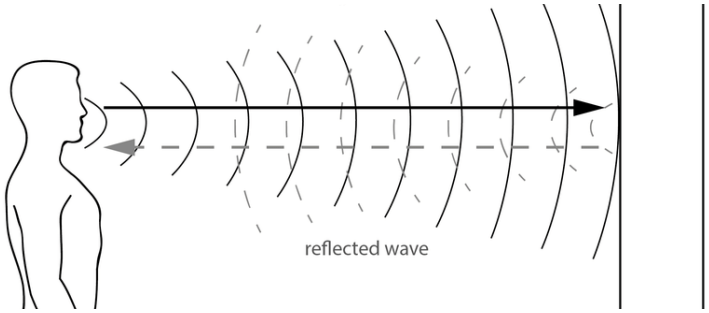


Fig. 4.
Echolocation navigation and orientation.

Technology also often comes to the aid of the visually impaired and can help them lead a more normal lifestyle. For example, text magnification applications are used via phones or speech synthesis functions for reading text (BigRentz 2019).

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pp. 142-161

INTERVIEW AND BRAINSTORMING

In the summer of 2021 a documentation trip took place at the Regina Elisabeta Special High School in Bucharest, sector III, situated on Vatra Luminoasă street. This school is intended for the education of blind students from all over the country. With the agreement of the school management and teachers, we made a photographic documentation and a recorded interview with blind teachers Iulian Leșeanu (a completely blind teacher), Cătălin Nicolaidi (a teacher with severe visual impairment) and students.

During the visit, photographs of the school space were taken which helped to better understand some of the special needs of blind people. From the entrance to the inner courtyard there were guide bars placed next to each wall (Fig. 5) and kept on the pathways, with the purpose of orienting students to the annex buildings. The benches in the rest areas were curved so that students or teachers would not injure themselves while using them.

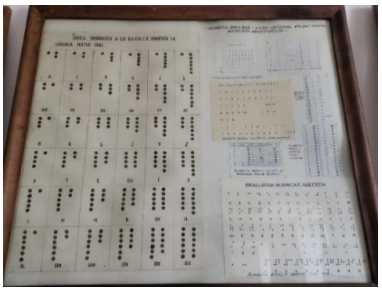
a.

b.

c.

Fig. 5.
Navigation and orientation using railings.

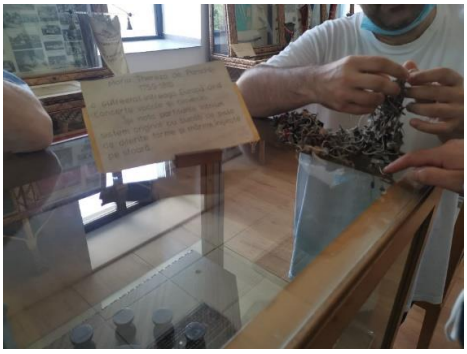
Inside the building we were led to a room called the school museum. There we learned various stories about the history of the visually impaired and experienced some of what it is like to actually "see" from a blind person's perspective. There were various devices, inventions and creations on display to teach the blind: special typewriters, drawing instruments, brushes, various upholstery and textures or technological devices. (Fig. 6c). There was also no lack of documents made in relief such as maps or books using the Braille alphabet (Fig.6a, Fig. 6b). Even the music score was based on tactile senses in the form of knots on a string (Fig. 6d). As for the furniture, we noticed that the museum's display cases had very high legs and did not allow bumping in the lower part. The upper parts of the cabinets were more recessed in volume. They were also made of a softer material. (Fig. 6e, Fig. 6f).



a.

b.

c.



d.

e.

f.

Fig. 6.
The school museum: a- Braille alphabet; b- Documents made in relief; c- Tactile music device; d- Tactile music score; e-Specially designed cabinets; f-Height of the cabinets.

After this visit we went into a classroom and selected from the interview the statements made by blind teachers Iulian Leșeanu, Cătălin Nicolaidi and students, each with different visual impairments. With their agreement, keeping the original text and the words used by the interviewees, we have tried to reproduce the importance of the issue of furniture for the visually impaired:

Q: What do you find disturbing about the furniture you use in your daily life?
A: - The right corner is dangerous [...] it can be masked [...], but ideally it should not protrude out of the volume. I've seen display cases where the glass is not surrounded by something... Never... Anything that means glass has to be surrounded by something [...] So glass must be avoided.

Q: Why do you use high legs for the school furniture?
A: - The height of the legs is higher for ease of cleaning and to prevent the risk of bumping into the feet [...] psychologically speaking we see the space under the table when we imagine it [...] we still mentally visualize that space. If I don't have the possibility to enter that area, I have the feeling that the room is not clean. Also these fixtures have to be very stable [...] When I move around the house I still trip over fixtures [...] It is not necessary to fix them in the floor.

Q: Do you consider additional markings on furniture helpful?
- Markings on major equipment can help: oven, hob, cooker [...] for the blind, touch and hearing are two extremely important senses.

Q: Would you rather use the Braille alphabet to mark certain functions?
A: - The Braille alphabet is used on a non-stop on a 24-hourbasis [...] Text is used in both the normal alphabet and Braille (showing the teacher's plate in Fig. 7)

Fig. 7.
The teacher's plate.

Q: Would you choose holders for various utensils specially placed on the top plate of the furniture?
A: - Preferably the working area should be as free as possible [...] Areas for stands can be marked, even for knives.

Q: Can you give us examples of tactile analysis of an object?
A picture was brought in on the basis of which the teacher interpreted by touch and showed how to analyze such an image (Fig. 8).

a. **b.**

Fig. 8.
Interpreting a picture: a- Interpretation by touch; b. visual reference.

A: - I palpate the entire surface, then move from the edges to the center to get the picture. There are very large textural contrasts when you put your finger on it. [...] Next to the painting there is a Braille guide that tells what is happening or what is found in the painting and how to interpret the various materials, for example velvet.
Reference was also made the game of chess specially designed for visually impaired.
- For example the size of the chessboard is not chosen randomly. When you open your palms you can feel the whole board.

Q: What do you find disturbing about the furniture you use in everyday life?
A: - I for one prefer to pull the doors shut and not have them protrude outwards. I forget that the door is open and I bump into them [...] preferably sliding doors [...] even with audible warning signals or the possibility of automatic door closing, for those with children. I have sharp handles at home that are annoying [...] There are soft guards as well as childproof ones [...] to be placed directly on the furniture.

Q: How do you use color contrast to your advantage?
A: - Blind people are guided by visual markers related to color, contrast that makes you stand out [...] Black or blue-white [...] light colors in contrast to dark ones [...] Contrast can be discussed depending on the vision problem. There are people who read black with a white background better, or vice versa.

