

Universal Design in Kitchen Furniture: A Case Study on Enhancing Accessibility and Safety for the Elderly and People with Mobility Challenges

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Abstract: *Universal Design in Kitchen Furniture: A Case Study on Enhancing Accessibility and Safety for the Elderly and People with Mobility Challenges.* The paper aims to explore the application of universal design principles in the development of kitchen furniture that promotes accessibility, safety, and independence for the elderly and individuals with mobility challenges. The study presents how innovative product design can contribute to the creation of an inclusive and barrier-free environment, emphasizing the importance of research and development works in this under-studied area. The results of the field tests that involved 200 participants with various types of disabilities, including people with motor challenges, are presented. The test results showed that the kitchen prototype developed by JATI company is comfortable and functional for the majority of test participants. The prototype has its undeniable strengths, nevertheless, several possible improvements were found during the field tests that could further improve the functionality and accessibility of the furniture for the elderly and individuals with special needs. Those are presented in the paper to inspire other furniture designers and manufacturers to create products that meet the needs and requirements of those essential society groups.

Keywords: universal design, kitchen furniture, accessibility, elderly, wheelchair users

INTRODUCTION

The concept of universal design has gained significant attention in recent years as a means to create inclusive and accessible environments for as many individuals as possible, addressing various body sizes and levels of cognitive and mobility abilities. This approach is critical in ensuring that individuals, irrespective of their physical condition or age, can safely and effectively use environments, products, communications, and services. The application of universal design principles is particularly beneficial in the development of kitchen furniture for the elderly and individuals with disabilities as it has the potential to enhance their safety and independence. The studies of Kłos et al. (2014) indicated that as many as 76% of the surveyed visually challenged people admitted that they did not have kitchen furniture adapted to their needs. The existence of a relationship between the adaptation of kitchen furniture to the needs resulting from the users' disabilities and the occurrence of dangerous situations in the kitchen has been demonstrated. A similar design challenge applies to the elderly as the aging process impacts among others the changes in anthropometric dimensions, predominantly concerning the height of the elderly. There is a tendency for a significant decrease in height dimensions with age (from 2 cm to even 5 cm per decade) which considerably affects the possibility of reaching the items located above. Research by Hrovatin et al. (2012) shows that 56 % of respondents aged over 55 years have an inappropriate work surface arrangement in their kitchens. Pennathur and Dowling (2000) described the functional limitations of the elderly in Mexico State, stating that wall cabinets in the kitchens could be reached without difficulty or assistance by just 26.67% of elderly females involved in the research. Also, the research of Hrovatin et al. (2015) proved that height accessibility is lower

for the elderly than for young people as a result of decreasing height in the elderly. Hrovatin et al. (2015) point out that if illnesses restricting joint movement are also taken into consideration, height accessibility would be even lower. The solution to this design challenge could be providing a range of adjustment features to the furniture. An inspiring example can be found in the Skaraborg Health Technology Centre (SHC) at the University of Skövde which is an exemplary demo arena of a senior-friendly assisted living facility apartment. It showcases among others the adjustable kitchen furniture (Figure 1).



Figure 1. Adjustable interior of kitchen cabinets in the exemplary AAL (Ambient Assisted Living) facility apartment in the Skaraborg Health Technology Centre in Skövde, Sweden (Source: Jakub Wittchen for BaltSe@nioR 2.0 project)

Although the above-described example is an interesting one, in the European furniture market there is a lack of similar solutions that could be accessible, safe, and affordable for the elderly and people with disabilities. Therefore, it is reasonable to conduct research and development works aimed at creating new products for the kitchens of socially vulnerable groups, including the elderly and people with disabilities to raise their comfort and quality of living. Universal design principles include equitable use; flexibility in use; simple and intuitive use; perceptible information; tolerance for error; low physical effort; and size and space for approach and use, guiding the design of environments, products, services, and communications in a way that is accessible to everyone, regardless of their body sizes, posture, cognitive or mobility challenges. Thus, they fit perfectly with the identified design challenge.

