GÜLÇİN AYDINGÜN

EXPLORING THE POKA-YOKE CONCEPT AS AN EXTENDED USABILITY CRITERION FOR AGE-FRIENDLY KITCHEN DESIGN

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A Master's Thesis

by
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Department of
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Ankara

May 2024

To my mom

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The Graduate School of Economics and Social Sciences
of
İhsan Doğramacı Bilkent University

by

GÜLÇİN AYDINGÜN

In Partial Fulfillment of the Requirements for the Degree of
MASTER OF FINE ARTS IN
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THE DEPARTMENT OF
INTERIOR ARCHITECTURE AND ENVIRONMENTAL DESIGN
İHSAN DOĞRAMACI BİLKENT UNIVERSITY
ANKARA

May 2024

EXPLORING THE POKA-YOKE CONCEPT AS AN EXTENDED USABILITY CRITERION FOR AGE-FRIENDLY KITCHEN DESIGN
By Gülçin Aydıngün

I certify that I have read this thesis and have found that it is fully adequate, in scope and in quality, as a thesis for the degree of Master of Fine Arts in Interior Architecture and Environmental Design.

…………………………….
Yasemin Afacan
Advisor

I certify that I have read this thesis and have found that it is fully adequate, in scope and in quality, as a thesis for the degree of Master of Fine Arts in Interior Architecture and Environmental Design.

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Burçak Altay
Examining Committee Member

I certify that I have read this thesis and have found that it is fully adequate, in scope and in quality, as a thesis for the degree of Master of Fine Arts in Interior Architecture and Environmental Design.

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Examining Committee Member

Approval of the Graduate School of Economics and Social Sciences

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Refet S. Gürkaynak
Director

ABSTRACT

EXPLORING THE POKA-YOKE CONCEPT
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AGE-FRIENDLY KITCHEN DESIGN

Aydıngün, Gülçin

MFA, Department of Interior Architecture and Environmental Design

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May 2024

This study proposes the Poka-Yoke Concept as a usability criterion for the improvement of residential kitchen design for older adults, using aging simulation suit (GERT suit). Thesis includes two separate study datasets. In the first data set, 152 older adults from the Geriatrics Department of Hacettepe Hospital participated to fill out the questionnaire. According to the results, error prevention, low physical effort, adequacy of lighting and workstation were the most important kitchen design criteria. In the second data set, tasks and scenarios were conducted with architects and interior architetcts using the kitchen of Bilkent University Graduate Housing. As a result of the heuristic evaluation adapted in the context of Poka-Yoke Concept, it can be used as a usability criterion by increasing empathy towards older adults with GERT simulation.

Keywords: Age-friendly residential kitchen, Usability, Poka-Yoke Concept, Heuristic evaluation, GERT suit

ÖZET

YAŞLI DOSTU MUTFAK TASARIMI İÇİN GENİŞLETİLMİŞ
KULLANILABİLİRLİK KRİTERİ OLARAK
POKA-YOKE KONSEPTİNİN İNCELENMESİ

Aydıngün, Gülçin

Yüksek Lisans, İç Mimarlık ve Çevre Tasarımı bölümü

Tez Danışmanı: Prof. Dr. Yasemin Afacan

Mayıs 2024

Bu çalışma, yaşlanma simülasyon giysisi (GERT giysisi) kullanarak yaşlı yetişkinler için konut mutfak tasarımının iyileştirilmesi için bir kullanılabilirlik kriteri olarak Poka-Yoke konseptini önermektedir. Tez iki ayrı çalışma veri setini içermektedir. İlk veri setinde, Hacettepe Hastanesi Geriatri Bölümü'nden 152 yaşlı yetişkin anketi doldurmak için katılmıştır. Sonuçlara göre, hata önleme, düşük fiziksel efor, aydınlatma ve iş istasyonu yeterliliği en önemli mutfak tasarım kriterleri olmuştur. İkinci veri setinde, Bilkent Üniversitesi Yüksek Lisans Konutu mutfağı kullanılarak mimarlar ve iç mimarlar ile görevler ve senaryo yürütülmüştür. Poka-Yoke Konsepti bağlamında uyarlanan sezgisel değerlendirme sonucunda GERT simülasyonu ile yaşlı yetişkinlere yönelik empati artırılarak kullanılabilirlik kriteri olarak kullanılabilir.

Anahtar kelimeler: Yaşlı Dostu Konut Mutfağı Tasarımı, Kullanılabilirlik, Poka-Yoke Hata Önleme Konsepti, Sezgisel Değerlendirme, GERT yaşlı simülasyon kıyafeti

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Moreover, I am grateful to my loved ones, my mom, Ayşin Doğan, and my sister, Burçin Yaman, for their lifetime love and support. I dedicate this thesis to my mom, Ayşin Doğan. Last but not least, I would also wish to thank Didem Zengin, İrem Yılmaz, Damla Tarman, Gülşah Ural Saydam, Samira Asadmosaffar, Dilay Seda Özgen Turan, Ceren Şahmaran, and Burcu Aydınalp Egel for their encouragement to finalize the thesis with full of support.

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CHAPTER I

INTRODUCTION

1.1. Problem Statement and Objectives of the Study

Aging means the deterioration of organisms that impact the body's health, vitality, and function throughout the years (Shinde et al., 2022). According to the World Health Organization's (WHO, 2022) estimation, by 2030, approximately one-sixth of the world's population will be sixty years or over. In Türkiye, since 1960, the country's general population has increased by three, while older adults aged sixty-five and over have risen sevenfold (Arun, 2014). Furthermore, according to Turkish Statistical Institute (TURKSTAT) 2021 data, in five years, the older population has increased by 24% (Büker et al., 2023). Currently, in Türkiye, the older population is 9.1% (Akbal et al., 2022). With aging older people tend to spend more time in their residential environment. Older adults must handle their housework if they do not have mobility assistance. The kitchen environment is the area that demands physical movements to do specific daily tasks, including preparing food, eating meals, and cleaning (Braileanu, 2017). Residential kitchen is one of the active environments in residential buildings, it involves home-based basic activities of daily living (BADL) and is considered as obligatory activities, such as eating and preparing food. Due to the physical limitations of older adults in the kitchen environment, such as seeing, hearing, reaching, bending, and stretching in a residential kitchen environment, accidents occur. Thus, accidents mainly cause back pain and injuries that unable older adults to perform kitchen tasks (Bhatia & Singla, 2019; Hrovatin & Vižintin, 2013; Maguire et al., 2011). Poka-yoke as a concept that detects errors by investigating all pieces independently at the assembly line through manufacturing (Dudek-Burlikowska & Szewieczek, 2009). It also prevents errors in the design process. To make designers understand the older adults' physical limitations in kitchen design and assess Poka-Yoke Concept items as usability criterion for future kitchen design, the emphatic tool (GERT suit) was used to examine whether the Poka-Yoke Concept item might be considered a usability criterion. The study utilized an aging simulation suit to extend usability criterion by gaining insights into the needs of older adults in residential kitchens. Despite having age-friendly kitchens, there can be a misalignment between the design and the specific needs of older adults, so this issue leads older individuals to makeshift their solutions to adapt to the kitchen environment due to design errors of the residential kitchen environment. As a result, the study has two main objectives: (i) extending usability criterion with the Poka-Yoke Concept (Poka-Yoke Concept) in kitchen design and (ii) investigating the effect of aging simulation suit to extend the usability criterion by adding Poka-Yoke Concept items (see Figure 1).

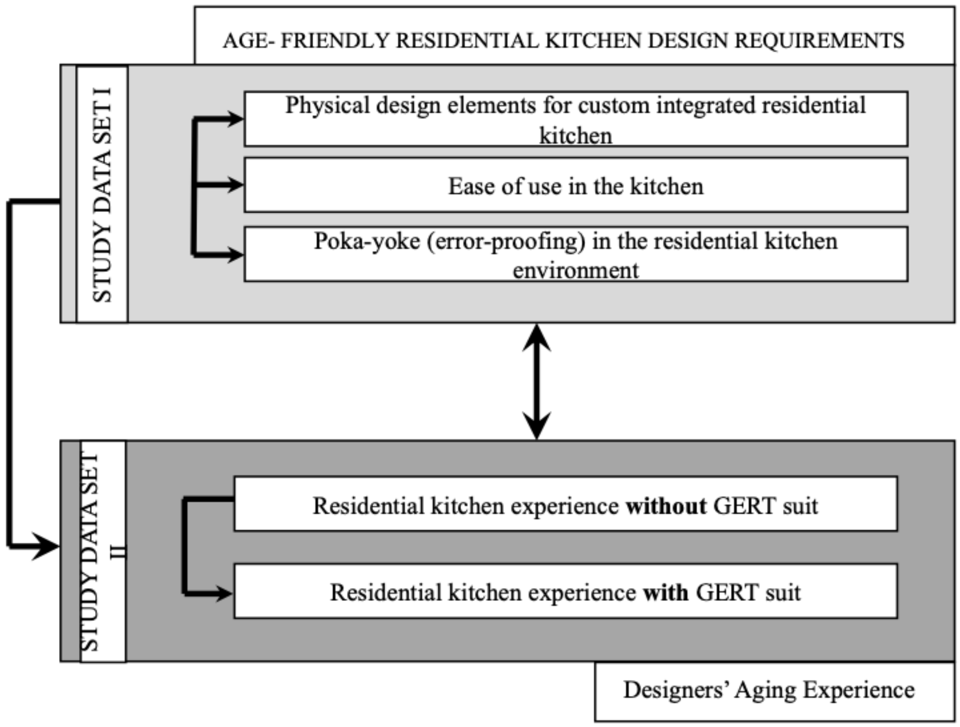

Figure 1. Conceptual framework of the study aim (drawn by the author, 2024)**.**

1.2. Structure of the thesis

To obtain the objectives of the thesis, Chapter 2 presents the literature review on Usability, Usability in Residential Kitchen Environments, Poka-Yoke Concept (Poka-Yoke Concept), and Aging Simulation. In Chapter 3, the methodology of the thesis is introduced. Firstly, the research questions and hypotheses are presented in the methodology part. Then, settings are explained to give information about the environment data, including study data sets I and II. Following this, participants are presented to provide insight into the people who both participated in two study data sets. The procedure section explained the two study data sets with sessions. Instrument and data collection contained questionnaires, task scenarios, and GERT suit. The data analysis section describes the statistical test methods to compare the results. Chapter 4 reports the results using quantitative analysis methods for Study Data Set I and Study Data Set II. Lastly, Chapter 5 is the discussion chapter, where the main aspects of the thesis are discussed. Chapter 6 is the conclusion chapter, which summarizes the main aspects of the thesis. Lastly, chapter 6 also includes limitations and recommendations for future studies.

CHAPTER II

LITERATURE REVIEW

2.1. Usability

In the past three decades, various discussions have been conducted on the field of usability, which relates to its origins in experimental psychology, measurement, and statistics. After usability has emerged in the direction of user-centered design and user experience, additional discussions about usability have arisen (Lewis, 2014). Defining usability is a complicated function because it is not a singular aspect of a person or object. There is no genuine "usability" measurement tool. It cannot be evaluated with a single attribute. As a substitute, usability depends on cooperation among users, products, tasks, and environments (Lewis, 2014). Also, diverse ways exist for defining usability and generating varied explanations of the usability concept, as authors have differing assumptions on determining usability. Numerous definitions of usability have been introduced, including Shackel's model, which highlights product acceptance and associates an adjustment between utility, usability, and likability. Another outstanding rationale by Nielsen focuses on five attributes: learnability, efficiency, memorability, errors, and satisfaction. Additionally, over 15 years, the International Organization for

Standardization (ISO) has developed usability standards that assess criteria that include effectiveness, efficiency, and satisfaction in accomplishing specified targets within a precise context of usability (Folmer & Bosch, 2002). Figure 2 illustrates three definitions of Usability by Shackle, Nielsen, and ISO 9241-11 (adapted from Folmer & Bosch, 2002).

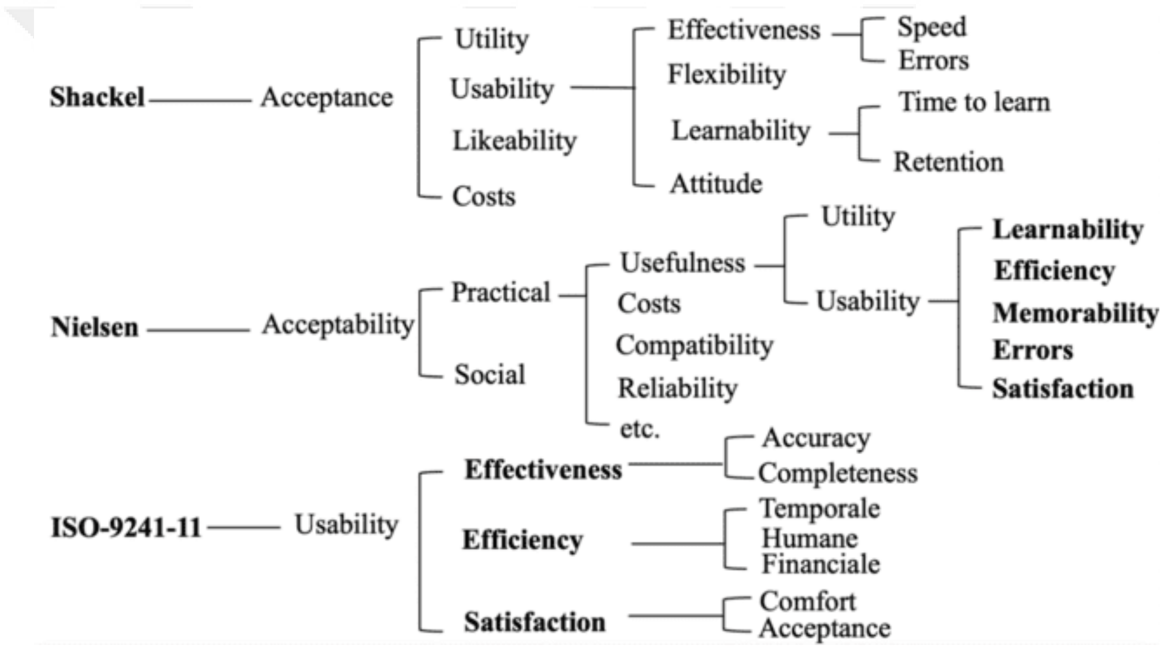

Figure 2. Illustration of three definitions of Usability by Shackle, Nielsen, and ISO 9241-11 (Adapted from Folmer & Bosch, 2002).

There are two essential viewpoints on usability to measure defined goals, known as summative and formative. Although there are resemblances between the two viewpoints, their differences are significant enough to assess specific definitions. Summative usability measurement on metrics is related to defining overall task and product purpose. Summative evaluations simulate traditional experiments, including minimal interaction between observers and participants during task performance and changes in product or system during the study (Lewis, 2014). The sample size for summative evaluations is a minimum of fifteen people.