Q: Do you think you would find raised guide elements on furniture helpful?
A: - (Cheerful) It would be interesting to have icons to express the shapes [...] rather to be recognizable and colored differently [...] Markings on the furniture that the person can move around [...] For the more non-disabled, these symbols or raised icons can be applied for guidance [...] Each person with the same visual impairment has adapted differently to the overall situation. [...] One aspect to take into account are the games - chess (Fig. 9), rummy. The rummy board is made with a stable base so that it does not move. In chess you can see differences with relief: black in relief, white at the bottom and holes for inserting the piece [...] pieces are pointy for differentiation and are not depending on the color [...] black has a sharper point.

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pp. 142-161

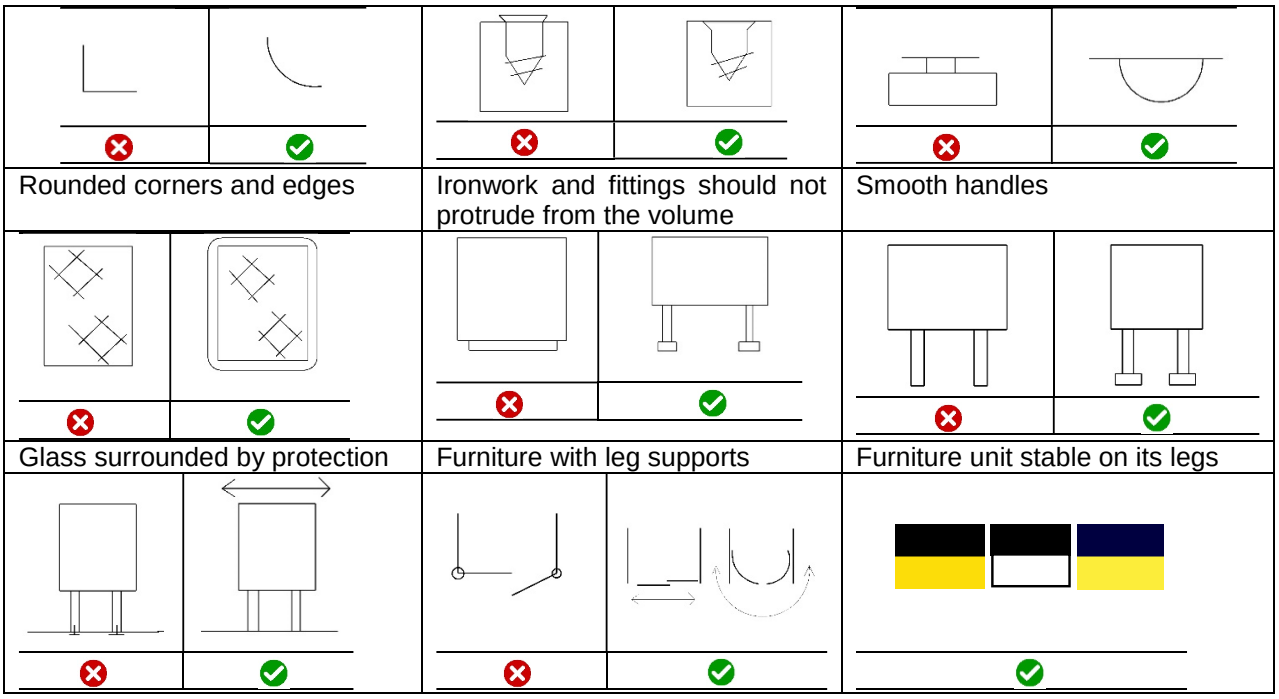
Fig. 9.
Chess board adapted for visually impaired.

Q: Do you think the use of suspended fixtures should be avoided?
A: - Suspended bodies need extra protection, a softness provided by other materials [...] The suspended body should be made so that it doesn't hit you.
Q: Do you consider the use of light necessary when talking about furniture?
A: - Light sources should be everywhere. Light helps me even if I only have small supplies in my sight at the moment.

After the interview Professor Nicolaidi addressed us as follows: “Thank you for your interest. This is the first time anyone has thought of something like this. Good luck with the project!”.

RESULTS - LIST OF SPECIAL REQUIREMENTS FOR THE VISUALLY IMPAIRED

While all people with sight loss are different and there are varying degrees of visual acuity impairment, there is also the problem of perceiving spaces and objects around in different ways. When designing for people with low vision, everyone's special needs must be taken into account. Putting into practice the knowledge gained about their diverse situations is a challenge for designers. For this reason the first step was to draw up a list of needs that would help in the development meeting with the standards for the final furniture product (Fig. 10).



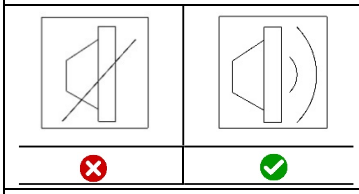
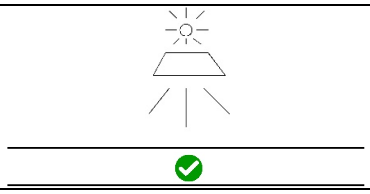
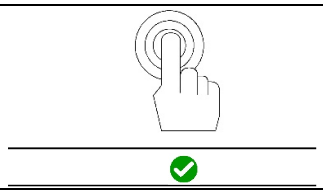
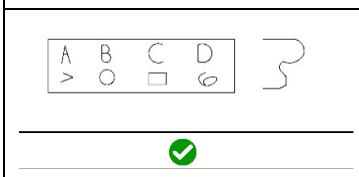
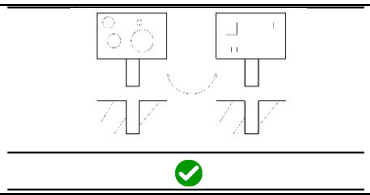
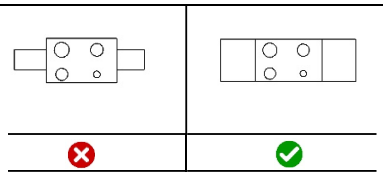
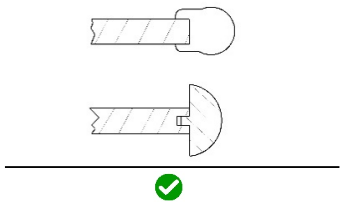
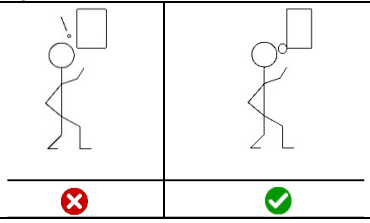
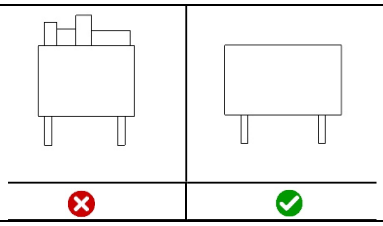
Furniture body not fixed into the floor	Sliding doors without protruding from the volume	Strong colour contrast
		
Auditory warning signals	Lighting throughout the whole work area	Tactile detection
		
Recognizable symbols with various roundings	Interchangeable recognisable symbols	Distance from risk areas
		
Rounded edges	Suspended cabinets with additional protection	Free worktop with no other obstacles

Fig. 10.
List of needs for visually impaired furniture.