The literature review concerning the recognition of the needs of the elderly and people with mobility challenges when using kitchen furniture indicates a number of valuable information essential to consider during the design process. The study of Wang et al. (2022), which aimed to explore the relationship between the efficiency of daily activities and the spatial layout of home kitchens in households of the elderly highlights the importance of understanding the specific needs of older adults in designing functional and accessible kitchens. The study of Wellecke et al. (2022) examined physical housing accessibility in Australia for older people and people with disabilities from the perspective of kitchen design and overall living conditions. The study focused on understanding how housing accessibility could be improved to accommodate the needs of these individuals. The practical hints on

designing kitchen furniture for visually challenged people can be found in the study of Kłos et al. (2014). The most important include among others: the recommendation that visible corners and protruding elements should be rounded, without burrs and sharp edges (e.g. $R \geq 5$ mm) or e.g. chamfered 5 mm, angle 45° ; to replace standard handles with recessed ones, use an open form of cabinets or sliding doors, ensure a high color contrast of vertical and horizontal elements. Furthermore, Wingler (2014) focused on five crucial aspects that should be considered when designing an accessible kitchen for wheelchair users. The study analyzed the importance of the height of work surfaces (kitchen counters), lowered kitchen sinks, options to lower wall cabinets, width of doorways, and lowered location of kitchen appliances. This research aimed to provide practical guidelines for designers and architects to create more inclusive kitchens.

The goal of this paper is to showcase the implementation of universal design in the process of developing innovative kitchen furniture, focusing on enhancing accessibility and safety for the elderly and people with disabilities. Additionally, the paper explores the design features that can be included in kitchen furniture to improve user satisfaction and overall quality of life.

MATERIALS AND METHODS

Based on the comprehensive literature review concerning the needs of the elderly and people with disabilities, the important aspects to consider when designing kitchen furniture were identified, including ergonomics, accessibility, safety, universality, and aesthetics. That constituted the basis for a design brief. Next, the specific ergonomic solution that can be incorporated into the design of kitchen furniture has been created by JATI company and manufactured in a 1:1 scale. The following phase constituted installing the prototype on the premises of the Bonifraterska Fundacja Dobroczywna in Konary (Poland) and conducting the field tests among the kitchen users. In the studies 200 people with various levels of mobility challenges took part. How this solution contributes to the safety and independence of the target population were analyzed. To improve accessibility and user satisfaction, it is necessary to understand the attitude of the customer. Therefore, for the assessment of the developed solution the SERVQUAL method, which evaluates customer satisfaction, including dimensions such as safety, reliability, responsiveness, empathy, and competences was used (Pakurár et al., 2019). The method of statistical grouping was used to identify the respondents' attitudes toward the design features of the presented solution.

RESULTS AND THEIR ANALYSIS

The prototype of kitchen furniture for people with special needs created by JATI company contains mechanisms for raising and lowering upper cabinets and a worktop with suspended lower cabinets on an independent frame structure supported by two stable elements of each room, i.e. the floor and the ceiling. Lowered and lifted cabinets, drawers, and worktops hung on this structure can be loaded with greater forces compared to competitive solutions, symmetrically and asymmetrically (upper cabinets - min 60 kg, bottom drawer - min 20 kg, worktop - min 300 kg.) In addition, the presented furniture includes an automatic pull-out and raising system enabling the drawers in the lower cabinets to be lifted. The created solution implements one integrated lifting and lowering control system.

There is a number of features that make the presented prototype unique. The prototype of kitchen furniture developed by JATI company is based on the following solutions:

1. The prototype enables the installation of the cabinets on a steel frame stretched between the floor and the ceiling - without the need to hang cabinets on the wall. This is an undeniable advantage in the case when kitchen cabinets are to be hung on lightweight walls of the

gypsum board type. None of the analyzed competitive solutions available on the market guarantees safety in such a case.

2. The original mechanisms for moving upper cabinets. This is the only solution of that kind developed in Poland. Moreover, a competitive advantage is the permissible load capacity of up to 60 kg and the possibility of asymmetrical loading of the cabinets.

3. The original solution for extending and lifting the bottom drawer. This is the only solution of that kind developed in Poland and the only mechanism known to the authors enabling lifting drawers in kitchen furniture. The maximum load is 20 kg.