In contrast, formative studies authorized a wide range of methods, which might be formal or informal, involving solo or paired participants and current, future, or competing products. Regarding sample size, the number of participants in the formative studies ranges from five to eight people (Lewis, 2014). Hence, defining attributes and viewpoints of the usability components is based on the context of the study.

2.1.1. Usability Attributes

Usability is a particular component compared to the genre that system acceptability's generous aspect on whether the system can achieve the goals and requirements of all stakeholders, including users, clients, and managers. It encircles diverse aspects beyond just usability, dealing with the long-term performance and functionality of the system to ensure that it suits the expectations and satisfaction of all relevant associations (Nielsen, 2010). Good usability is vital for providing a satisfied user experience that might be completed with aesthetics and interactivity. Maintaining good usability in a system can immensely subsidize positive user experience. This system aims to make a product, system, or interface easy for users to understand and use. This ease of use is just one of the general features affiliated with usability (Nassar, 2012).

According to Nielsen (2010), usability consists of a few elements that identify with five usability attributes; learnability, efficiency, memorability, errors, and satisfaction (Abran et al., 2003; Nielsen, 1994). Figure 3 illustrates attributes of usability according to usability attributes).

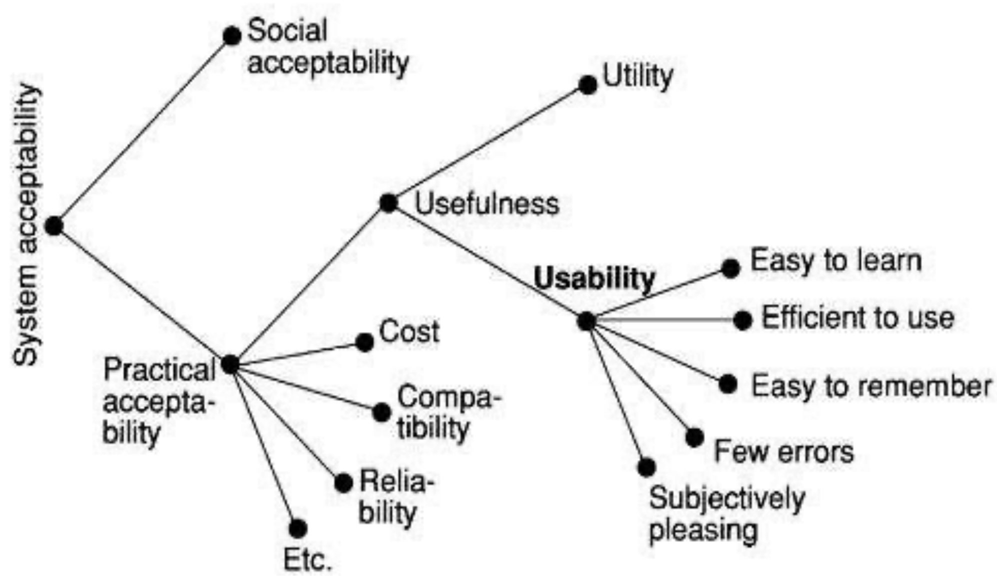

Figure 3. Attributes of Usability (Nielsen, 1994).

Social and Practical acceptability are the initial steps for application development. These components have links with usefulness that have directly connected criterion (Nielsen, 2010). Learnability aligns with the easiness of the task when encountering the design for the first time. Efficiency is related to performing design features after experiencing a specific job regarding speed. Memorability is essential to gaining knowledge and repeating it effortlessly about particular design tasks. Error detection contains the number of detects and the problem-solving process. Lastly, satisfaction is related to users' level of contentment about experiencing design (Sibarini, 2021).

According to ISO 9241-11(2018), the latest definition of usability is the extent to which specified users can effectively, efficiently, and satisfactorily use a product to achieve definite goals within a unique context (Nassar, 2012). The link between the attributes involved in the usability process can be visualized in the usability framework proposed by ISO 9241-11 (Castro, 2023; Nassar, 2012). Figure 4 indicates the definition of usability in terms of ISO standards. Effectiveness in usability is related to the accuracy and completeness of users' definite goals, while efficiency refers to the optimal application of resources aligned with those goals. On the other hand, satisfaction is mainly associated with the comfort and acceptability of the user experience in achieving their goals (Folmer & Bosch, 2002).

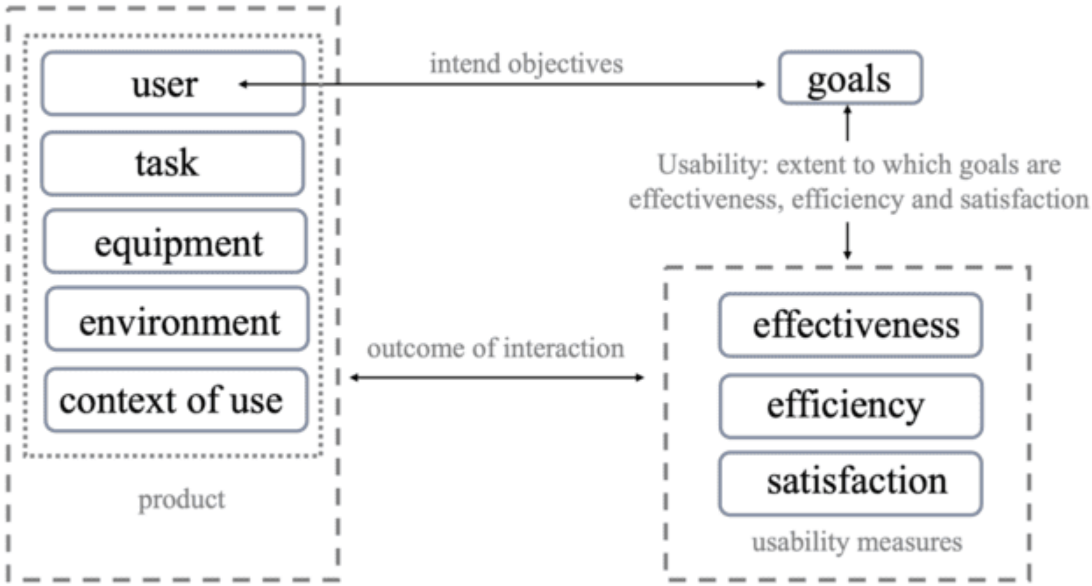

Figure 4. Definition of Usability according to ISO 9241-11 with three attributes (adapted from Nassar, 2012).

Within the thesis framework, ISO-9241-11 (1998) is the international definition of usability criterion used to explore the extension of the Poka-Yoke Concept as a usability criterion. Currently, the ISO 9241-11 (2018) definition is used to define usability problems within the scope of ISO standards. The requirements for usability regarding ISO standards are discussed in a detailed way to understand the three attributes for understanding and applying the concept of usability in a system or environment according to three features: effectiveness, efficiency, and satisfaction (Adilawati et al., 2023).

Effectiveness, as Folmer & Bosch (2002) mentioned that according to an exact definition of ISO 9241-11 (2018), contains completeness of users' goals and the accuracy to achieve the specified purposes. According to Green and Pearson (2006), the definition of effectiveness was clarified by indicating that there should be a connection between accurate results' after specified goals and the correctness of these goals. Over the years, Dutsinma et al. (2022) mentioned that several research methods might be used to measure effectiveness within the scope of usability. Yet, quantitative methods such as questionnaires are the primary tool for measuring the effectiveness of a particular system or environment.

According to ISO-9241-11 (2018), efficiency is defined as the accuracy of time management while using the system or performing a task in the environment. Hence, achieving a specified goal is related to the efficiency of resources needed during the experience (Jokela et al., 2003). Bevan et al. (2015) extended the definition of efficiency by emphasizing the relationship between resources such as human effort, costs, time and materials, and the experience of specified goals. Testing efficiency within the scope of usability is related to observing the task completion within the given time and purpose. Thus, efficiency refers to resources the user can use to accurately complete the task during the given timetable (Arthana et al., 2019).

Satisfaction refers to being pleased with the product, system, or task (Bevan et al., 2015). This affects users' happiness and trust (Pins & Paul, 2022). Harna et al. (2022) extend the definition of the ISO-92411-11 (2018) by emphasizing the importance of user recommendation after experiencing the task to enhance the meaning of satisfaction.

Measuring user satisfaction is similar to testing effectiveness by using a questionnaire tool. Hence, the last usability criterion refers to users' overall contentment according to ISO standards to achieve usability goals at the end of the experience with certain products or specified tasks in built environments (Syafrizal et al., 2022).

2.1.2. Usability in Built Environments

Typical issues in interior design directly cover diverse aspects, including items where user satisfaction aligns with usability factors (Viyanon & Sasananan, 2018). When dealing with the built environment in terms of usability issues, the fundamental focus of interest is the practical environment. Conventional approaches to determining built environments mainly consider the physical aspects of the domain. However, the environment includes additional dimensions that are not limited to the physical environment. It is necessary to comprehensively broaden the perspective to understand usability in different practical environments. One way to broaden knowledge of the environment is by categorizing it into three dimensions; the environment should be examined from three perspectives: social, virtual, and physical (Rasila et al., 2010).

The type of environment pursues the application of attributes in built environments. Usability may be associated with several characteristics in built environments. Rasila et al. (2010) categorized theoretical usability dimensions into 11 categories with the gathered definitions of usability throughout the years. The most common usability dimensions in built environments are efficiency, flexibility, learnability, memorability, number of errors, accessibility, navigation, functionality, atmosphere, visual design, interaction, feedback, and satisfaction. Figure 5 illustrates the iterative workflow of usability in the building process regarding human-centered design (Attaianese & Duca, 2012).

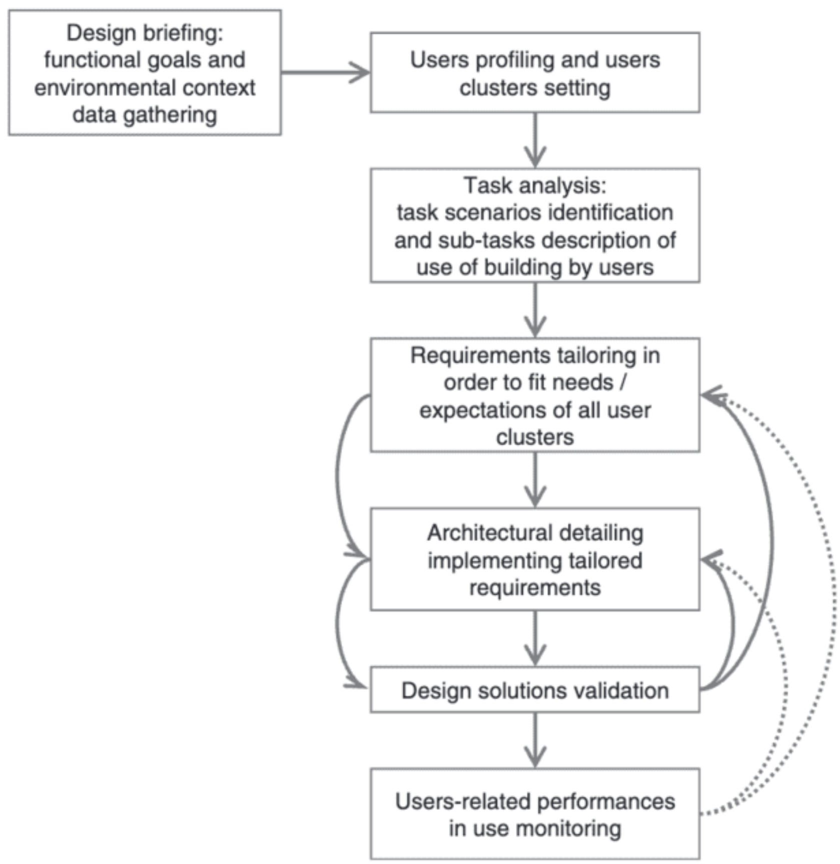

Figure 5. The iterative workflow of the usability in the building process regarding human-centered design (Attaianese & Duca, 2012).

Hong et al. (2014) also supported previous literature that determined usability issues in built environments have different contextual evaluation methods for specific usability problems to evaluate the built environment. Jimenez et al. (2016) identify new sets of usability heuristics by improving Nielsen's usability heuristics by defining usability as the detection of problems in the user's interaction in the built environment as

Afacan and Erbuğ (2009) mentioned the evaluation of the built environment regarding heuristic evaluation. Although the study aims to enhance existing heuristic evaluation methods, there is no improvement in developing existing strategies. Current usability methods, especially the heuristic evaluation method, adapt to general Nielsen's heuristic evaluation set. Harte et al. (2017) studied usability to detect and predict falls in older adults in built environments using usability evaluation methods such as cognitive walkthrough and heuristic evaluation. On the other hand, Mosca and Capolongo (2018, 2020) focused on the reliability of usability evaluation methods in built environments for efficient performance to solve usability problems by guiding designers. The study emphasizes that usability is related to the maximization of the comfortable use of spaces in a built environment by indicating accessibility has a link with usability. Watchorn et al. (2022) clarified that usability in the built environment aims to reduce environmental barriers by emphasizing the importance of evaluating built environments to enhance usability. Mosca (2023) focused on healthcare-built environments by highlighting the need for usability in different environments. Ultimately, usability is improving within the context of built environments to evaluate and enhance the usability of built environments to reduce errors.

The kitchen, previously known as the cookhouse, is the center of the house because it's an environment that requires accessible and usable design features when performing kitchen tasks for older adults independently, such as cleaning floors, preparing meals, eating and washing dishes that took time to perform (Sobouti, 2016; Taha, 2010). Due to the time spent in this environment, all kitchen design features must be well-designed.

Especially with aging, conducting kitchen tasks might be challenging due to physical limitations while cooking, such as bending/reaching, stooping, lifting/carrying, opening packages, cleaning, mobility, cutting, stirring, and fatigue (Ibrahim & Davies, 2012). According to a study conducted by Maguire et al. (2014), the most alerting physical limitations in the kitchen among 48 older adults are reaching and bending to the cabinets when they want to put some kitchen utensils in the cabinets or want to get some kitchen utensils for preparing meals. Then dexterity is also a problem when older adults want to use their hands when they cut vegetables (see Figure 6). Considering these problems when designing or adapting a kitchen environment for a health-aging process is a problem though there are age-friendly kitchen designs (Wang et al., 2023).