SKETCHES AND CONCEPTUALIZATION

One of the most important steps is to find conceptual solutions to the new idea by making sketches and 3D models. These are intended to guide you towards certain visual references or ideas that can be further developed in the concept. In the following sketches will be presented the starting point where the new object will be born.

It was decided to use the L-shaped furniture layout in the following creations. This shape offers a functional layout that is advantageous for the blind (Fig.11).

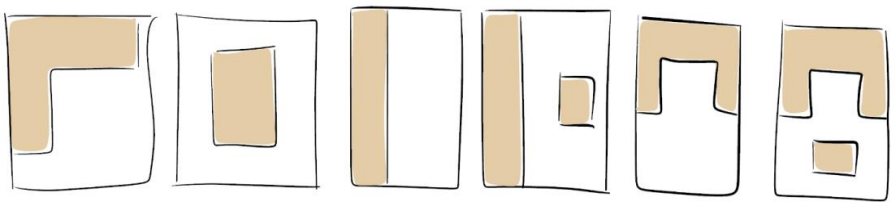


Fig. 11.
Sketches of ideas for arranging kitchen furniture.

The most favourable light source for this type of furniture is LED strip or profiled (Fig.12).

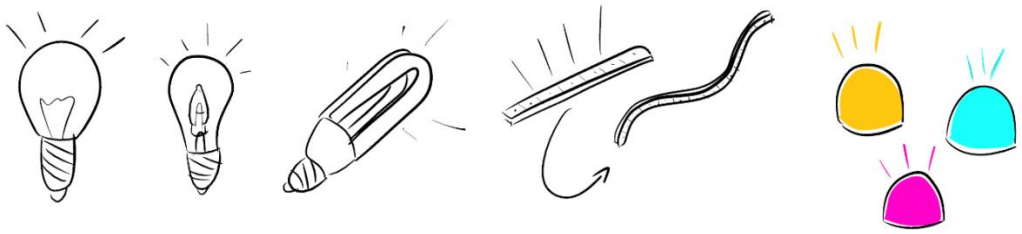


Fig. 12.
Sketches for the lighting source of furniture.

In addition to the appliance (sink, hob, oven, hood), integrated or next to the kitchen furniture are other instruments such as fridge, toaster, knife rack, microwave, kettle, dishwasher that should be considerated (Fig.13).

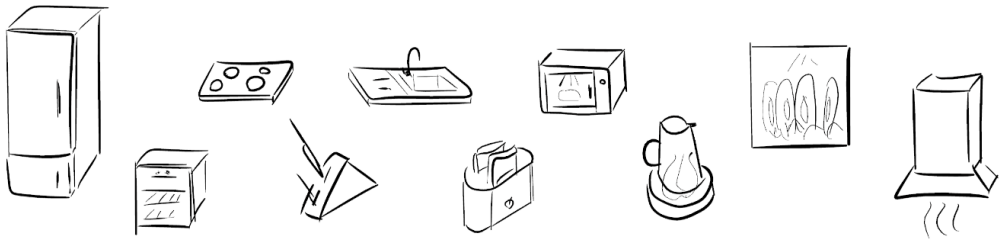


Fig. 13.
Sketches of equipment integrated in or assembled with furniture.

In the design of the new concept, the senses that visually impaired people rely on should not be omitted. These perceptions must be stimulated by shape, color or texture and by the emission of sounds (Fig.14).

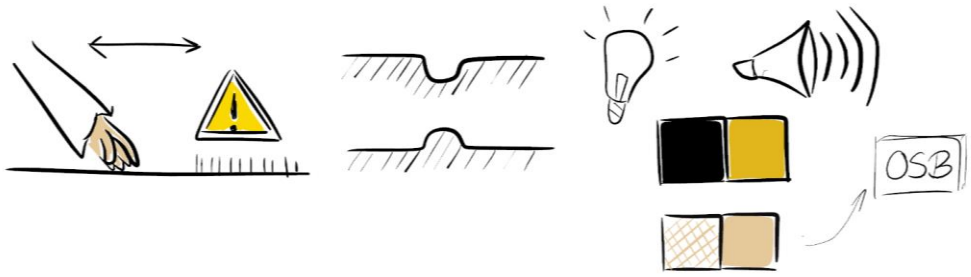


Fig. 14.
Sketches on various ways of alerting users.

The objective of the new kitchen furniture design is to guide the user through the shape to different areas without obstructing movement. This help must be available both horizontally and vertically to prevent various injuries (Fig.15). The guide bar will have a section allowing it to be reached by hand, acting as a tactile signal for orientation (Fig.16).

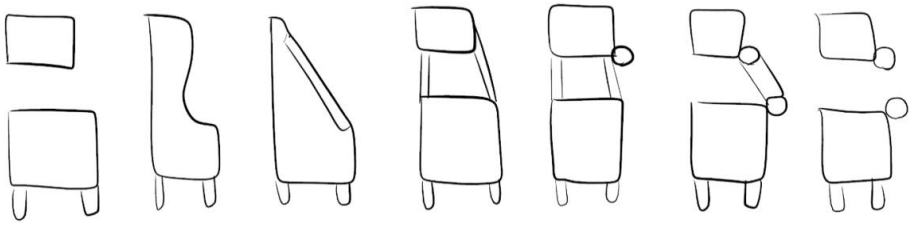


Fig. 15.
Sketches of the shape of the furniture object.

The legs will have extra lengths to meet the requirements of blind people to be able to reach under furniture for cleaning. These will have rounded edges and corners, extra guards or be more recessed to prevent bumping or tripping (Fig.17). It is also desired to eliminate head injury by subtracting the upper cabinet or by adding material with a certain roundness and softness (Fig.18).

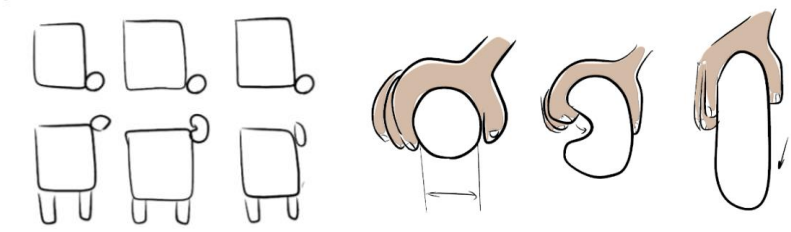


Fig. 16.
Sketches of the shape of the guide bar section.