4. The developed supporting structure of the worktop ensures stiffness at higher loads (up to 300 kg with a worktop width of 2.4 m) than in the case of competitive solutions available on the market. This is essential in the case of suspending the lower cabinets at the movable worktop and at the same time gives more possibilities to design various kitchen arrangements.

The concept of kitchen furniture presented above is in line with the first and the second principle of universal design being equitable use and flexibility in use, adequately. The first principle of universal design, equitable use, emphasizes the importance of creating designs that are useful and marketable to people with diverse abilities. This principle promotes inclusivity and accessibility by ensuring that the design caters to various user needs, regardless of their body size, posture, or mobility (Molly Follette Story, 1998). In the context of kitchen furniture design for the elderly, the implementation of equitable use involves considering the unique requirements and challenges faced by the elderly users, such as reduced strength or mobility. The second principle of universal design, flexibility in use, emphasizes the importance of creating designs that cater to a wide range of individual preferences and abilities (Molly Follette Story, 1998). This principle is also very relevant when designing kitchen furniture for the elderly, as it seeks to maximize usability and accommodate the diverse needs and characteristics of this population. Flexibility in use entails designing products or environments that can be customized to meet the unique requirements of individuals. In terms of the kitchen furniture design that concerns for example the adjustable countertops and cabinets.

During the tests, participants were asked to evaluate the designed kitchen furniture in terms of comfort, functionality, and usability for people with disabilities. Participants were also asked to indicate what changes in the kitchen furniture are necessary to make it more useful for people with special needs. Altogether 200 people aged 18+ and mobility challenged tested the created solution for kitchen furniture. The age structure of the analyzed sample is presented in Figure 2. Women constituted 41.5% of the analyzed sample.

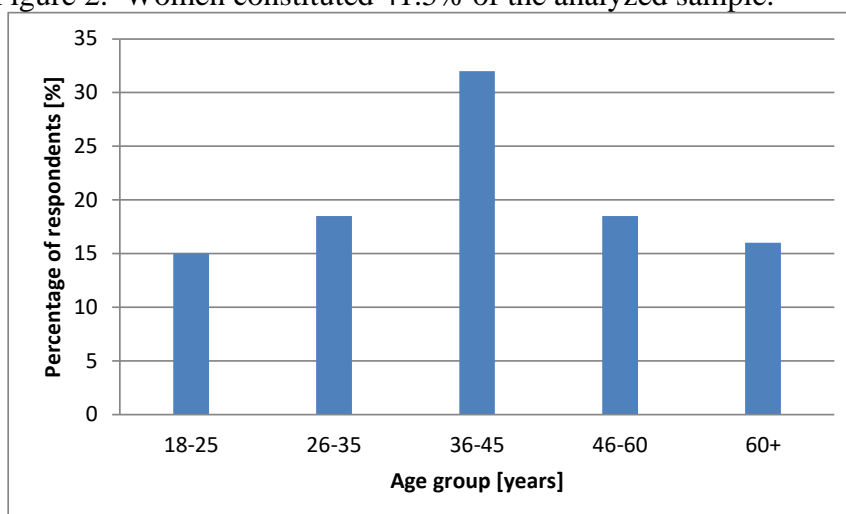


Figure 2. The age structure of the analyzed sample of respondents
Source: Own elaboration based on performed empirical research

Accessibility features are essential to consider in the design of kitchen furniture. However, it is no less important to take into account also the aesthetic features of the furniture. Thus, the respondents were asked to evaluate their subjective first impression when they saw the solution developed by JATI company. The vast majority (75%) of the respondents experienced enthusiastic emotions concerning the kitchen's overall design (very good - 59% and good - 16%) (Figure 3). It needs to be highlighted that 24% of people taking part in the test admitted they like the presented kitchen furniture, which in total gives 99% of positive responses. The results of the research conducted with the SERVQUAL method confirmed the high visual attractiveness of the prototyped solution. The respondents were asked to evaluate various aspects of the solution on a scale of 1-5, where 5 was the highest possible grade. The mean evaluation of the visual attractiveness of the presented new product, based on 200 responses, amounted to 4.71.