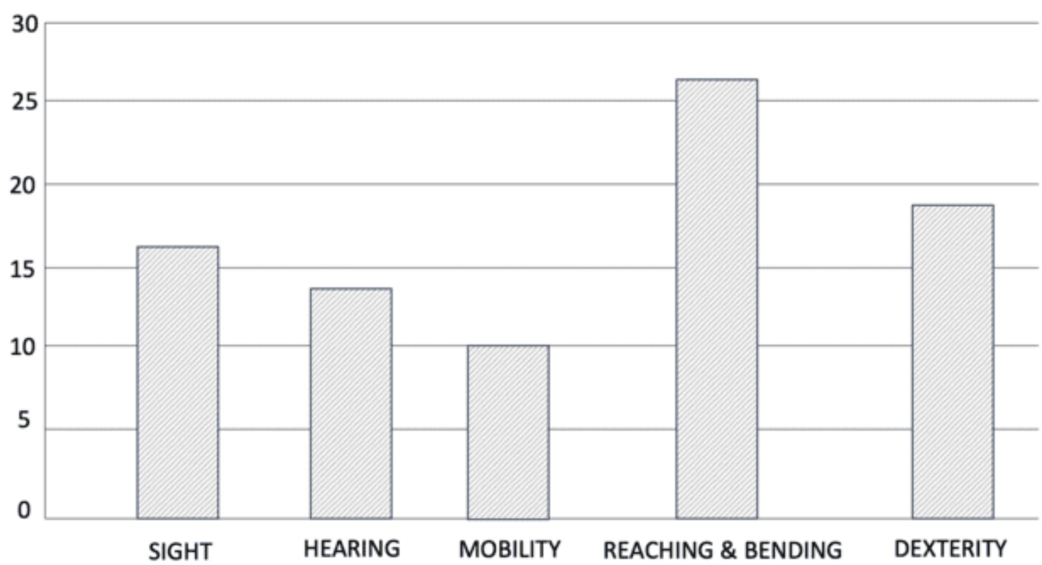

Figure 6. Illustration of older adults' physical limitations (adapted from Maguire et al., 2014).

Unfortunately, some of the kitchens are designed only for aesthetic considerations. Thus, the usability in the kitchen environment might be ignored to enable older adults to reach deep storage areas or metal surfaces that cause glare which is harmful in old age. (Ibrahim & Davies, 2012). Thus, several design solutions might be considered to improve the usability of the kitchen environment for older adults. Main design solutions might be listed as follows; proper kitchen layout, suitable lighting arrangement to alter the limitations due to sight problems, safer material choices for surfaces (worktop and floors), designing handle-free cupboards (e.g., pressure-based or sliding door cupboard) that enable older adults open them quickly. Lastly, designing round-edged furniture and counters is crucial for kitchen design (Hrovatin et al., 2012).

2.1.3. Usability Testing

Measuring usability depends on the context of the usability problem, including the user, task, and product. Usability research includes the efforts of individuals in designing systems, scenarios, or any related component with the usability problem by testing them, creating educational materials, and studying users (Sullivan, 1989). To find the appropriate method for usability testing, three techniques are titled with sub-categories to find out the proper measurement method for the usability problem as follows: Usability Testing, Usability Inquiry, and Usability Inspection (Dubey & Kumar, 2012; Gulati & Dubey, 2012).

Regarding Usability testing, distinctive tasks or prototypes are used to test specific components with measurement methods. First, the coaching method includes a relationship between the expert and the user while trying to solve usability problem or any type of prototype (Cajander et al., 2010). Regarding software evaluation, the Performance Measurement method is used without interacting with the user and the expert. However, the Question-asking Protocol method contains an interactive protocol in that experts ask questions while users perform the given task, product, or scenario (Campbell, 2004). Thus, this method helps to understand which part of the component is evident to the user. In the Retrospective Testing method, the operator gives users a walkthrough experience to test the usability of a given task with the videotaped testing session (Bastien, 2010). With the Thinking Aloud Protocol method, experts can videotape specific subjects on passed examinations to the evaluators.

Similarly, the Teaching Method is used as an alternative method to the Thinking-Aloud Protocol by recording actions (Hori et al., 2011). On the other hand, the Co-discovery Learning method includes the observation of two evaluators while working on the same given task mutually, including sharing their ideas about the performance. Within the scope of usability testing, the last method is remote testing which involves a given task being performed distantly. The users and the experts are not in the same place within the same time zone. Hence, the Usability testing technique covers eight methods to specify usability (Rubin, 1994).

In Usability Inquiry, communication with the users is central to operating the usability problems with five methods. The field Observation method involves observing the real place to identify which components are necessary for usability. In Interviews / Focus Groups, procedures are done to understand the users' thoughts about a specific topic, task, or interface (Virzi, 1992). In the Proactive Field, the study defines the initial usability problem at the first stage of the design process. In the Logging Actual Use method, a statistical technique represents users' frequency of usage of each component. The last usability inquiry technique is questionnaires, which test the response and performance of the given task with several related questions within the given context (Gulati & Dubey, 2012).

Usability Inspection covers the judgment of each component to improve usability principles with eight methods. In Cognitive Walkthrough tests, the expert observes users' actions while performing a task (Barnum, 2010). In the Heuristic Evaluation method, the performance is evaluated individually with the given study, interface, or product by checking the usability criterion in terms of error defection, flexibility, and efficiency of use by providing a ranking by the users (Dubey & Kumar, 2012; Gulati & Dubey, 2012). The feature inspection method checks long processes with typical tasks for usability. The Pluralistic Walkthrough method tests most software components to identify usability issues. Standards inspection /guideline checklists are also used to ensure the components have an industrial standard. Perspectives-based Inspection includes lists to perform required tasks with specified guidelines (Dubey & Kumar, 2012). The card sorting method includes user combinations of usage items on websites where signs are used to improve the interface's usability. Lastly, the Tree Testing method is the opposite of the previous method because, in this method, the findability of the given task in the interface is tested (Hass, 2019).

2.1.4. Scenario-based Usability Testing

A scenario is a planned description encompassing actors, individuals, details, and assumptions regarding the environment in which the given description takes place by including stories (Carroll, 1999; Go & Carroll, 2004). Scenario-based design is related to elements such as the user's level of activity, preferred shortcuts, prioritized needs, variability in their actions, and the broader integration of the given designed device or the environment (Vincent & Blandford, 2015). Before analyzing the scenario, the development of scenario evolution primarily involves establishing foundational concepts rooted in real-world actions, and everyday challenges involving tasks are executed. Subsequently, articulated concepts apply, crafting detailed scenarios corresponding to the identified problems. Figure 7 visually represents the evolution of ideas and scenarios (Go & Carroll, 2004).

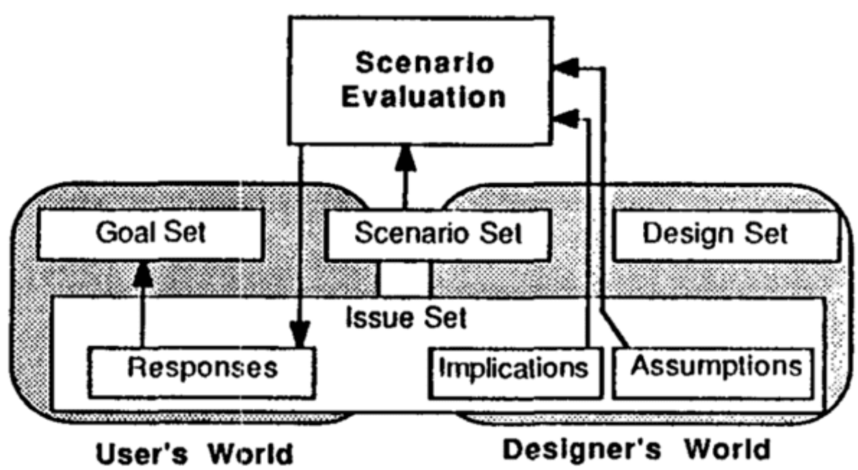

Figure 7. Visual representation of the evolution of concepts and scenarios (Go & Carroll, 2004).

There is no singular evaluation approach to test scenario-based design methods. The assessment of the usability of learning environments should encompass a variety of techniques derived from both empirical and analytical sources. (Granic et al., 2019; Hussain et al., 2015). Incorporating usability principles into learning environments involves extending Nielsen's (1994) original ten heuristics to a set of guidelines that include the sociology of knowledge. In summary, various empirical testing methods are employed to assess the performance of scenario-based designs (Gonzalez-Holland et al., 2017; Granic et al., 2019) in terms of analyzing scenario-based design evaluation. The stage of scenario evaluation involves collecting user feedback on the design's behavior within a given scenario set and making corresponding adjustments to the goal set. The whole design is not obligatory before entering the scenario-based design evaluation process, and the designer initiates this phase based on the significance of the issues or scenarios to be reviewed. Figure 8 illustrates the scenario evaluation phase (Holbrook, 1990).

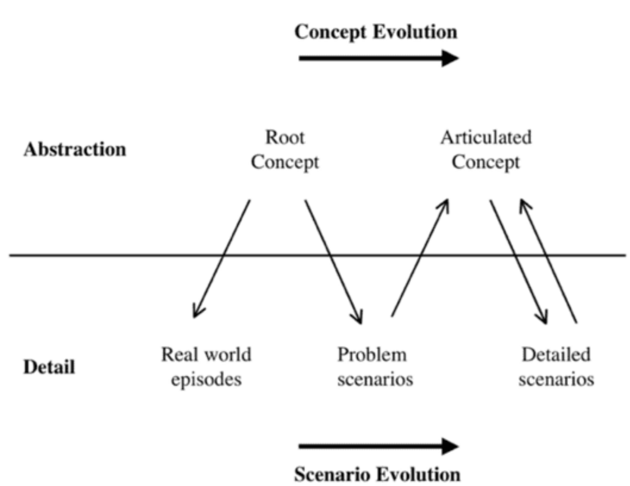

Figure 8. Scenario evaluation phase (Holbrook, 1990).

Scenario-based design, the primary design representation includes how individuals carry out tasks containing problems in the given design context (Carroll, 1999). Participants for the scenario-based design are based on the given task and the focus of the design problem. The participation number is based on the problem. If researchers want to focus on e-learning, the participant number exceeds 30 students. According to Lewis (2014), formative studies measuring the ability to cover five to eight people in the second data collection stage.

2.1.5. Heuristic evaluation

Heuristic evaluation is a usability testing method (Goldman & Bonedoly, 2003). The heuristic analysis evaluates the interface and evaluates its adherence to usability principles as part of an iterative design process (Nielsen, 1990; Nielsen 1994). Heuristic evaluation is an inspection method originating from Nielsen's Heuristic Evaluation. Heuristic Evaluation enhances in two dimensions: firstly, it introduces additional domains of consideration to the existing set of heuristics guiding to usability problems within a given system, design, or environment, and it includes users who are experts in the relevant work domain (Muller et al., 1998). A few evaluators do heuristic evaluation to test the system, device, design, or environment's usability (Kumar et al., 2020). The guideline that prepared by Nielsen (1994) includes testing system usability. Throughout the years, heuristic evaluation has been adapted to test different types of systems, designs and environments (Kumar et al., 2020).

During the heuristic evaluation, inspectors experience the system, design, or environment and discover the usability problems. The banking system did the review. Each row represents the evaluators while each column represents the usability problem. If the column is black, it means that there is a usability problem in that system, design and environment among 16 usability problems (Nielsen, 1994). Figure 9 indicates the heuristic evaluation banking of the system.

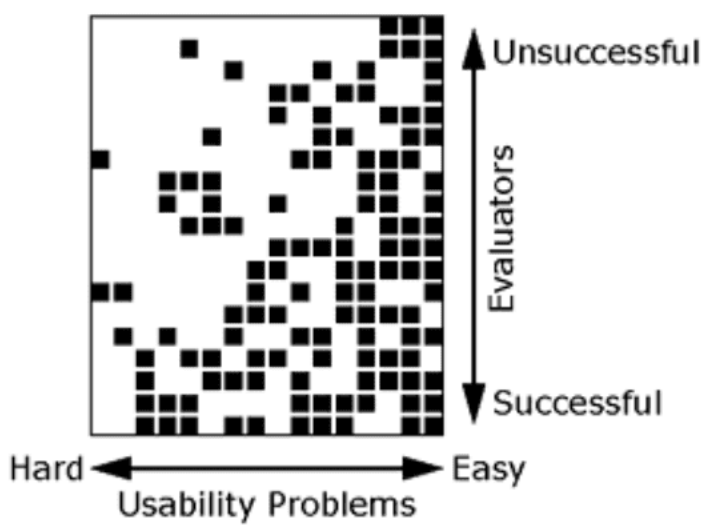

Figure 9. Indication of the heuristic evaluation banking system (Nielsen, 1994).

Afacan and Erbuğ (2009) specifically stated usability testing measurements in an architectural design context through heuristic evaluation due to extensive studies on usability engineering rather than usability in a built environment. Heuristic evaluation, which includes the number of users in usability analysis, was the method to evaluate built environments regarding usability (Nielsen & Molich, 1990). Furthermore, the study indicates that universal usability is suitable for application in an architectural design context by problem-solving within the interdisciplinary scope of using heuristic evaluation usability testing measurement. This approach, which includes the reduction of possible errors for usable built environments, highlights further studies to evaluate the built environment's usability regarding different evaluation methods. Attaianese & Duca (2010) supported the idea that usability in a built environment is crucial for ergonomics with an iterative workflow. The workflow starts with determining the specific goals in a built environment to conduct continuous task analysis to identify architectural requirements regarding usability, then design solutions and users' performance, a continuing workflow harmonizing architectural requirements. Hence, determining requirements for usable built environments has an infinite relationship with design solutions and users' feedback about the design according to their performance in the built environment.

2.2. Residential Kitchen Environment

2.2.1. Kitchen Layouts

The kitchen is a workspace of the home (Surmann et al., 2017). It contains both aesthetical and usable components in terms of design. Regarding aesthetic components, there are several kitchen layouts for different kitchen sizes. Yazıcıoğlu (2010) defined kitchen layouts into six categories. These layouts are as follows; Onewall, Corrior-shaped, U-shaped, Peninsula, and Island (see Figure 10). One wall kitchen layout is compact in that the sink and the cooker are close. In L-shaped kitchens, the work process includes cooking, preparing, and storing loops around two walls. In a U-shaped kitchen, mainly walls are not used often. In Island kitchen layouts, the space must be plentiful (Sundaram & Rukmangadhan, 2016). The main focus of designing a residential kitchen after the floor plan includes kitchen layout is user-friendly design solutions. To achieve this aim, one main aspect of creating adequate residential environments is the kitchen working triangle.

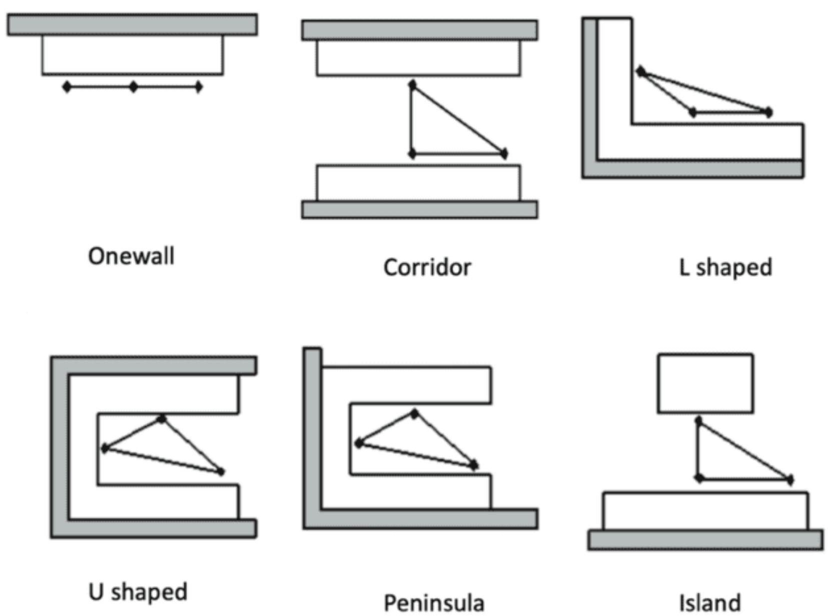

Figure 10. Illustration of Kitchen Layouts with working triangle (Yazıcıoğlu, 2010).