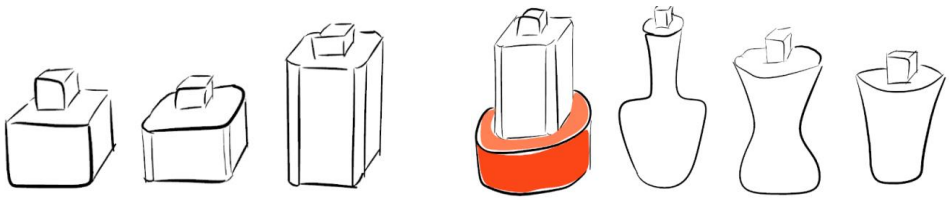


Fig. 17.
Sketches of the shape of the legs of new kitchen furniture.

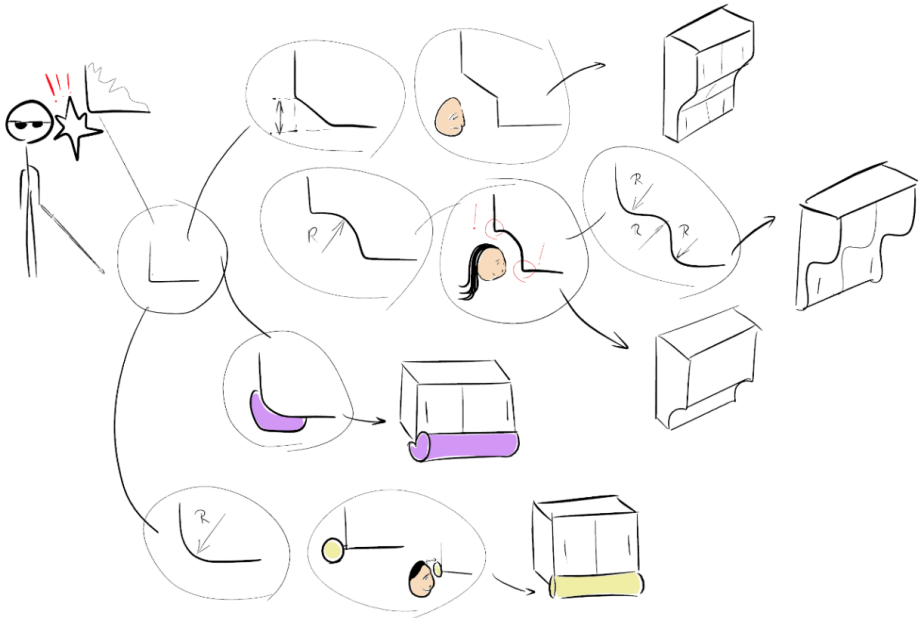


Fig. 18.
Sketches on solving the head banging problem.

One of the problems with doors is that blind users may forget they are open and trip or bump into them. For these reasons, furniture will feature sliding or roller shutter door systems that do not protrude out of their volume when opening and also prevent people from unwanted accidents (Fig. 19, Fig. 20).

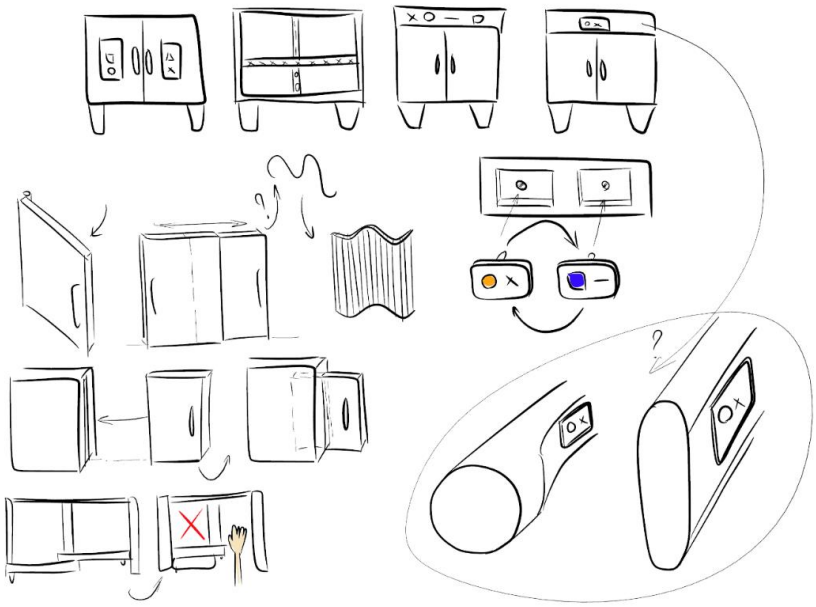


Fig. 19.
Sketches on the use of identification symbols on the furniture surfaces.

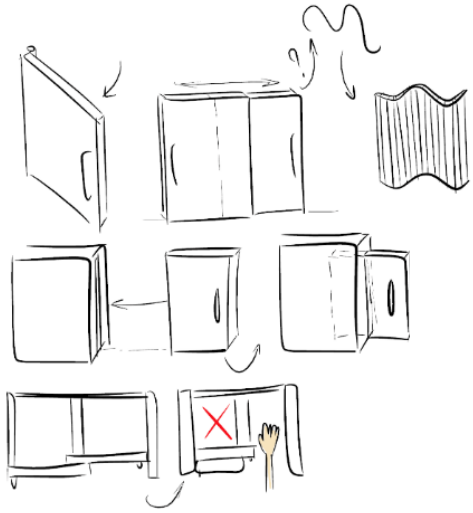


Fig. 20.
Door opening system sketches.

This analysis found that the optimal place to use recognizable symbols to identify object compartments or device areas is the guide bar that users will touch when moving. This idea also represents a desire for tactile design for the blind. At the same time, these elements should perform the function of interchangeability according to their preferences. This function can be performed by means of magnets. These magnets shall be present on both the symbol plates and the support bar to ensure positioning in the intended location. The tiles will have different textures and the symbols will be embossed for easier tactile detection. Consideration will be given to rounding the edges or even providing additional protection (Fig. 21). The symbols that will appear on the furniture plates will illustrate various utensils used or stored in the kitchen, warnings or instructions related to the use of the kitchen appliances. For example, a wet zone warning in the sink area or tactile instructions to switch on or off the hob burners (Fig. 22).