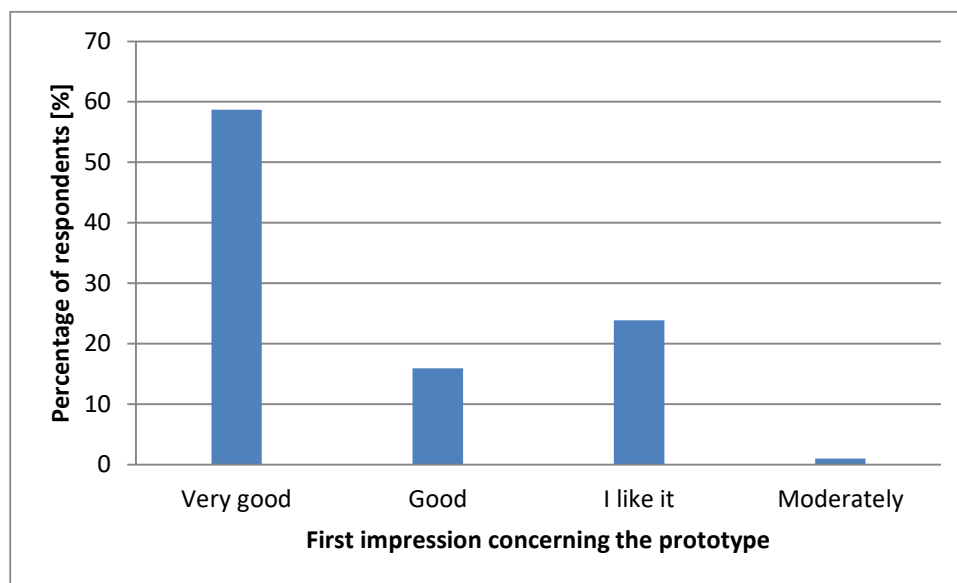


Figure 3. The structure of respondents' opinions concerning the first impression of the kitchen furniture
Source: Own elaboration based on performed empirical research

Ergonomic solutions are necessary for the design of kitchen furniture to reduce the risk of occupational injuries and improve comfort and safety for users of the kitchen. The individual challenges of the elderly such as difficulty with reaching or bending increase with age. The same is faced by people with mobility challenges. Ergonomically well-designed kitchen furniture can offer comfortable use, while design aesthetics of kitchen furniture can positively influence perceived usability (Zhang et al., 2014; Maguire et al., 2014). Thus several design features having an impact on the comfort and ease of use were analyzed. As many as 99% of respondents declared the furniture is easy and comfortable to use, which is also in line with the third principle of universal design being: Simple and intuitive use. This principle is met when the design is easy to understand, regardless of the user's experience, knowledge, language skills, or current concentration level. Implementing the simple and intuitive use principle in kitchen furniture design for the elderly involves creating spaces that are straightforward and uncomplicated, while still being functional and aesthetically pleasing. This can be achieved through clear communication of essential information, consistency in design elements, and accommodating various user preferences and abilities. The tests with end users were of crucial importance in this case as they allowed us to check whether the use of the presented solution was easy for people who's never used it before.

The participants of the test were also asked if the range of lowering and lifting of individual elements of the kitchen furniture is appropriate. The majority (95%) were positive

about it, 1% were negative, and 5% weren't sure. Furthermore, detailed feedback e.g. on the speed of lowering and lifting the cabinets or the location of the control panel, was gathered. It turned out that 82% of respondents agreed that the speed of lowering and lifting the kitchen cabinets is sufficient. Nevertheless, 11% answered that the speed of the movement of the upper cabinets is too slow. Moreover, as a drawback, it was noted that there is a necessity to hold the control panel during the whole time of cabinet movement. All respondents evaluated the location of the control panel as a proper one concerning the height. One person pointed out that it could be bigger, and some suggestions appeared that it could be accompanied by an electrical outlet. Furthermore, 6% of participants pointed out that it should not be located under the sink as they were afraid it might be easily flooded when washing the dishes. This corresponds to the universal design principle 5: Tolerance for Error, which indicates that the design should minimize hazards and the adverse consequences of accidental or unintended actions. This principle is particularly significant when designing kitchen furniture for the elderly and people with mobility challenges, as it can help prevent injuries and enhance the overall usability of the kitchen space. Tolerance for Error in kitchen furniture design involves anticipating potential mistakes and incorporating features that reduce the likelihood of such errors occurring. It also entails creating an environment that is forgiving and allows for easy recovery in case an error does happen. The objective is to create a supportive and safe kitchen environment for users who may face cognitive, sensory, or mobility challenges.