Frederick (1913) clarified that the proper equipment arrangement is vital to support the working triangle. The working triangle is not separated from the kitchen layouts because designing the kitchen and arrangement of the kitchen appliances is genuinely related to the proper work triangle to ease kitchen movements while doing kitchen activities step by step to minimize the walking distance between the countertop and appliances

(Overhill, 2014). The working triangle should not exceed 6.5 meters. The activities in residential kitchens mostly happened between three main appliances: the refrigerator, the sink, and the cooker (Özalp, 2020). Kitchen layouts should be designed to create a proper working triangle to minimize the movements in the kitchen for and allow the appropriate flow of work to reach the three main appliances. Figure 11 illustrates the proper and improper working triangles to indicate the movements during kitchen activities (Frederick, 1913).

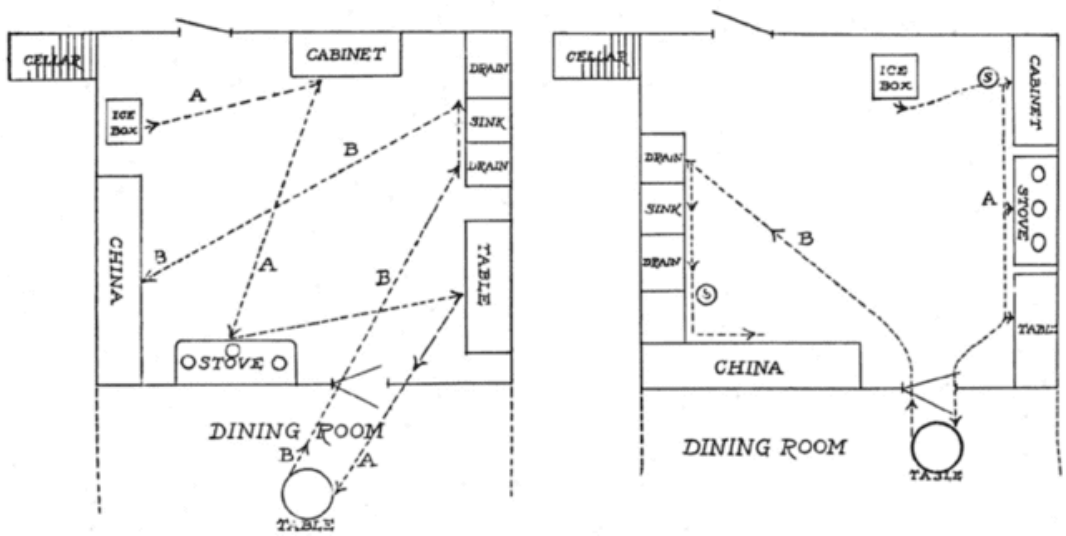

Figure 11. Illustration of the proper and improper workflow in a kitchen environment (Frederick, 1913).

Although there is a term difference, Pejić et al. (2019) classified kitchen layouts also into six categories to create a proper working triangle as follows; I-shape, II-shape, L-shape, U-shape, G-shape and with island (see Figure 12). Pejić et al. (2019) also added that the kitchen layout is related to aesthetics and functionality. Hence, as well as the functionality of kitchen designs, the aesthetics of residential kitchens should not be ignored.

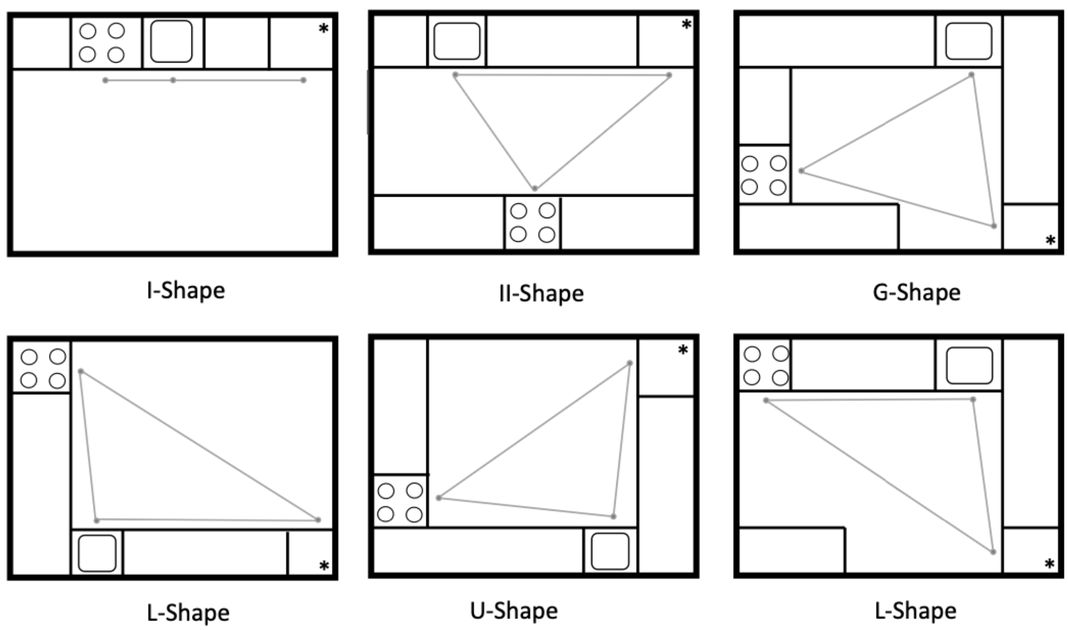

Figure 12. Illustration of Kitchen Layouts with working triangle (adapted from Pejić et al., 2019).

As Kors (2013) clarified, the kitchen layouts might be changed to make residential kitchens more flexible and usable. Ollár et al. (2022) supported kitchen layouts with their variations because of the kitchen's capability that supports adaptability. The potential for adaptation of the kitchen layouts is crucial for renovation projects. Hence, the layout is not the same for residential kitchen environments. User needs, the kitchen's capacity, safety requirements, and any other related residential kitchen requirements affect the design of the kitchen layouts (Sydora & Stroulia, 2020). Figure 13 illustrates the different kitchen layout types with three various adaptations.

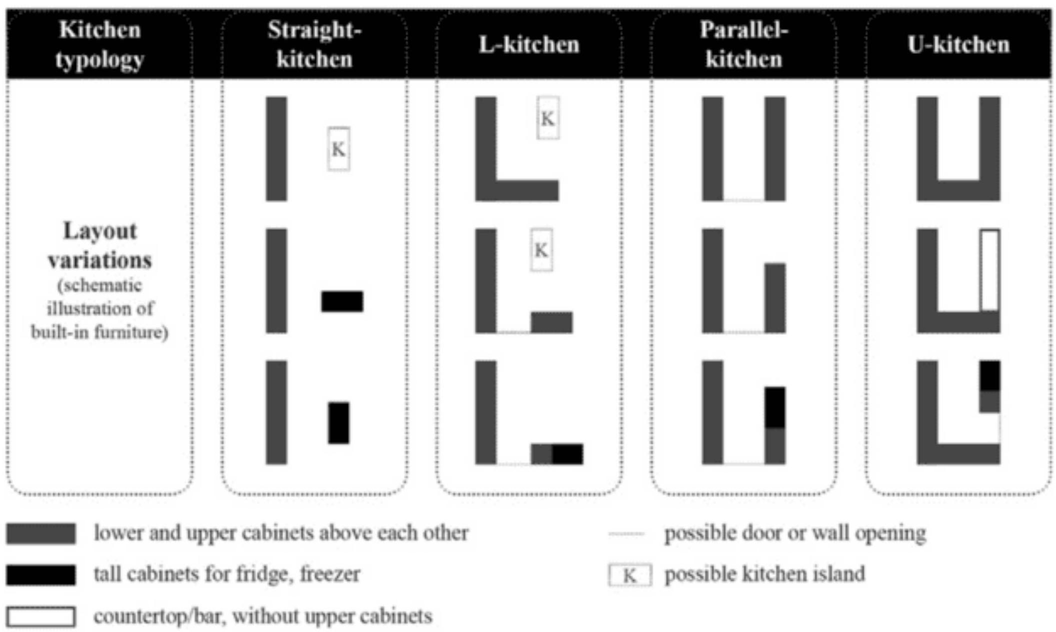

Figure 13. Illustration of Kitchen Layout variations (Ollár et al., 2022).

The kitchen design has several components, such as cabinets, countertops, and appliances. Kitchen layouts might change according to the arrangement of kitchen components (Tao et al., 2018). According to different terms and approaches to kitchen layouts throughout the years, designing kitchen layouts is a crucial step for a residential kitchen environment by considering specific kitchen requirements. Both adaptation and new design layouts of the residential kitchen are essential in designing according to users' needs within the capacity of the built environment (Walley, 1957). As a result, Zafirovska (2023) added that the kitchen layout depends on several factors, such as the kitchen area's dimensions, the users' specific needs and the consideration for a comfortable domestic kitchen environment.

2.2.2. Kitchen Components

The kitchen is essential for doing fundamental steps that work as a house laboratory through preparation, cooking, and cleaning (Charytonowicz et al., 2011; Surmann et al., 2017). The arrangement of the kitchen components is crucial to consider users' needs with proper workstations. With lifestyle and technology alterations, the kitchen's design has changed over the years (Tarboush & Erçin, 2021). According to Moody and Vineyard (2007), the kitchen design and its related components have changed regarding people's needs at a certain time, including health/ safety issues, alteration role of the women, enhancements in technology, and domestic science issues. Figure 14 illustrates these five influential factors in Kitchen Design.

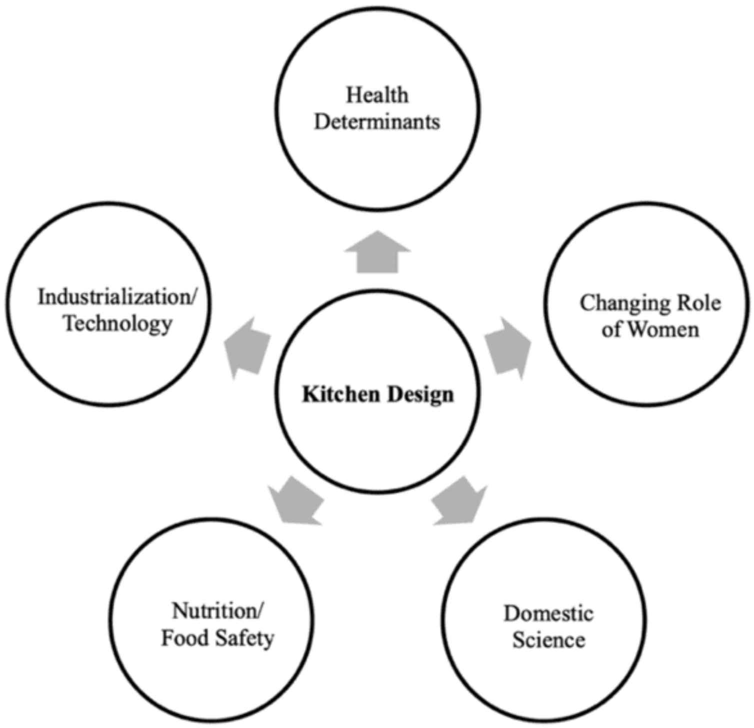

Figure 14. Five influential kitchen factors on Kitchen Design (adapted from Moody & Vineyard, 2007).

Furthermore, Galford & Peek (2021) thought that the role of the kitchen due to the design of the semi-open or open kitchen layouts, the meaning of privacy in domestic kitchens has changed. The kitchen environment turned out to be a social place for most families. Similarly, Can & Söğüt (2022) also indicated that the kitchen could be used as a social space and multi-purpose area. Furthermore, due to the size of the apartments in Türkiye, the kitchens must be well-organized, which is required, and flexible kitchen designs. However, the meaning of the kitchen differs due to the different needs of human beings throughout the centuries. Currently, kitchen components have settled (Moslehian et al., 2023). Kitchen components are related to the working triangle areas, including preparation, washing, and cooking (Charytonowicz, 2018; DeMaio et al., 1997; Mihalache et al., 2021). The kitchens' main components are listed within this thesis's framework: cabinets, countertops, and appliances.

2.2.2.1. Cabinets

Kitchen cabinets are crucial furniture used in a residential kitchen as a storage unit (Xiaolei et al., 2014). Historically, the need to store kitchen items has led manufacturers to make furniture for the kitchen environment. The design of the kitchen storage units began with the term “kitchen pantry.” Beecher (2001) explained that around 1900-1950, kitchen pantries had several purposes, such as looking like a closet, including opening shelves for food items and helpful kitchen utensils. Also “butler’s pantry” had glass-fronted cupboards to store dishes, silvers, and linens with customized-sized drawers. During the nineteenth century, carpenters made kitchen and butler’s pantries on-site. Figure 15 illustrates the nineteenth-century kitchen cabinet type (Beecher, 2001).

Figure 15. Illustration of the nineteenth-century kitchen cabinet type as a “kitchen pantry” or “butler’s pantry” (Beecher, 2001).

Furthermore, also Beecher (2001) added that in the 1920s, office desk-type kitchen cabinets turned out to be a more current look type of cabinet style. In the mentioned era, after on-site construction of the kitchen pantries by manufacturers, architects shared their cabinet designs with details including perspective, plan, section, and elevation drawing with dimensions. The term “kitchen pantries” and “butler’s pantry” was replaced by “kitchen case.” Figure 16 illustrates the nineteenth-century architect’s kitchen cabinet drawings.

Figure 16. Illustration of nineteenth centuries' architects'' cabinet design as a "Kitchen Case" (Beecher, 2001).

On the other hand, Wilson (1947) mentioned the storage unit with a "kitchen cabinet" term. The study highlights the planning of the kitchen cabinets in terms of proper width, depth, and height of cabinets with location and type of use.

The author highlights several roles of the cabinets for different usage areas: a) cabinets at the side of the sink, b) sink cabinets, c) free-standing mixing unit cabinets, d) adjacent to another cabinet, mixing unit, e) pastry board, f) cabinets adjacent to cooker, g) serving cabinet, h) cabinet adjacent to the refrigerator, and ı) planning desk-cabinet (see Figure 17).