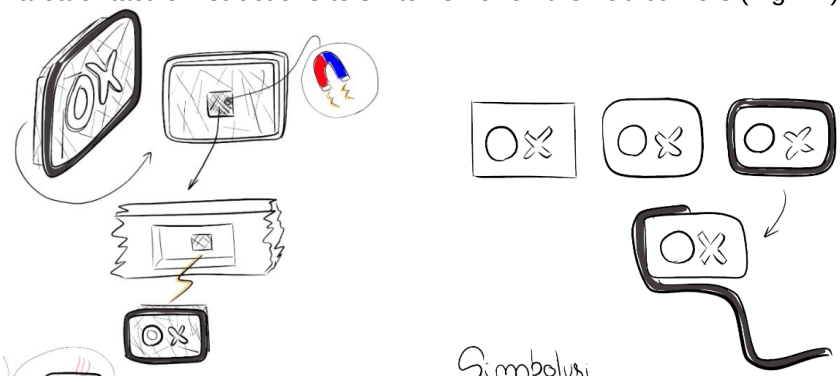


Fig. 21.
Sketches for the edges with interchangeable plates.

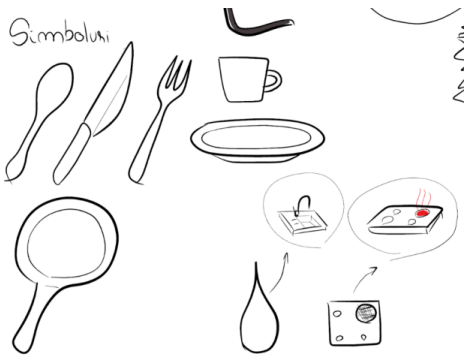


Fig. 22.
Sketches for creating interchangeable tile symbols.

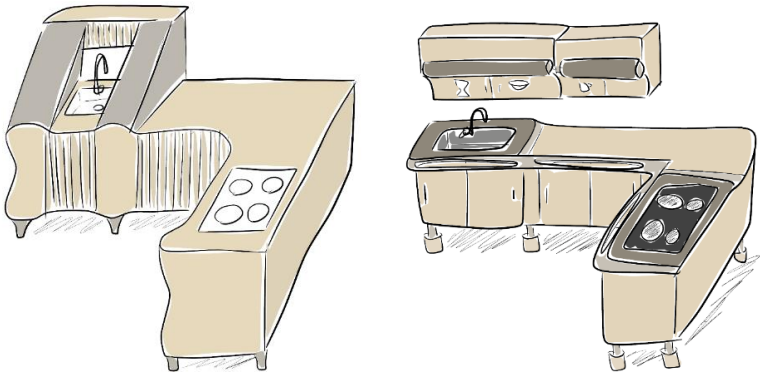


Fig. 23.
Sketches containing some furniture concept variants.

In the phase of finalising the conceptual idea for the kitchen furniture addapted to visually impaired, the sketch was selected as the foundation on which to continue the design concept (Fig.24), followed by the 3D representation of the new model in the SOLIDWORKS design program (Fig. 25).

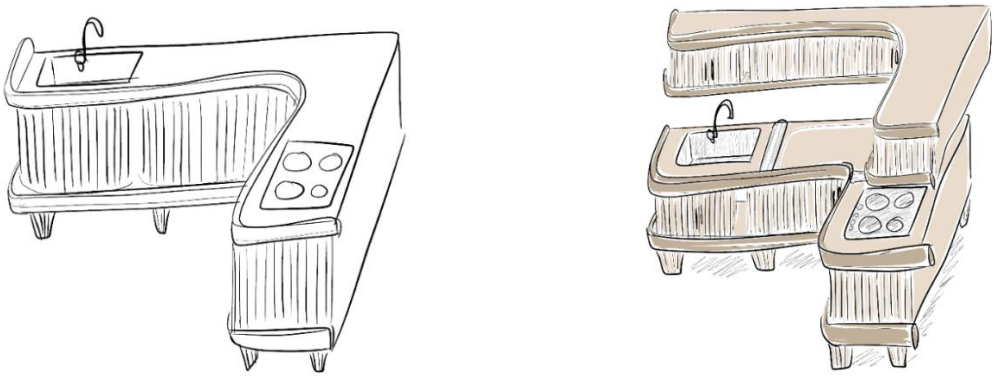


Fig. 24.
Final concept sketches.

Fig. 25.
3D modelling of the new concept (SOLIDWORKS).

With the help of 3D modelling of the product concept, certain problems or potential improvements that may occur in the final structure were detected. These include the choice of the imaginary built-in apparatus (only according to the standardised dimensional recommendations) which may cause additional sizing and design errors.

However, the 3D modelling of the design presents important components and ideas that will be reflected in the design of the final product:
 The shape of an L-shaped kitchen furniture assembly should provide an orderly flow of work in the kitchen;
 Delimitation of the three zones (sink - work area - hob/cupboard);
 Use of sliding lamellar doors to avoid going out of volume and causing accidents;
 Marking the route to be followed with guide rails;
 Presence of an upper body in a symmetrical relationship with the lower body and its retraction to prevent head impact;
 The height of the legs must be favourable to the psychological requirements and the need of cleanliness;
 Presence of grooves on legs to provide visual continuity;
 The use of interchangeable magnetic plates with distinct texture;
 Presence of curb bumps to identify certain high or low hazard areas;
 Presence of LED light for additional visual guidance and delimitation.

FINAL PRODUCT

In the final design of the kitchen assembly, all requirements, recommendations and aspects of furniture for the visually impaired were taken into consideration. The name of the product will be LIGHTOUCH, symbolizing the idea of "touching the light".

Fig. 26.
Lightouch kitchen furniture for the visually impaired.

LIGHTOUCH is a set of kitchen furniture designed specifically for the needs of people with (partial or total) visual impairment. Its design considerably reduces the risk of injury and offers new possibilities for personal independence compared to the conventional kitchen furniture. The cabinets have no edges or corners and all volumes are rounded. The vertical compartments of the upper and lower units can be modified according to the user's preferences. The materials used in the production of this product are fireproof poplar plywood, poplar lumber, magnetic and metallic materials.

Both the lower and upper units are accompanied by darkly colored borders to guide the person to the different working areas, so that the borders are higher on the hob and sink area, signaling areas with a high risk of accidents (Fig. 27).