The sixth principle of universal design, low physical effort, emphasizes the importance of creating designs that can be used efficiently, comfortably, and with minimal fatigue for the user. It aims to reduce physical strain and promote ease of use, which is vital for maintaining independence and quality of life among the elderly and people with mobility challenges. In detail, low physical effort involves minimizing the force or effort required to operate or maintain a particular design. To achieve this, designers should consider various factors such as the placement of objects, ergonomics, and accessible features that cater to the diverse needs of the elderly population. Practical ideas for implementing the low physical effort principle in kitchen furniture design include for example height-adjustable work surfaces: design countertops and tables with adjustable heights to accommodate different users, allowing them to work comfortably while seated or standing. This feature enables users to perform kitchen tasks without straining their backs, necks, or shoulders. Furthermore, within this universal design principle, it is recommended to design pull-out shelves and drawers in cabinets and pantries to minimize the need for reaching and bending.

The last principle of universal design: size and space for approach and use, emphasizes the importance of providing appropriate size and space for individuals to approach, reach, manipulate, and use objects and spaces regardless of their body size, posture, or mobility. In the context of kitchen furniture design, implementing the seventh principle involves considering various aspects, such as the height and depth of countertops, the accessibility of cabinets and storage spaces, and the placement of appliances and fixtures. The features presented above constituted the basis for the innovative kitchen furniture design created by JATI company within the research and development activities described.

Additionally, an important part of the research was the evaluation of the safety of the developed solution. As many as 92% of respondents evaluated the furniture as safe. However, several valuable safety-based insights were gathered. The users had doubts about whether the door of the upper cabinets won't hit them while the lowering process. Furthermore, they suggested changing the folding door of the upper cabinets to the traditional one with a vertical axis of the opening. Respondents suggested installing security sensors in the lower kitchen cabinets to enable automated stop of the cabinet's movement when encountering resistance.

Considering the height and accessibility of kitchen furniture during the creation process contributes to a more ergonomic and user-friendly kitchen design. Pinto et al. (2000)

point out that designing kitchen furniture with adjustable shelves or pull-out drawers can improve accessibility and reduce the need for head extensions. At the same time, it confirms the benefits derived from the presented new product design. Implementation of the SERVQUAL method in the studies confirmed that the participants of the tests highly evaluated the accessibility and functionality of the developed solution. The mean evaluation, calculated based on 200 responses, reached 4.52 in both cases. It is worth highlighting that the participants evaluated the solution based on their own experiences derived from using the furniture by themselves (Figure 4).



Figure 4. The field tests of the developed prototype
Source: Own elaboration

The incorporation of universal design into kitchen furniture can create a plethora of advantages for elderly individuals and people with mobility challenges. Research has shown that including universal design options in kitchen furniture can foster active engagement in life for these individuals, and can serve as a stepping stone toward successful aging as it supports independence in activities of daily living (Carr et al., 2013). Additionally, as Carr et al. (2013) indicated universal design, implemented e.g. in kitchen furniture, enables physical self-maintenance and facilitates engagement in domestic activities. It is essential to stress once again, that the application of universal design principles in designing kitchen furniture, in particular, holds significant importance for the elderly and people with disabilities. The rationale for this lies in the fact that as individuals age or face physical impairments, they may encounter challenges in performing daily activities, including those that take place in the kitchen. The use of kitchen furniture designed with universal design principles, as the one presented in this paper, can therefore play a crucial role in enabling these individuals to continue to complete activities of daily living independently. The implementation of universal design principles in kitchen furniture design includes features such as adjustable heights for counters and cabinets and easy-to-reach shelves, being design features applied in the created product.