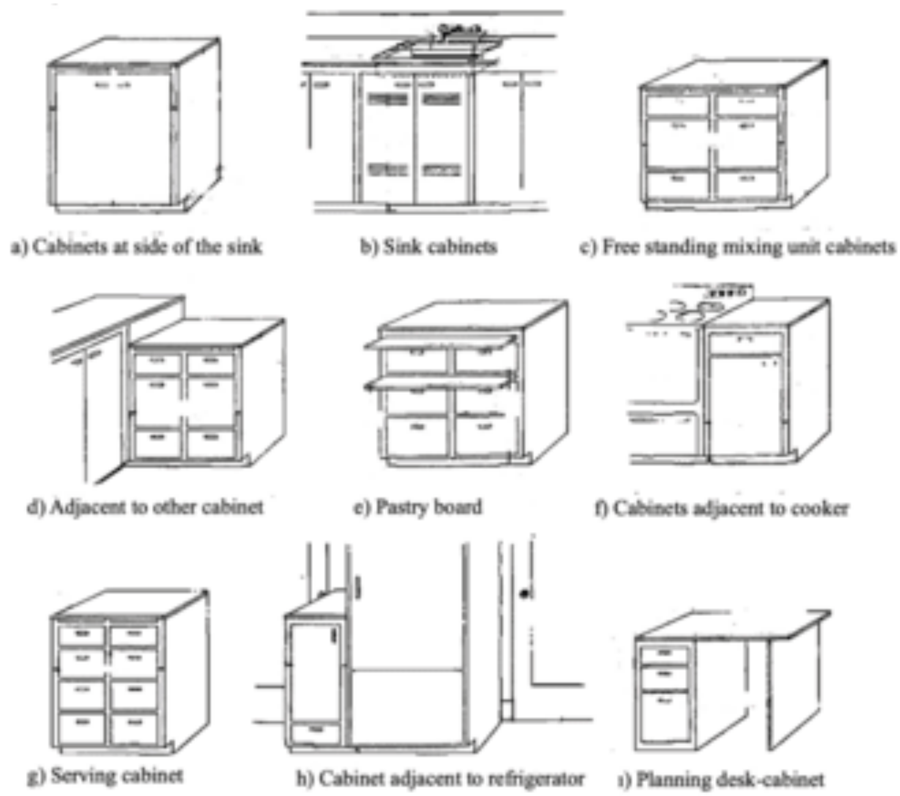

Figure 17. Illustration of several usage areas of the base cabinets (adapted from Wilson, 1947).

Wilson (1947) also emphasizes three components of kitchen cabinets: Floor-to-ceiling cabinets, wall cabinets, and base cabinets. Currently, floor-to-ceiling cabinets are known as wall cabinets. Although, in the past, a "pantry cabinet" was known as a whole storage unit in the kitchen, a pantry cabinet is used as a tall cabinet in the current residential kitchen environment (Anacker, 2018). Furthermore, base cabinets consist of six components: a compartment, tier of drawers, apron, pullout board, facing strip, toe space, counter, and overhang to fix on the wall (see Figure 18).

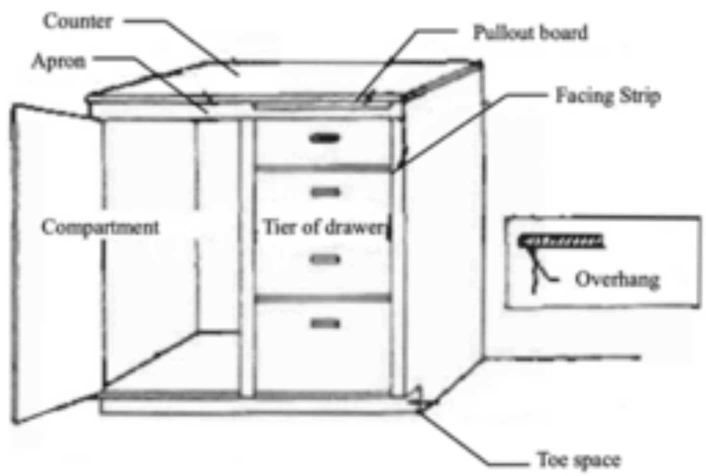

Figure 18. Parts of the kitchen base cabinet (adapted from Wilson, 1947)**.**

Cieraad (2002) also emphasizes that, before, kitchen cabinets had to harmonize with the furniture style in the living area. Regarding the design standard of the kitchen cabinets, even in the mass production process, the efficiency standards of the kitchen cabinet (working triangle) have not overturned flexibility yet, and the kitchen cabinet design remains as flexible (Frederick, 1913). In general, the ideal storage area, especially the size of the wall cabinets, might be between 800 mm and 1100 mm. Although wall cabinets are part of the cabinet types in residential kitchen environments, Hrovatin et al. (2015) suggested that due to visibility and accessibility problems, it is beneficial to avoid wall cabinets for older adults' usage.

Although the kitchen cabinets' context and parts did not face radical changes, different designs have emerged. With the help of technological enhancements, Balaji et al. (2020) proposed an intelligent kitchen cabinet system to track food records through wireless technological devices to see the quantity of the product inside the cabinet. This study might benefit prominent families and the food industry, especially in tracking quantity. Similarly, Lam et al. (2023) work with augmented reality (AR) to indicate the changes in kitchen cabinets for a better design process. Possible users can interact virtually through a 3D model to experience the changes in kitchen cabinets to test the usability of the wardrobe. As the AR experience allows participants to touch possible kitchen cabinet designs through the virtual 3D cabinet, the further design process might be more user-friendly due to experiencing likely kitchen cabinets. Besides these technological improvements, Rühr et al. (2012) used Socially Assistive Robots to detect usability problems and lead robots to experience the kitchen environment by considering easy-to-use kitchen cabinets. Hence, the technological era allows for the improvement of the design of kitchen cabinets in terms of usability for in the future.

2.2.2.2. Countertops

The countertop is a horizontal work surface attached to a based cabinet to do several kitchen tasks, such as preparing food and putting the most useful kitchen utensils (Anacker, 2018). Due to its purpose, countertops must be durable, easy to clean, resistant to heat, and keep out food stains (Salvini et al., 2018). The countertop's materials might have several features, pros, and cons. Cheng (2004) analyzed the various countertop materials, such as granite, quartz, marble, stainless steel, and concrete. However, these materials are not limited because Pourtahmasi et al. (2007) investigated glued laminated panels. Although new materials had to be examined to be used daily, the enhancement of kitchen countertop studies is improving.

Flores et al. (2013) examined different components rather than the material choice for the countertops. The hygiene of the countertops is also essential for the users to avoid bacteria. Hartje (2005) discussed the Universal Design (UD) side of the countertop. According to UD guidelines, continuous countertops are preferable for easier workflow between the refrigerator, sink, and stove to carry heavy things. Designers might consider several factors when choosing materials for the counter, including users' choice, needs, and appropriate materials features to suit the kitchen design with aesthetical considerations (Liu & MacGregor, 2006).

2.2.2.3. Appliances

Appliances such as a sink, refrigerator, stove, dishwasher, and microwave are considered kitchen components in the residential kitchen environment. Appliances make kitchen tasks easier, as well as usage areas for store items (Parrott et al., 2005). In terms of appliances in residential kitchen environments, in literature, kitchen appliances were considered from different perspectives. In the literature, Tanaka (2001) emphasizes the energy-saving feature of kitchen appliances to enhance environmentally friendly products in the kitchen. However, Siio et al. (2007) focused on future features of the appliances. The main example for that might be indicated by Lee et al. (2006), the study improved KitchenSense technology to interact technology with appliances through augmented reality (AR) to see the inside of the kitchen appliances, such as seeing foods inside of the refrigerator with open the door of the refrigerator. As for the importance of kitchen ventilation, Kosonen et al. (2006) worked on the effects of kitchen appliances on thermal comfort. Yu and Sung (2023) conducted a study on intelligent kitchen appliances to indicate the functionalities to enhance user experience positively by adding functionalities such as monitoring, control, optimization, and autonomy.

2.3. The Poka-Yoke Concept

In 1961, the Poka-Yoke Concept was proposed by Shiego Shingo while he was an engineer at Toyota Motor Corporation. This approach intends to prevent mistakes and distinguishes by implementing measures that act as a shield for the product. Diverse attributes of poka-yoke can be found in the literature, although they only differ in terms and accuracy. Shingo defines poka-yoke as a concept that detects errors by investigating all pieces independently at the assembly line through the manufacturing process (Dudek-Burlikowska & Szewieczek, 2009). Grout (2007) described poka-yoke as a design feature to prevent errors or alleviate the negative impact of the errors. Plonka (1997) views poka-yoke as a source that detects, eliminates, and corrects errors before they reach the customer. Middleton (2001) designated poka-yoke as the systematic practice of eliminating errors by identifying their original cause. Some studies provide examples to define the poka-yoke and its concept, either by alternating it with different labels like sensors or translations such as mistake-proofing or Poka-Yoke Concept (Saurin et al., 2012).

During the 1950s, Shiego Shingo was the defender of making production with zero errors in Japanese companies, but that is not the component that might be not handled alone. Thus, Japanese organizations began implementing a Zero Quality Control (ZQC) approach, with one of its crucial elements being the Poka-Yoke Concept which aims to ensure no one might make mistakes without any safety problems (Kurhade, 2015; Saurin et al., 2012). The philosophy behind the Poka-Yoke Concept is respecting human perception and rights by eliminating errors to improve their quality of life. By incorporating mechanisms that prevent errors in monotonous tasks, poka-yoke can save time and free up workers' minds for more creative actions. Ultimately, this approach increases their value. At the production line stage, errors are possible in each process and operation (Lazarevic et al., 2019). These errors can lead to damaged products and complaining customers. In the Poka-Yoke Concept, even detecting the small size of the errors are not acceptable because everything must be error-proofed. Thus, for companies, accomplishing a production rate of 100% without any errors is not only a challenge but an obligation. As a result, regarding this approach to the production process, Poka-Yoke Concept offers a simple technique to achieve such high quality production before it reaches the customer (Dudek-Burlikowska & Szewieczek, 2009).

There is currently no specific distribution of the Poka-Yoke Concept because the concept continues to vary and evolve. As organizations and individuals increasingly focus on implementing Poka-Yoke Concept measures, more innovative approaches will emerge and develop additional categories (Grout, 2007). However, Zhang (2014) mentioned four approaches to the Poka-Yoke Concept as follows: preventing mistakes in the work environment, detecting mistakes through informative analysis, which is reflected in Shingo's approach, preventing mistakes through source analysis also reflects Shingo's approach and minimizing the impact of mistakes (Fisher, 1999).

As the Poka-Yoke Concept emerged for the manufacturing process that prevents errors from the production wheel in Toyota company, the implementation process was as follows; understand what is the process or product and its need with analysis, identifying mistakes with careful observation, analyze mistakes by evaluation of frequency of the errors, apply source analysis that includes preventing errors at the beginning of the design process which can be done by checklists, visual clues or special mechanism and using specific control methods and evaluate (Lazarevic et al., 2019). However, Estrada & Lloveras (2008) described a method for the Poka-Yoke Concept that is applied to prevent errors during the assembly in the production process with five stages which are as follows; identify the potential errors, make priorities to detect alerting errors, identify the main source of the error and use poka-yoke design requirements. Besides Lazarevic et al. (2019) and Estrada and Lloveras's (2008) definition of implementations of Poka-Yoke in the production line, Estrada & Lloveras (2008) also defined the implementation stages for future designs to include user, design process, qualitative and quantitative statistics of the design, focusing on alerting errors and time confining. Lastly, there are different methodologies and stages to concentrate on the Poka-Yoke, which can be listed as follows according to the literature review; identifying the main problem, observing the area or product that has errors, proposing a Poka-yoke solution to the main error, evaluating the solution, choosing the best option for the solution, design Poka-Yoke

Concept area or product, implementing, testing, monitoring and maintaining the improvement of the solution.

The literature reviewed the basic principles, major categories, and possible methods. Regarding two categories, prevention includes protecting the product or system error from occurring, while detection is related to errors that occurred (Malega, 2018). Figure 19 illustrates the diagram of Poka-Yoke Concept categories.

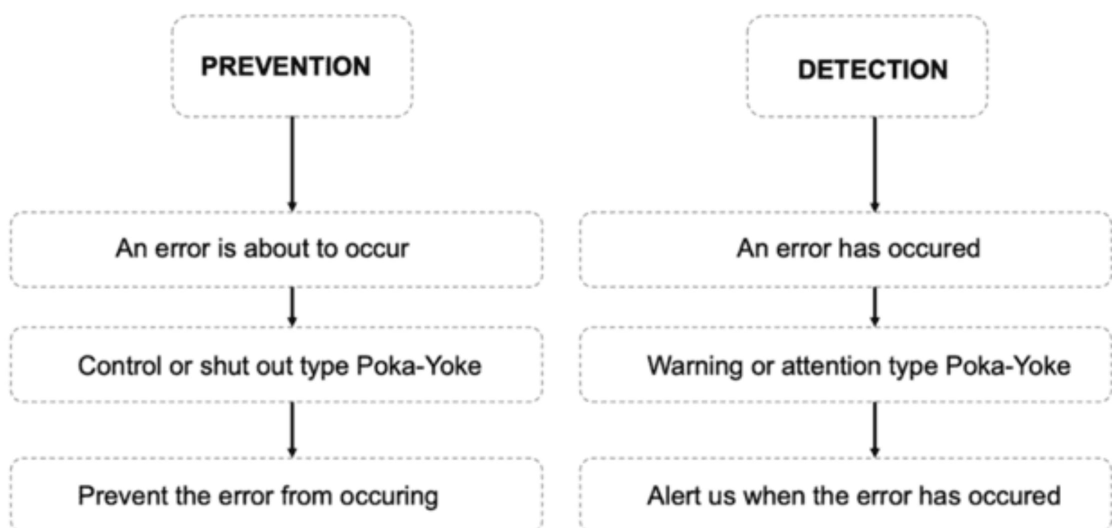

Figure 19. Diagram of Poka-Yoke Concept categories (adapted from Malega, 2018).

In terms of principles, there are five principles as follows: elimination, replacement, facilitation, detection, and mitigation. Malega (2018) emphasizes that elimination is related to the possibility of removing errors to redesign the process or product.

Replacement is finding a new reliable process or product instead of an old process using automation. Facilitation is related to making a process or product easier using color coding. Furthermore, detection is associated with the early detection of errors by developing more efficient designs. Lastly, mitigation consists of minimizing the effect of error by utilizing the system or product. Figure 20 illustrates the diagram of Poka-Yoke Concept principles.