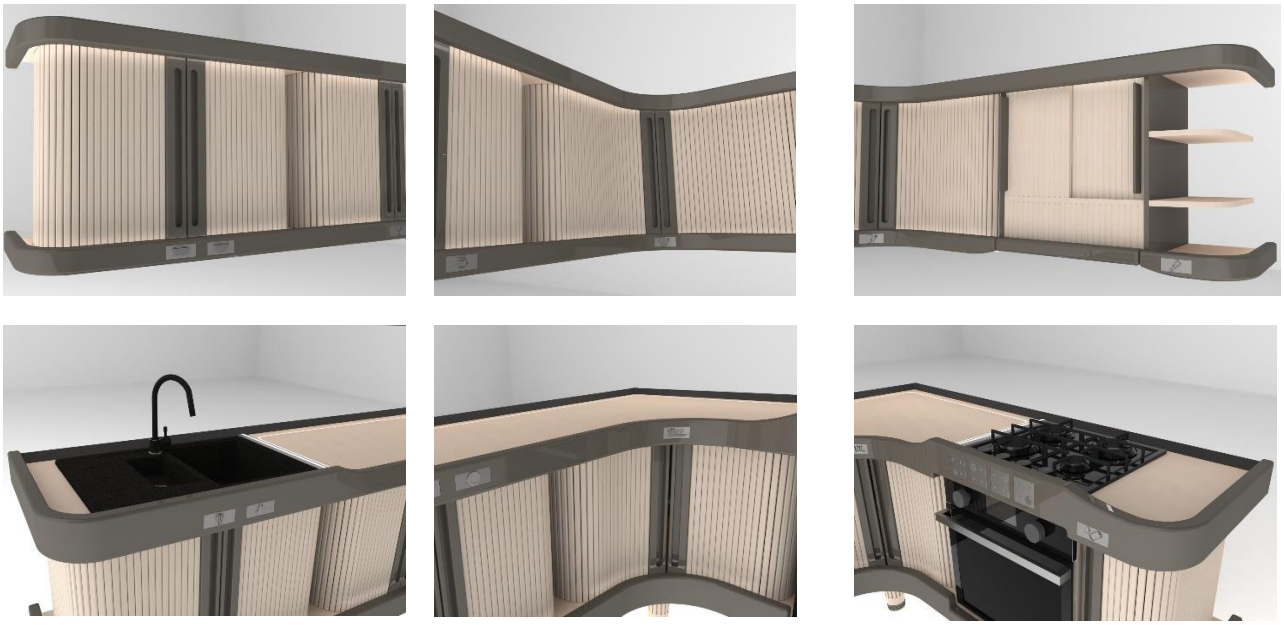


Fig. 27.
Guide rails marked in dark colours.

Certain processing interventions were necessary to put in relation the assembly to its functionality and to the needs of the users. For the upper unit, the option of placing a hood ornament was chosen to make it easier to handle and, at the same time, to give visual continuity of the edging (Fig. 28). For the lower section, certain cut-outs were made in the rails in order to improve access to the oven knobs and allow its door to open according to the standard regulations (Fig. 29).

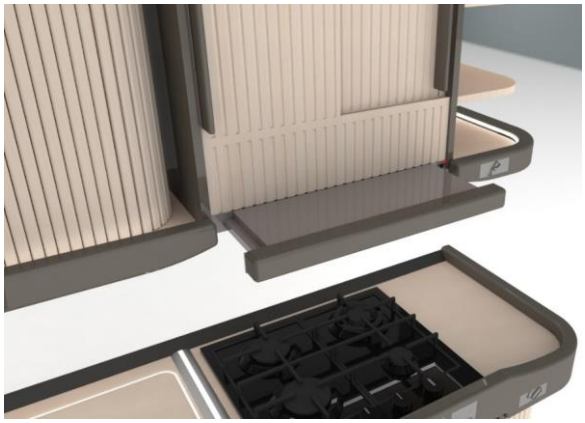


Fig. 28.
Placement of the hood ornament.

Fig. 29.
Cut-outs of the edges for the oven handling.

Interchangeable metal plates with a magnetic system are mounted on the edges to mark the various storage areas (cutlery, plates, pans, etc. - Fig. 30). They are made of metal materials with two areas: a rough metal area and a central area showing the figurative symbol of the objects in the compartment (Fig. 31). These are smooth to the touch so that there is tactile contrast. At the same time, button signal pads have been designed to operate a particular burner of the hob (Fig. 32) and curved plates have been adapted for corner placement (Fig. 33).

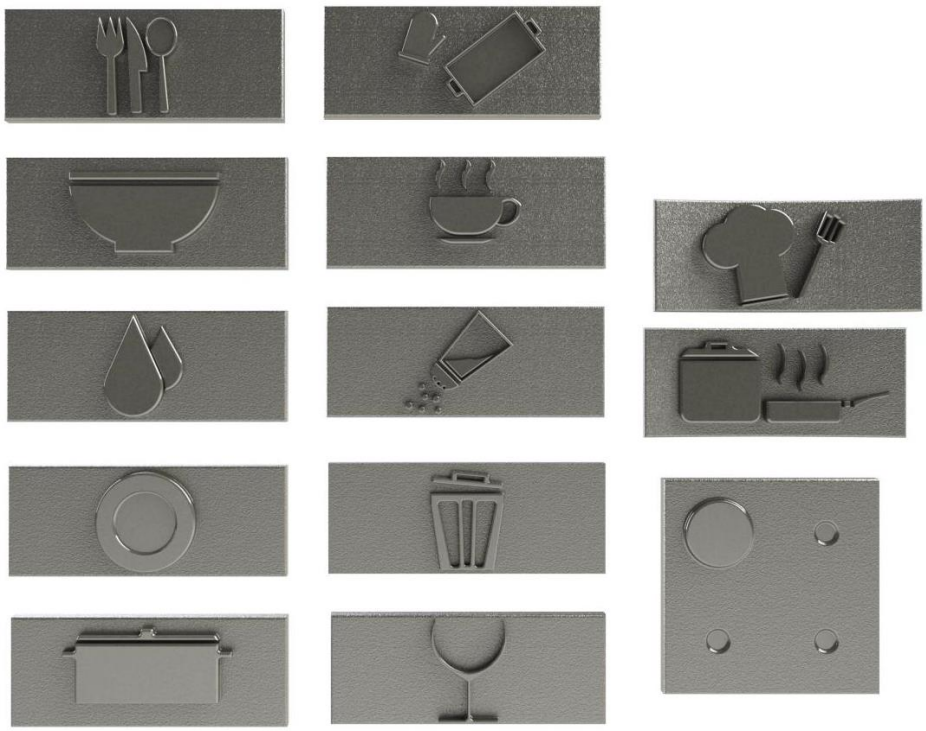


Fig. 30.
Interchangeable metal signalling plates.

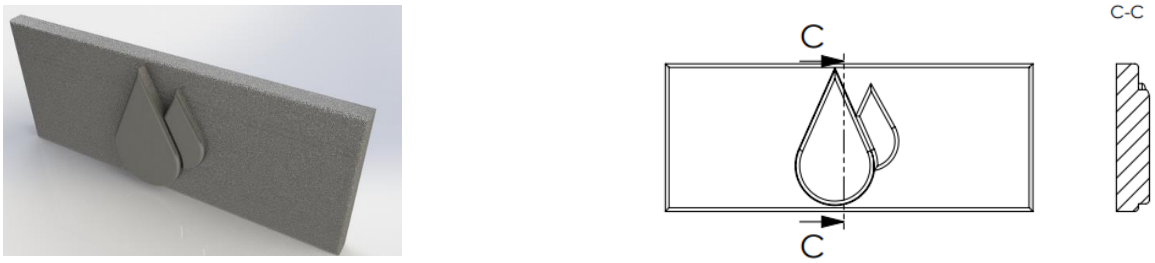


Fig. 31.
Metal plate identifying the sink.