CONCLUSIONS

Designing furniture for the elderly and people with disabilities is an important issue that requires the highest possible attention and work of designers and furniture manufacturers. Disability affects various spheres of life, and one of the key elements that have an impact on the quality of life of a person with a disability is furniture. Properly designed furniture can

increase the comfort and functionality of life for the elderly and people with disabilities, which can significantly improve their quality of life. Accessibility and functionality of furniture for the elderly and people with disabilities are crucial and should be considered at every stage of the furniture design and manufacturing process.

In designing furniture for the elderly and people with disabilities, it is also important to take into account aesthetics and style. Furniture should be designed to be functional, but also visually appealing and fashionable. Appreciation of beauty and stylish solutions in interior design is important regardless of age and mobility challenges. Thus, this design feature should not be lost or forgotten in the creation of furniture for the elderly and people with disabilities. Research on furniture for the elderly and people with disabilities is crucial to the design and production of furniture for those user groups. Furthermore, it is important to highlight that this type of research and development process should be conducted in close cooperation with the elderly and people with disabilities and ergonomics and design specialists, to provide as much inclusion as possible. Designing furniture for the elderly and people with disabilities also has the potential to benefit not only this group of people but also society as a whole. Thus it is crucial to consider universal design principles in research and development activities.

The presented research provides information on the needs and expectations of furniture users being the elderly or facing mobility challenges. Based on this research, furniture designers and manufacturers can create products that meet the needs and requirements of the above-mentioned groups of users. Based on the performed research the following conclusions can be drawn, indicating the preferred design features:

Accessibility and functionality of furniture when designing for the elderly and people with disabilities is crucial. Furniture should be designed to provide easy and comfortable use for people with different types of disabilities, without the need for manual adjustments. The presented prototype developed by JATI company has succeeded in achieving this goal.

The furniture should be designed with different types of disabilities in mind. That is in line with the universal design principles and increases the chances that the furniture will meet the needs of various users. In the presented study the testers were people facing both motor, sensory and intellectual challenges. The vast majority of these people were satisfied with the tested furniture.

An objective evaluation of furniture should be provided. Designing furniture for the elderly and people with disabilities requires a thorough analysis of users' needs and expectations. This research was conducted in close cooperation with both target groups.

ACKNOWLEDGEMENTS

These examined issues constitute a part of the project: "Development of innovative kitchen sets for the elderly and disabled people" co-financed by the National Center for Research and Development (NCBIR) under the agreement "Rzeczy są dla Ludzi/0095/2020" of 07/09/2021.

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Streszczenie: *Projektowanie uniwersalne w tworzeniu mebli kuchennych: studium przypadku dotyczące poprawy dostępności i bezpieczeństwa użytkowania mebli kuchennych przez osoby starsze i osoby z niepełnosprawnością ruchową.* Artykuł ma na celu przedstawienie potencjału zastosowania zasad projektowania uniwersalnego w procesie rozwoju mebli kuchennych wspierających dostępność, bezpieczeństwo i niezależność osób starszych i osób mających trudności z poruszaniem się. W pracy przedstawiono, w jaki sposób innowacyjny proces projektowania produktów może przyczynić się do stworzenia inkluzywnego i wolnego od barier otoczenia, podkreślając tym samym znaczenie prac badawczo-rozwojowych w tym nadal niedostatecznie zbadanym obszarze wiedzy. Przedstawiono wyniki badań, w których udział wzięło 200 uczestników z różnymi rodzajami niepełnosprawności, w tym osoby z niepełnosprawnością ruchową. Wyniki testów wykazały, że prototyp kuchni opracowany przez firmę JATI jest komfortowy i funkcjonalny dla większości uczestników testu. Zaprezentowany prototyp ma swoje mocne strony, ale też w trakcie testów zidentyfikowano kilka możliwych ulepszeń, które mogłyby jeszcze bardziej poprawić funkcjonalność i dostępność mebli dla osób starszych i osób o specjalnych potrzebach. Pomysły te zostały przedstawione w artykule, aby zainspirować innych projektantów i producentów mebli do tworzenia produktów spełniających wymagania tych ważnych grup społecznych.

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