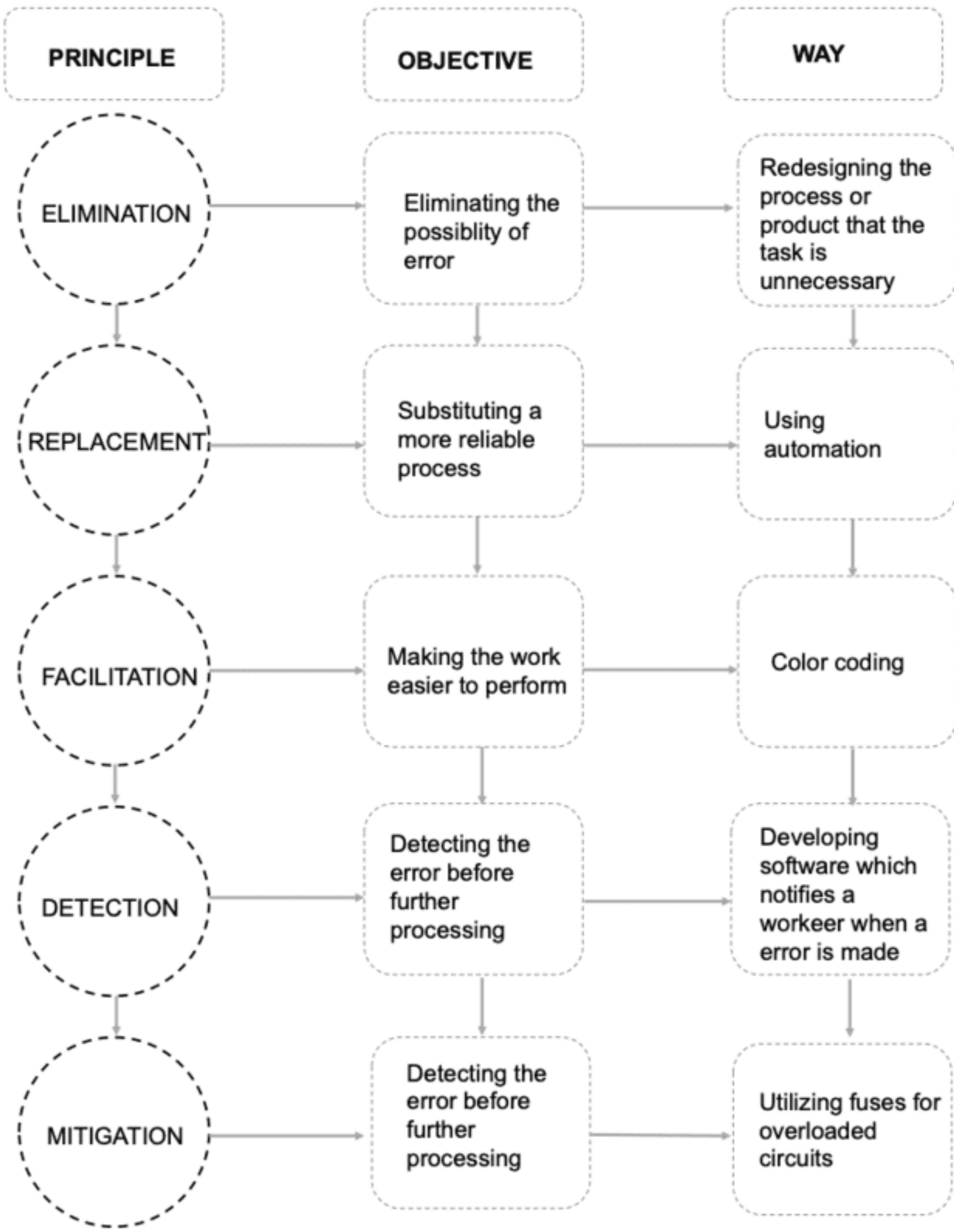

Figure 20. Diagram of principles of Poka-Yoke Concept (Adapted from Malega, 2018).

Saurin et al. (2012) described the Poka-Yoke Concept as designed to prevent or detect errors that might negatively influence product quality, employees' and users' health, and even safety. The Poka-Yoke Concept highlights two major components: prevention and detection. Although the Poka-Yoke Concept has emerged to prevent and detect errors in products and systems, currently Poka-Yoke Concept is used during the process to detect errors in the design phase (Chao, 2004; Chao et al., 2021). However, no implementation of poka-yoke is seen in physical environments, especially in residential kitchen environments. Thus, the Poka-Yoke Concept can be applied to physical environments through error prevention during design.

Within the framework of this thesis, prevention and detection of errors during the design process are considered to assess the Poka-Yoke Concept as an extended usability criterion in the residential kitchen environment. The principles of the Poka-Yoke Concept, which are elimination, replacement, facilitation, detection, and mitigation, might be used for error prevention in the design process (Malega, 2018). According to Chao (2004), errors in the manufacturing process is occurred because of errors during the design process of the system, product, or physical environment. 72% of the errors are defects during the design process, while only 10% are manufacture-related. Figure 21 illustrates the Pie-chart diagram of percentages of quality losses in the manufacturing process.

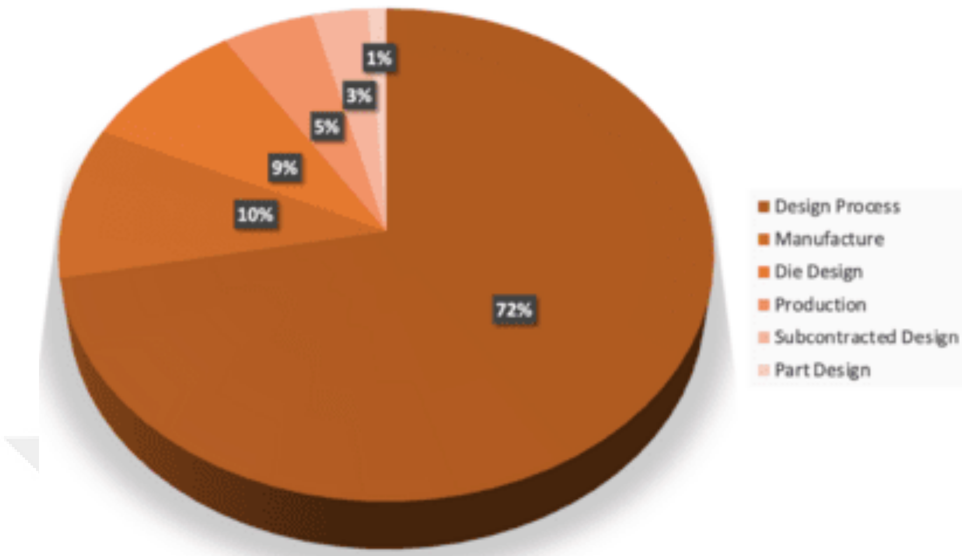

Figure 21. Pie-chart diagram of percentages of quality losses in the manufacturing process (Adapted from Chao, 2004).

A study by Ohashi et al. (2021) applied the Poka-Yoke Concept within the scope of Universal Design (UD) by indicating assistive devices for older adults. The study's results demonstrate that applying a risk management framework using error detection during the design process enhances the life quality of older adults by using Poka-Yoke Concept principles.

2.4. Empathy in Design

Understanding another person's life and accurately interpreting their feelings at the moment is the essence of empathy (Kalisch, 1973). The United Nations stated that virtually all countries can experience older adults' physical limitations, such as sensory, motor, and cognitive domains, at a young age (Vieweg & Schaefer, 2020). Age simulation suit (ASS) is an emphatic tool that enables people to put themselves in older adults' age (Chen et al., 2018). Aging suits includes several components that help to replicate the effects of older adults' physical limitations on the wearer, such as mobility limitations, muscle weakness, reduced dexterity, and impairments in vision and hearing. The torso, wrist, and ankle weights might help to feel mobility limitations, while gloves feel reduced dexterity. Glasses and ear protections are used in aging suits to replicate reduced vision and hearing (Bowden et al., 2021).

Aging simulation suits develop a better consideration and empathy towards older adults to understand their physical limitations by instructing future caregivers, nurses, engineers, architects, interior architects, and urban planners. With the growing older population worldwide, understanding their needs is getting more critical daily (Łapko, 2023; Sari et al., 2022a).

Yeşiltepe (2023) examined that how students' growth in the various dimensions of empathy, their design process and final products, and their perceptions of their learning experience are impacted by an empathic design process. This will help shed light on the effects of building empathy and its reflections on interior architecture education.

The types of age simulation suits have differed throughout the years (Figure 18). As Vieweg and Schaefer (2020) listed the types of aging simulation suits, the first complete set of age simulation suits that contains full body aging simulation suits is AgeExplorer which was invented by Blum and GERT (GeronTologic) suit that German company

Produkt+ Projekt Wolfgang Mool invented. Then, LM-60 was designed in Japan. The AGNES (Age Gain Now Empathy System) suit was invented by MIT (Massachusetts Institute of Technology) AgeLab in the USA. Figure 22 illustrates the AgeExplorer, GERT, LM-60, and AGNES suit.

Figure 22. *Age simulation suits* (i) AgeExplorer, Retrieved from https://www.blum.com/ca/en/company/quality-innovation/product-quality/requirement-research/age-explorer/ (ii) GERT suit, Retrieved from https://www.age-simulation-suit.com/age-simulation-suit.html (iii) LM-60, Retrieved from https://www.helago-cz.com/eshop-lm60-souprava-pro-simulaci-stari-133770.html (iv) AGNES suit (Sebesi et al., 2016).

With developments in medical care, and advancements in both educational and work settings, the global population is experiencing aging, so this issue makes researchers excited to understand older adults' needs due to the future high proportion of older individuals (Vieweg and Schaefer, 2020). To improve the healthy aging process, age simulation tools are invented to stimulate older adults' physical limitations to serve or design efficient needs for older adults to empathize with their experience.

As older adults have the right to conduct their daily life easily in a public environment, in terms of healthcare environments, Sari et al. (2022a) examined that wearing aging simulation impact nurses' perspective towards older adults' needs. This issue will enhance young people's awareness of older adults' physical conditions. Similarly, to support healthcare-care staff in gaining knowledge and understanding of older adults' physical limitations, Bennett et al. (2022) conducted a study with an aging simulation suit. Thus, healthcare providers enhance their communication skills, expand their horizons about aging, and be aware of the daily struggles that older adults face. Experiencing aging in built environments, Caglayan and Afacan (2021) conducted an experiment in airport environments to improve airport service quality in terms of architecture for older adults' needs. Wearing an aging simulation enhances awareness of the professions to be aware of older adults' struggles in the airport environment by experiencing their physical limitations by GERT suit.

Moreover, Taşoz and Afacan (2020) emphasized the effect of aging simulation suits in senior housing environments through the prioritized persona-based model. Hence, the aging simulation suit is an effective emphatic tool to improve professionals' understanding of older adults' necessities (Lavallière et al., 2017).

GERT (GeronTologic) Suit is invented by Gerthe man company Produkt+ Projekt Wolfgang Mool (Vieweg et al., 2023). Laurentius et al. (2022) described that the GERT aging simulation suit was designed to replicate the physical and sensory limitations of older adults, and it contains eight components, including a weighted vest, wrist weights, ankle weights, a ruff, bandages, glasses, ear protection, and special shoes. Approximately suit weighs 19.8 kg. All these wearable components create an understanding for young people. Figure 23 illustrates the GERT suit with its components.

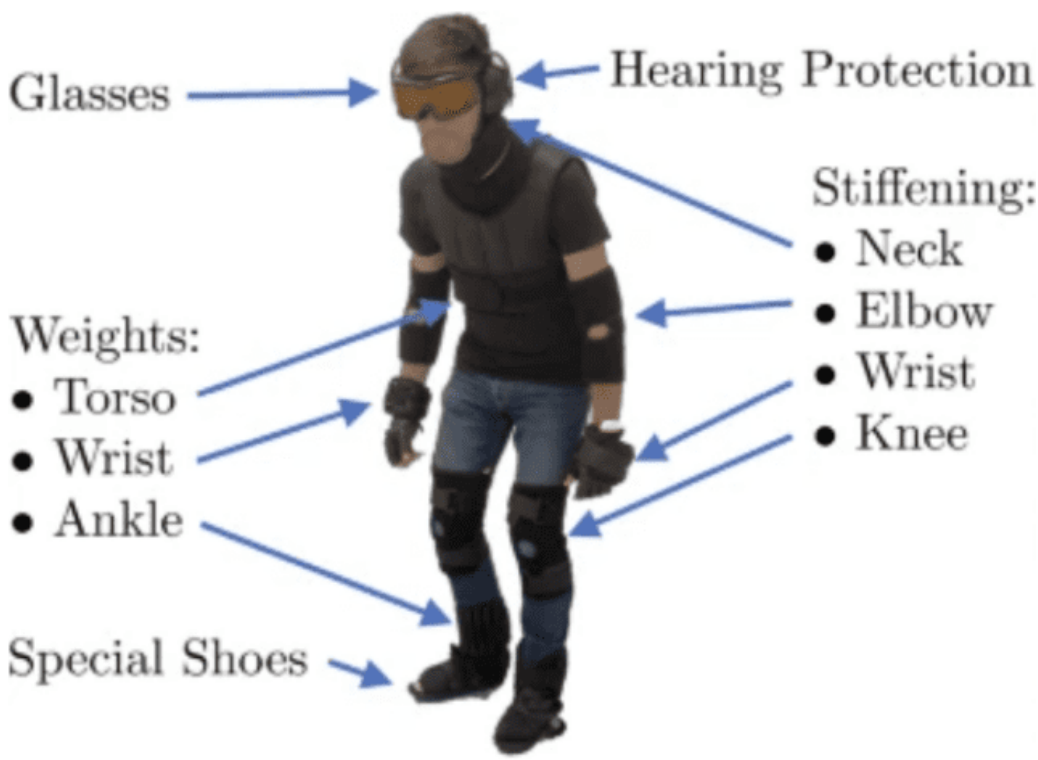

Figure 23. GERT suit with its components (Laurentius et al., 2022).

Timm et al. (2020) discussed that the GERT suit led people to experience older adults' physical limitations with different modules. Bandages and weights are used to understand older adults' joint stiffness and declined strength. Furthermore, specific modules are also used to experience mobility restrictions in particular body parts: a 10 kg weight vest, bandages for elbows and knees, weighted cuffs for ankle and wrist joints, a neck brace, overshoes, and gloves. In addition to these, simulation of visual and hearing impairments can be experienced through goggles and ear protection. Figure 24 illustrates the GERT suit with its modules in detail.

Figure 24. GERT suit with its modes in detail (Adapted from Timm et al., 2020).

In this study, the Poka-Yoke Concept, which focuses on Poka-Yoke Concept, was applied to kitchen design to enhance its usability for older adults. The study applied for this extension through an aging simulation suit, which helped designers gain a better understanding of older adults' needs in residential kitchens because, even though age-friendly kitchens, sometimes the older adults' needs are not aligned with each other. This issue leads older adults to adapt to makeshift solutions like using chairs to reach upper cabinets. Unfortunately, this can result in accidents such as falls and injuries. Thus, the primary goal is to extend the Poka-Yoke Concept by indicating differences in experience with and without wearing an aging simulation suit. Doing so aims to promote error-proofed kitchen designs that prioritize safety and functionality.

CHAPTER III

METHODOLOGY

3.1. Research Questions and Hypotheses:

3.1.1. Study Data Set I Research Questions:

RQ1: What are the most important design requirements for age-friendly residential kitchen design for older adults?

RQ2: Is there any statistically significant correlation between ease of use in the kitchen and Poka-Yoke Concept among kitchen environment design requirements?