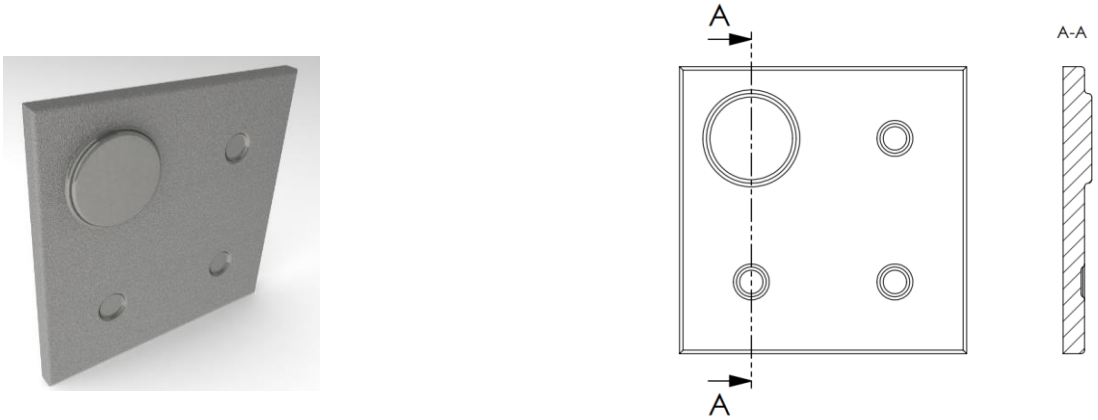


Fig. 32.
Metal plate marking the stove burner.

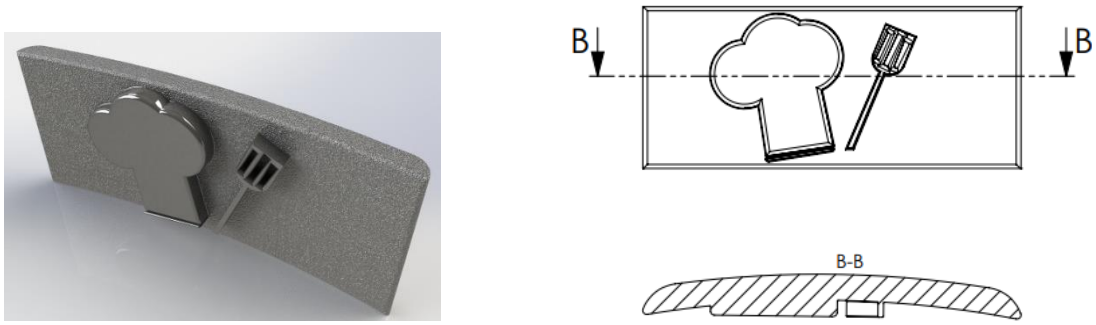


Fig. 33.
Metal corner plate.

The doors of the LIGHTOUCH kitchen furniture assembly are lamellar and sliding to avoid protruding or causing accidents when opening (Fig. 34). Their sliding paths are defined by the milled grooves on the bottom and top panels (Fig. 35). The access doors to the hood are slideable through overlapping. These are made of milled plates with grooves to provide visual continuity.

Fig. 34.
LIGHTOUCH before and after opening the doors.

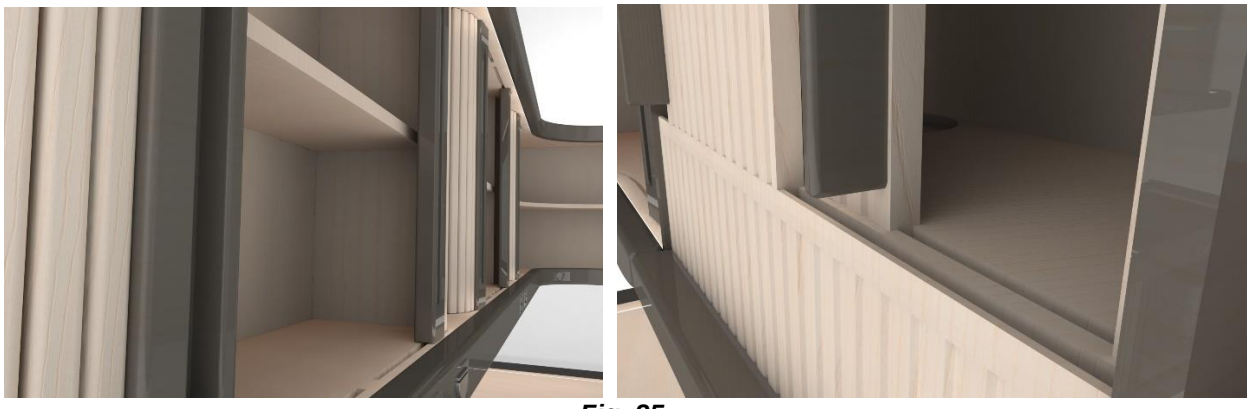


Fig. 35.
Doors and their sliding routes.

The door handles are chromatically marked with a darker shade giving quicker identification of the handling location (Fig. 36).

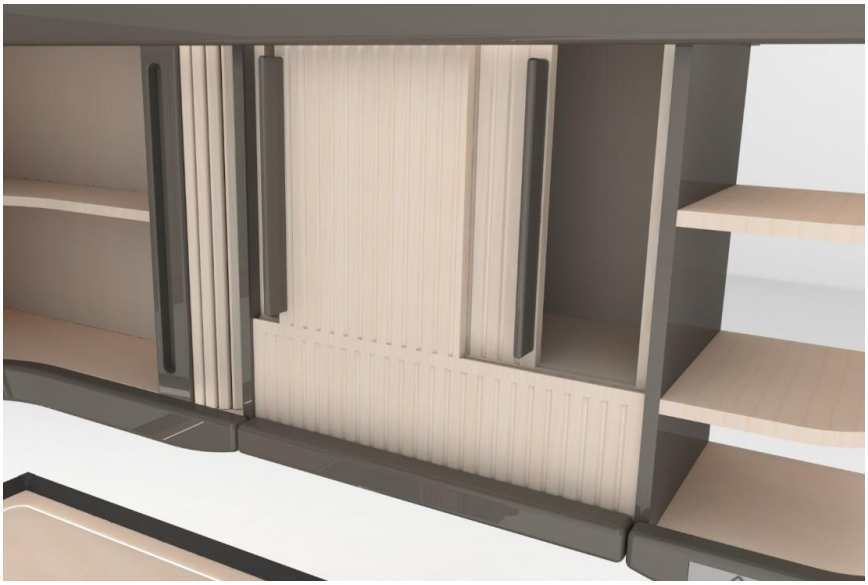


Fig. 36.
Dark shaded door handles.

The worktop is highlighted by visual warning zones that separate it from the sink and hob area. These illuminated worktop zones are complemented by LED strips fixed to the upper and lower body to guide and assist the visually impaired user (Fig. 37).

Fig. 37.
Countertop lighting and warning systems.

The legs (fig.38) are made of turned wood and have the ability to adjust their height while providing increased stability of the lower part of the furniture. Consideration has also been given to their retraction in relation to the volume of the lower part of the object without the risk of the user bumping. The grooves on the surface of the revolution are designed to integrate the legs with the body door system in textural terms.

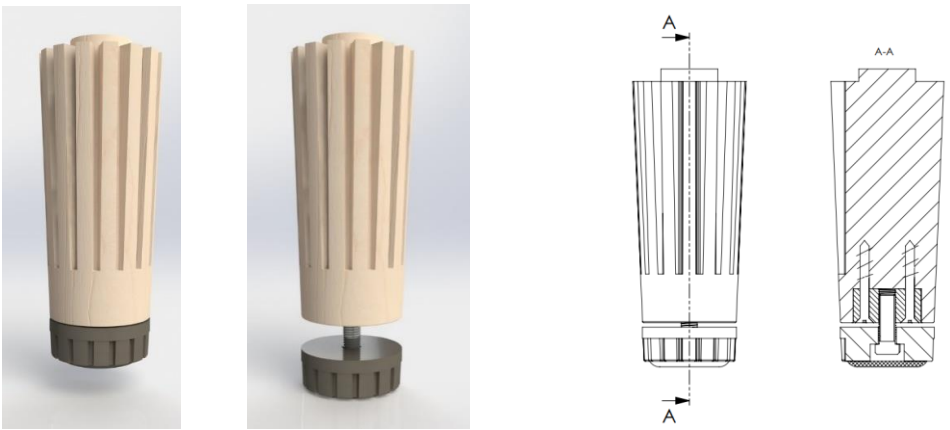


Fig. 38.
Height adjustable legs.

To provide additional stability to the lower section, metal corner profiles were used. These are not visible after the skirting board has been placed on the worktop (Fig.39). For the upper section, these are used to suspend it on the wall. This solution also makes it possible to slide the doors from one end to the other.

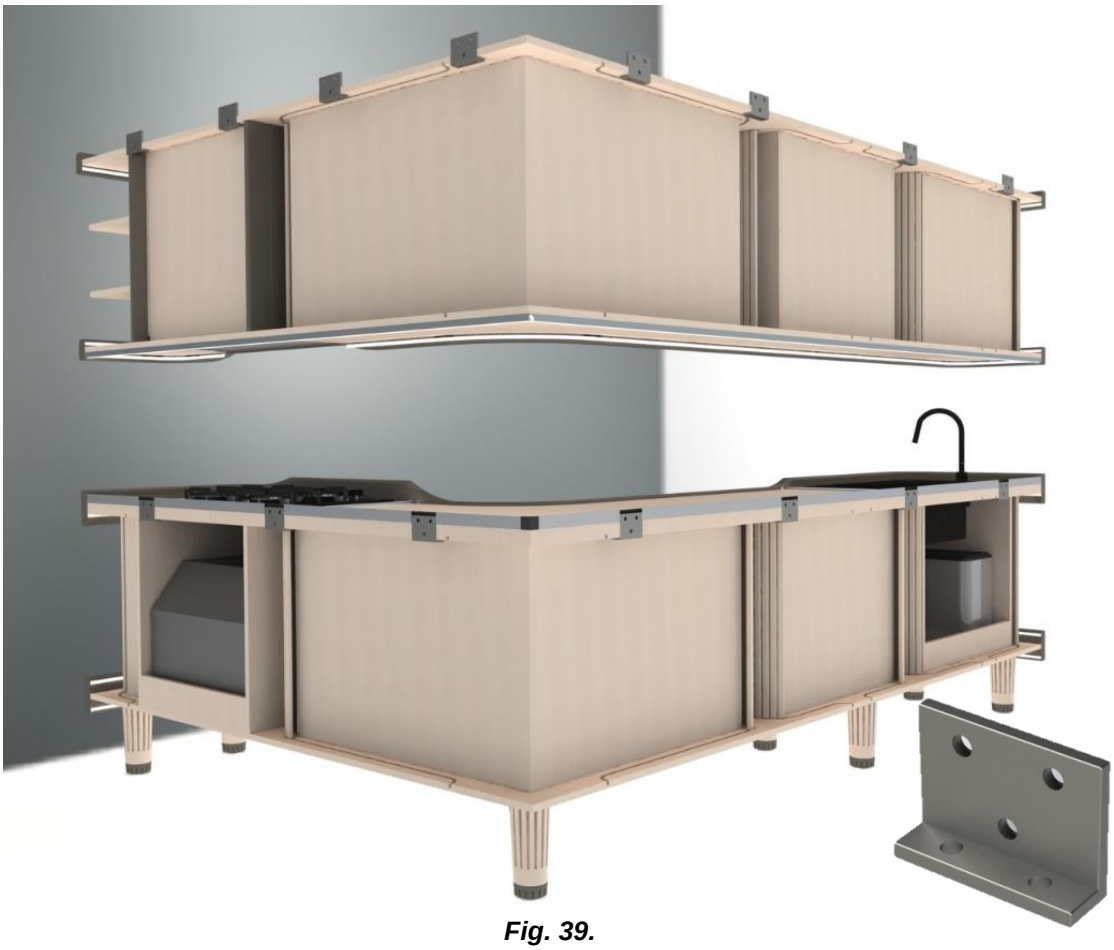


Fig. 39.
Metal corner profiles for suspending the structure.

CONCLUSION AND DISCUSSION

With the final version of the LIGHTOUCH furniture set many solutions to avoid accidents were implemented, such as: rounded edges or corners, the placement of guiding elements - the border-rails, highlighting of different areas by chromatic contrast, replacement of the classic doors with tambour doors, raising the height of the legs on which the cabinets rest, retraction of the upper cabinets to prevent head

bumping, additional light sources have been added to provide extra guidance for visually impaired users and interchangeable metal plates with magnetic system for faster identification of compartments by touch. The concept aims to make design feel through touch, texture and shape.

Through the technical and technological design, it is demonstrated that this concept can be realised in reality, having at the same time a unique design and approaching a new problematic, too little or not treated at all in the furniture industry. The assembly is made almost entirely of poplar lumber and plywood, a light-coloured, fast-growing species that also offers the possibility of providing a strong chromatic contrast while forming a sustainable product. In terms of materials, this ensemble has the power to enhance the value of the species and has a positive impact on the environment, using eco-friendly, water-repellent finishing materials. Last but not least, this product has an affordable final price for the social category concerned.

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