RQ3: Is there any statistically significant difference between the importance level of ease of use in the kitchen and Poka-Yoke Concept among residential kitchen design requirements?

3.1.2. Study Data Set II Research Questions:

RQ4: Is there any statistically significant difference in heuristic evaluation between designers while performing residential kitchen scenarios with and without GERT Suit?

RQ5: Does GERT suit enable designers to increase their empathy towards older adults' experience in residential kitchen environments?

3.1.3. Study Data Set I Hypotheses:

H1: The most important design requirements for age-friendly residential kitchen design for older adults are related to eliminating errors, lighting, the effectiveness of workstations, and less effort in the kitchen.

H2: There is a significant correlation between the residential kitchen's ease of use and older adults' level of importance in the Poka-Yoke Concept.

H3: There is a statistically significant difference between the importance level of ease of use in the kitchen and Poka-Yoke Concept in the residential kitchen design requirements.

3.1.4. Study Data Set II Hypotheses:

H4: There is a statistical significance in heuristic evaluation between designers while performing residential kitchen scenarios with and without GERT Suit.

H5: There is statistical evidence that the GERT suit enables designers to increase their empathy towards older adults' experience in residential kitchen environments.

Table 1. Independent and dependent variables of two study data sets.

		Independent variable	Dependent variable
STUDY DATA SET I		AGE-FRIENDLY RESIDENTIAL KITCHEN DESIGN REQUIREMENTS i. Physical design elements for custom integrated residential kitchen ii. Ease of use in kitchen iii. Poka-yoke (error-proofing) in the kitchen environment	Importance ratings of the older adults
STUDYDATA SET II	SESSION I	Designers' residential kitchen design experience without GERT suit	Poka-Yoke (error-proofing) concept Empathy Level
	SESSION II	Designers' residential kitchen design experience with GERT suit	Poka-Yoke (error-proofing) concept Empathy Level

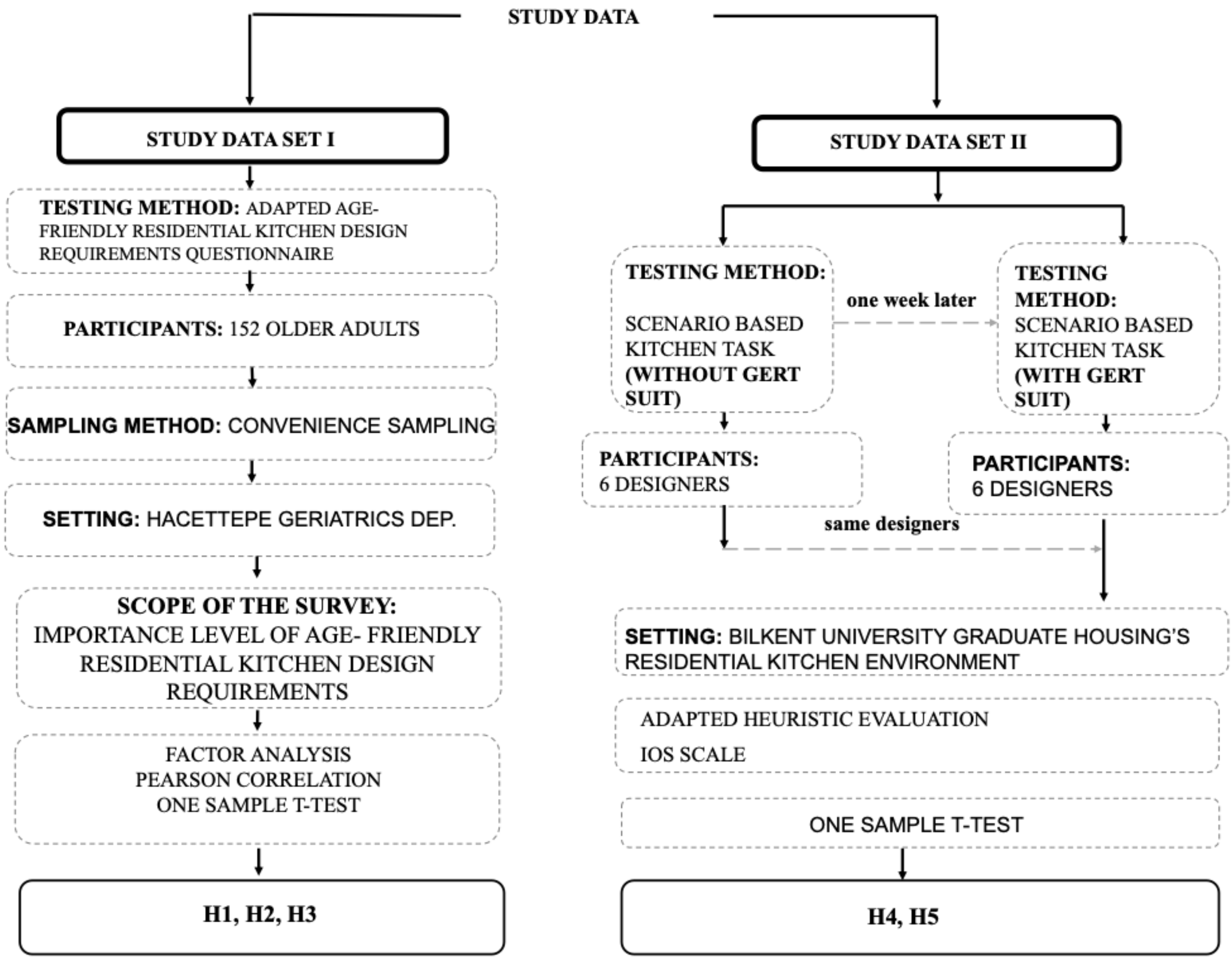

Figure 25. Study Data Chart (drawn by the author, 2024).

3.2. Settings

To assess the Poka-Yoke Concept as an extended usability criterion in residential kitchen design, the data was collected using a questionnaire method and scenario-based kitchen tasks in a real residential kitchen. Before exploring the task scenario, in the Study Data Set I, the adapted importance level of age-friendly residential kitchen design requirements and the Poka-Yoke Concept was measured through a questionnaire in the Department of Geriatrics of Hacettepe University Hospital. Figure 26 illustrates where the Study Data Set I conducted. The data was collected during the two months between October 2023 and November 2023.

Study Data Set II was conducted in residential kitchens with the participation of designers. Task scenarios were performed in Bilkent University Graduate Housing, Ankara, Türkiye's residential kitchen during the two weeks between April 2024 and May 2024. Residential kitchen was selected because it is one of the active environments in residential buildings, it involves home-based basic activities of daily living (BADL) and considered as obligatory activities, such as eating and preparing food. Bilkent University's 34th Graduate Housing's residential kitchen was selected due to the hypothetical kitchen environment in terms of the need to perform kitchen task scenarios in a real setting. The kitchen environment is six square meters with a dining table (see Figure 27).

Figure 26. Hacettepe Hospitals Geriatrics Department where Study Data Set I conducted (photo taken by the author, 2024).

Figure 27. Bilkent University Graduate Housing's residential kitchen where Study Data Set II conducted (photo taken by the author, 2024).

3.3. Participants

A suitable distribution can be achieved with a ratio as modest as five subjects for each variable (Afacan, 2017). Regarding participant number, 152 older adults filled out the questionnaire in the Study Data Set I. Depp and Jeste (2006) proposed that adults 60 and above might be suitable for engaging with older adults. The age ranges of older adults from 60 to more than 80. One hundred fifty-two older adults were recruited by random sampling method. The inclusion criterion for the first data collection stage are (i) being an older adult with a specific age range and (ii) being available and willing to complete the questionnaire for the study. The questionnaire was recruited through both an online questionnaire platform and a paper-based form.

According to Lewis (2014), formative studies measuring ability in Study Data Set II cover five to eight people in the second data collection stage. Furthermore, Virzi (1992) states that 80% of the usability problems might be found in the first few subjects. Thus, formative studies that measure usability cover from five to eight people. A non-probability sampling method with convenience sampling was assessed. Six designers were the participants because they were the target group to empathize with older adults' needs by wearing aging simulation suit to consider error-proofed items as an extended usability criterion. The inclusion criterion for this stage were: (i) being a graduate of design-related disciplines (e.g., interior architecture and architecture), (ii) having practice experience for three years in a design field, and (iii) not having any physical limitations.

The Bilkent University Institutional Ethical Review Board approved the study (Ethics file no:449, 535). In Study Data Set I, older adults were asked to sign the consent form to complete the questionnaire, including the study's aim and the precision of their involvement. In the Study Data Set II, designers were asked to sign the consent form for performing task scenarios in a real residential kitchen environment, including the study's aim, the precision of their involvement, and possible risks. After this process, participants performed the given kitchen tasks. All participants were assured of participating in this study and were informed that their participation was voluntary and that they could withdraw from performing tasks and completing the questionnaire. After performing kitchen tasks, designers were asked to complete a questionnaire adapted to assess usability problems.

3.4. **Procedure**

The study consisted of two study data sets. Study Data Set I consisted of the following five stages: (Stage I) adapting a usable kitchen factors questionnaire, (Stage II) questionnaire with older adults, (Stage III) analyzing questionnaire results, (Stage IV) developing factor analysis from the questionnaire answers, (Stage V) constructing tasks and a scenario that was based on the factor analysis results.

Study Data Set II consists of two sessions. In session I, there are three stages as follows: (Stage I) introducing the kitchen environment to designers, (Stage II) performing kitchen tasks in a residential kitchen environment by designers, and (Stage III) conducting close-ended heuristic evaluation after completing the kitchen task scenario. One week later, session II was conducted with a GERT suit. Session II consists of four stages as follows: (Stage I) introducing the GERT suit to designers, (Stage II) performing kitchen tasks in a residential kitchen environment, (Stage III) conducting the close-ended heuristic evaluation questionnaire, and (Stage IV) synthesizing results to extend poka-yoke as a usability criterion. Figure 28 illustrates the details of the procedure diagram of the study.

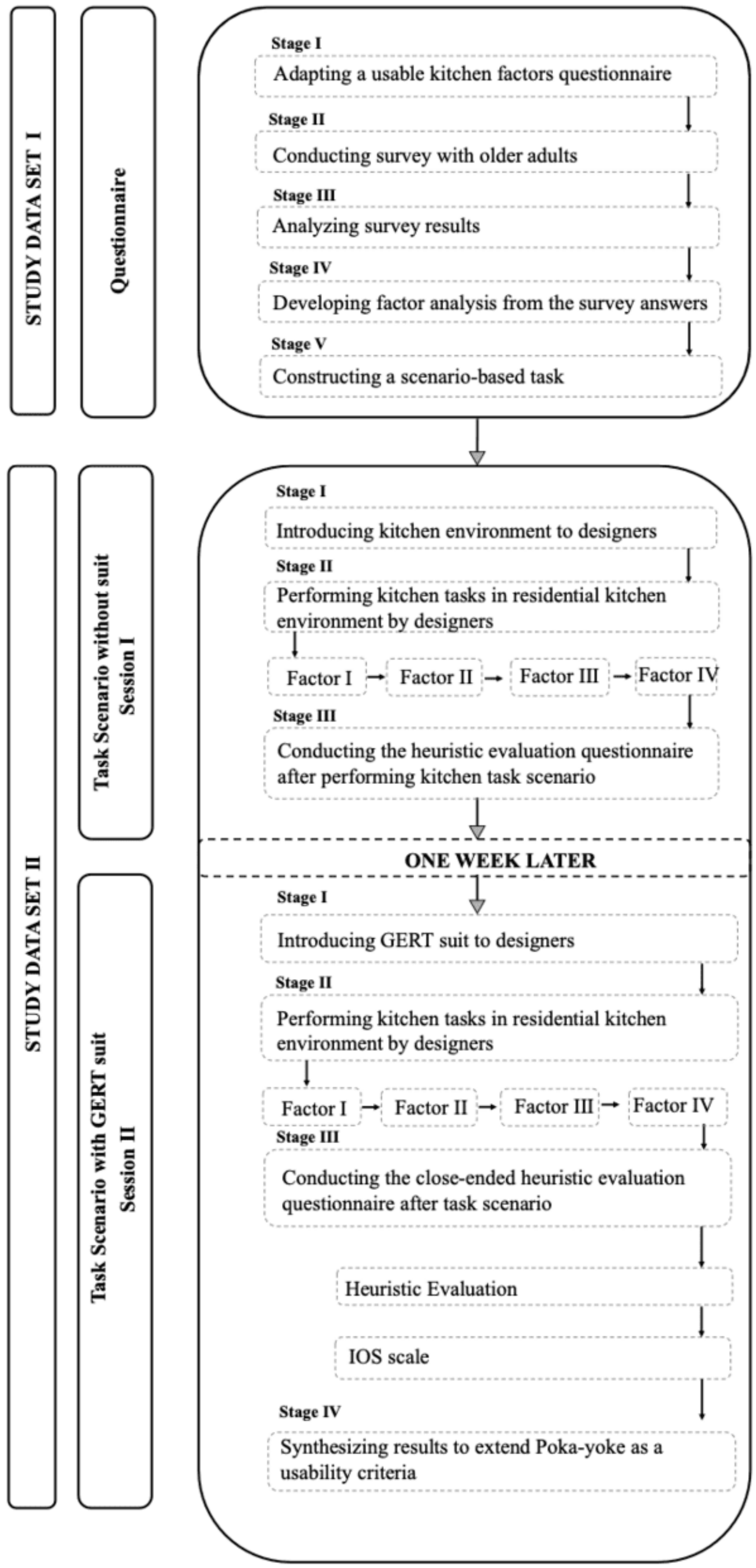

Figure 28. Study Procedure Chart (drawn by the author, 2024).

3.5. Instrument and Data Collection

In Study Data Set I, 13 questions were assessed on the importance level of kitchen environment factors for older adults. Bonenberg et al. (2019) adapted the first eleven questions to measure the importance of requirements for a kitchen environment. Questions from twelve to twenty-three were related to ease of use in the kitchen to measure older adults' importance in terms of usability in the kitchen environment, as adapted from Demirkan & Olguntürk (2014). Questions from twenty-four and twenty-six contained principles of the poke-yoke (Poka-Yoke Concept) concept, adapted from Lixia and Bo (2010). The last four questions were adapted from Saurin et al. (2012) to test the importance of error detection in residential environments during design. The scale came on a five-point Likert scale ranging from 1 as less important to 5 as most important for the age-friendly residential kitchen design requirements (Appendix B). The second part of the questionnaire is translated from Demirkan and Olguntürk's (2014) Turkish translation. However, the author self-translated the first and third parts of the questionnaire.

In Study Data Set II, a kitchen task scenario and Poka-Yoke Concept-based heuristic evaluation were used to measure kitchen experience with and without a GERT suit. A task-based residential kitchen task scenario has been formed according to the results of the questionnaire in Study Data Set I. The questionnaire was related to heuristic evaluation (Appendix D). This scale in this study was a five-point Likert scale ranging from 1 to 5. Heuristic evaluation generally is associated with Nielsen's (2010) 10 principles. However, heuristic evaluation adapted within the study context (Afacan & Erbuğ, 2009). Thus, since this thesis explores the Poka-Yoke Concept, heuristic evaluation was adapted from Shanklin et al., including error-proofed items with usability items (2020).

3.5.1. Residential Kitchen Task Scenario

The scenario used in Study Data Set II is as follows;

“You can imagine that you are an older adult living with your older sister, and you're tasked with preparing lunch for her. While in the kitchen, you suddenly fall. You must stand up, find appropriate lighting, and switch on the fixture. Next, reach for the pan in the upper cabinet and place a bowl on the countertop. Get a bowl of vegetables from the refrigerator and set it on the countertop. Wash the vegetables in the sink, then chop them and add them to the pan. Heat the vegetables in the oven, then turn off the oven and set the pan aside. Open the upper cabinet again to get plates, then open the base cabinet to grab forks. Serve the heated vegetables on two plates. Grab the prepared food from the counter, placing plates and forks on the table first, then bring the food to the dining table.

According to Kuoppamäki et al. (2021), tasks are developed according to Study Data Set I factor analysis results. Task scenarios were organized according to scenario-based design (Vincent & Baldford, 2015). The scenario was based on the falling into the kitchen as an older adult living with an older sister. Table 2 illustrates the constructed kitchen tasks regarding age-friendly residential kitchen factors. Figures 28, 29, 30, 31, and 32 indicate the participants performing kitchen tasks, starting with falling.

Table 2. Constructed kitchen task scenarios regarding age-friendly residential kitchen factors.

Factors	**Tasks**
Usage of color and lighting	PMT1_1: Finding appropriate lighting fixture PMT1_2: Switching lighting fixture on
Working Efficiency	PMT2_1: Getting pan from the upper cabinet and put it on the countertop PMT2_2: Getting bowl with vegetables from the refrigerator PMT2_3: Washing vegetables in the sink PMT2_4: Cutting and chopping the vegetables on the cutting board PMT2_5: Heat chopped vegetables with the pan in the oven by using oven buttons PMT2_6: Put heated vegetables aside and turn off the oven
Low Physical Effort	PMT3_1: Opening the upper cabinet again by grabbing the door handle to get the plates PMT3_2: Opening the base cabinet by grabbing the door handle to get forks
Access to the workstations	PMT4_1: Put heated vegetables on the plate PMT4_2: Getting prepared food from the counter PMT4_3: First, put plates and forks on the dining table PMT4_4: Then return to the countertop, put prepared food on the dining table

3.5.3. GERT Suit

The tool used in this study is the GERT suit (GERontologic Test) produced by the German-based company Produkt+ Projekt Wofganf Moll. It enables us to understand older adults' physical experiences at a young age. With this suit, people empathize the older adults' needs such as mobility, balance, strength, vision, and audition (Timm et al., 2020).

Figure 29. Designer I perform falling scenario (photo taken by the author, 2024).

Figure 30. Designer II perform falling scenario (photo taken by the author, 2024).

Figure 31. Designer I perform kitchen task scenario using the oven (photo taken by the author, 2024).

Figure 32. Designer I performs a kitchen task scenario by serving the prepared food (photo taken by the author, 2024).

3.6. Data Analysis

The data were analyzed statistically on IBM SPSS (Social Package for Social Sciences) Statistics 25. In the findings of Study Data Set I, descriptive statistics were identified to determine the number and percentage of the participant's age, gender, marital status, education level, age of the residential kitchen, and physical limitations. Factor Analysis (Principal Component Analysis) was conducted to identify the most crucial age-friendly residential kitchen design requirements that include (i) physical design elements for custom integrated residential kitchen, (ii) ease of use in the kitchen, and (iii) Poka-Yoke Concept in the residential kitchen environment. Pearson correlation test was conducted to identify the relationship between ease of use in the kitchen items and Poka-

Yoke Concept in the residential kitchen environment items. Lastly, one sample t-test was performed to indicate the difference between ease of use in the kitchen and Poka-Yoke Concept in the residential kitchen environment items. The confidence interval for the t-test was defined as 95 percent.

Study Data Set II continued after Study Data Set I findings. In Study Data Set II, descriptive statistics were identified to determine the number and the percentage of the participant's age, gender, marital status, education level, age of the residential kitchen, profession, smoking habit, and physical limitations. Mean values were calculated for each factor with each item under the four factors. One sample t-test was conducted to indicate the difference between with and without GERT suit experience. Lastly, one sample t-test was also conducted for the IOS (Inclusion of Other in the Self) Scale to indicate the perceived closeness of designers to older adults with and without GERT suit experience. Table 3 illustrates the data analysis table of the study.

Table 3. Data analysis table of the study.

Data set	Methods and Tools	Major Focus	Hypotheses	Analysis
Study Data Set I	Adapted Age-Friendly Residential Kitchen Design Requirement Questionnaire 5 Point Likert Scale 30 items	To explore the importance level of the residential kitchen design requirements	H1/H2/H3	Factor Analysis T-test Pearson Correlation
Study Data Set II	Scenario-based kitchen tasks GERT (aging simulation suit)	To explore the Poka-Yoke concept as an extended usability criterion	H4/H5	T-test

CHAPTER IV

RESULTS

4.1. STUDY DATA SET I FINDINGS

4.1.1. Descriptive Findings

In total, 152 older adults participated in the questionnaire study, including age-friendly residential kitchen design requirements. Regarding age, 40% (n=56) of the participants were between 60 and 65. 23% (n= 35) of them were from 65 to 70, while 20% (n=30) of the older adults aged between 70-75. While, 11% (n=17) of the participants were aged 75 to 80, 9% (n=14) were above 80. According to the gender ratio, there is no equal distribution. While 73% (n=111) of the participants were female, 27% (n=40) were male. Only 7% (n=1) of the participants did not prefer to say.

Among the participants, 64% (n=97) were married, while 20% (n=30) of them were widows. 9% (n=14) of the participants were single, while 7% (n=11) divorced. Regarding education level, 30% (n=46) of the participants had primary school degrees, while 18% (n=27) had middle school degrees. 14% (n=21) of the older adults had high school degrees and 22% (n=33) of them had bachelor's degrees. Regarding graduate studies degrees, while 11% (n=17) of the participants had master's degrees, only 5% (n=8) of them had Ph.D. degree.

There is an identical distribution in the age of the residential kitchen data. Among the participants' residential kitchen age, 19% (n=28) of them were from 15 to 20, 17% (n=25) were from 10 to 15, 14% (n=21) were from 20 to 25, 13.8% (n=21) were from 25 to 30, 14% (n=21) were from 5 to 10), and 15% (n=22) were above 30 years.
Among participants, 53% (n=80) had no physical limitation, while 28% (n=43) had mobility problems. Lastly, 10% (n=15) of the participants had hearing problems, and 9% (n=14) had sight problems. Table 4 illustrates the descriptive statistics of the Study Data Set I findings.

Table 4. Descriptive table of demographic data.

Characteristics	Number (n)	Percent (%)
Age (years)		
60-65	56	40
65-70	35	23
70-75	30	20
75-80	17	11
80+	14	9
Gender		
Female	111	73
Table 4. (continued).		
Male	40	26
Prefer not to say	1	7
Marital Status		
Single	14	9
Married	97	64
Divorced	11	7
Widow	30	20
Education Level		
Primary school degree	46	30
Middle school degree	27	18
High school degree	21	14
Bachelor's degree	33	22
Master's degree	17	11
Ph.D. Degree	8	5
Age of the residential kitchen		
0-5	14	9
5-10	21	14
10-15	25	17
15-20	28	19
20-25	21	14
25-30	21	14
30+	22	15
Physical Limitation		
No	80	53
Sight	14	9
Hearing	15	10
Mobility	43	28
Total	152	100

Adapted older Friendly Residential Kitchen Design Requirements questionnaire has three items as follows: (i) Physical design elements for custom integrated residential kitchen, (ii) Ease of use in the kitchen, and (iii) Poka-Yoke Concept in the residential kitchen environment. The first item is the physical design elements for a custom-integrated residential kitchen. The highest mean value is due to the height of the wall cabinet (M= 4.60, SD= 0.663). The lowest mean value is safety such as placement of the breakable items on lower shelves (M= 4.10, SD= 0.968).

Secondly, ease of use in the kitchen is the highest, including easy movement (M= 4.60, SD= 0.567). The lowest item is the color contrast between the counter and cabinets (M=2.65, SD= 0.944).

The third item includes Poka-Yoke Concept in the residential kitchen environment items. The highest mean value is the prevention of errors in the kitchen during the design process (M= 4.39, SD= 0.587), the lowest belongs to using visual control items such as using sensors and labels to detect errors in the residential kitchen design process (M=3.30, SD= 1.072). Table 5 indicates the descriptive frequencies with mean values of items that meet age-friendly residential kitchen design requirements items.

Table 5. Descriptive frequency table of age-friendly residential kitchen design requirements.

Age-friendly Residential Kitchen Design Requirements	**Mean**	**Median**	**SD**
1.Physical design elements for custom integrated residential kitchen			
1.1. Functionality of kitchen use (e.g., no need for special support)	4.38	5.00	.812
1.2. Communication (e.g., elimination of door sill)	4.14	4.00	.838
1.3. Working triangle (e.g., distances of appliances to workstations)	4.11	4.00	.842
1.4. Existence of rest seat/ width of the rest seat	4.20	4.00	.884
1.5. Height of the wall cabinet	4.60	5.00	.633
1.6. Safety (e.g., placement of the breakable items on lower shelves)	4.10	4.00	.968
1.7. Storage capacity	4.38	5.00	.779
1.8. Storage height	4.17	4.00	.867
1.9. Washing station (e.g., usability of kitchen sink)	4.50	5.00	.661
1.10. Cooking station (e.g., usability of oven, microwave, and cooker)	4.53	5.00	.586
1.11. Cooling station (e.g., placement and adequate space for refrigerator)	4.40	4.00	.674
2. Ease of use in the kitchen			
2.1. To move the easily in kitchen	4.60	5.00	.567
2.2. Adequate illumination	4.22	4.00	.670
2.3. To have color contrast between the sink and counter	2.67	3.00	.995
2.4. Main counter to be used easily	4.38	4.00	.562
2.5. Task lighting on top of the counters	3.49	4.00	1.036
2.6. To have color contrast between the counter and cabinets	2.65	3.00	.944
2.7. Cabinet handles to be used easily	4.01	4.00	.651
2.8. Cabinets to have pullout shelves	3.63	4.00	.947
2.9. To have illumination inside of kitchen cabinets	3.11	3.00	1.064
2.10. Floor to be slip-resistant	4.38	4.00	.718
2.11. To have a short distance between the kitchen and the dining table	3.91	4.00	.983
2.12. To have enough electrical outlets	3.95	4.00	.770

Table 5. (continued).

3. Poka-Yoke Concept in the residential kitchen environment			
3.1. Elimination of errors in the kitchen during the design process	4.33	4.00	.617
3.2. Prevention of errors in the kitchen during the design process	4.39	4.00	.587
3.3. Detection of errors in the kitchen during the design process	4.34	4.00	.672
3.4. Problems should be controlled during the kitchen design process	4.30	4.00	.587
3.5. Designing simple to make problems visible in residential kitchen	3.59	4.00	.800
3.6. People have their attention focused on kitchen tasks rather than focusing on errors in the kitchen	3.53	4.00	1.104
3.7. Using visual controls, so no problems are hidden (e.g., using sensors and labels to detect errors)	3.30	3.00	1.072

This study conducted factor analysis. Using the Kaiser Normalization rotation method, the principal component analysis determined the loadings according to Varimax. Before running the factor analysis, floor and ceiling effect values were observed, so factor analysis was done to estimate these effects by eliminating items with mean values below 1.50 and 4.50 above.

In terms of exploratory factor analysis results, four usability factors were identified. Factor Analysis was done to test Hypothesis 1 (H1), “The most important age-friendly residential kitchen design requirements for older adults are related with four main factors: usage of usage of color and lighting, working efficiency, low physical effort, and access to the workstations”.

Factor 1 is defined as "usage of usage of color and lighting" and has four components. The first two components of Factor 2 are related to the importance of color selection in cabinets, counters, and sinks. The last two components indicate the significance of lighting for the kitchen task. Among the components of Factor 1, the item "to have color contrast between counter and cabinets" was rated as the most important item.

Factor 2 is "working efficiency" and has the following components: (i) storage capacity, (ii) storage height, and (iii) safety (e.g., placement of the breakable items on lower shelves). Components i,ii, and iii are highly associated with each other because these three items were related to kitchen access to ease kitchen working for the users. Among the components of Factor 2, the item "storage capacity" was rated as the most important item.

Factor 3, "low physical effort" related to required factors in the residential kitchen environment. All components are related to ease of use while working in the kitchen. Among the components of Factor 3, the item "cabinets to have pullout shelves" was rated as the most important item.

Factor 4 is "access to the workstations," which had the following three components: (i) to have a short distance between the kitchen and the dining table, (ii) a working triangle, and (iii) the floor to be slip-resistant. The first and the second components are to distance, while the third item is related to safety issues regarding efficient usage of the residential kitchen environment. Among the components of Factor 4, the item "To have a short distance between the kitchen and the dining table" was rated as the most important item. Table 6 illustrates the variance table.

Table 6. Variance table of the age-friendly residential kitchen requirement questionnaire.

Factor	Scale	Eigenvalue	Variance (%)	Cumulative (%)
1	**Usage of color and lighting**	2.953	11.357	35.860
2	**Working Efficiency**	1.293	4.973	54.617
3	**Low Physical Effort**	1.502	5.777	49.644
4	**Access to the workstations**	2.082	8.007	43.867

The color contrast between the counter and cabinets (0.884) and color contrast between the sink and counter (0.856) have significant positive loadings in Factor 1. The storage capacity (0.769) and storage height (0.763) have significant positive loadings in Factor 2. Cabinets with pullout shelves (0.679) and enough electrical outlets (0.604) have significant positive loadings in Factor 3. To have a short distance between the kitchen and the dining table (0.823), have a sizeable positive loading in Factor 4. Table 7 describes the factor analysis loadings of age-friendly residential kitchen design requirements.

4.1.2. Factors of Age-friendly Residential Kitchen Design Requirements

Table 7. Factor analysis loadings of age-friendly residential kitchen design requirements.

Variables	**Factors**						
	1	2	3	4	5	6	7
To have color contrast between the counter and cabinets		**.884**					
To have color contrast between the sink and counter		**.856**					
To have illumination inside of kitchen cabinets		**.563**					
Task lighting on top of the counters		**.528**					
Storage capacity			**.769**				
Storage height			**.763**				
Safety (e.g., placement of the breakable items on lower shelves)			**.708**				
Cabinets to have pullout shelves				**.679**			
To have enough electrical outlets				**.604**			
Cabinet handles to be used easily				**.511**			
To have a short distance between the kitchen and the dining table					**.823**		
Working triangle (e.g., distances of appliances to workstations)					**.636**		
Floor to be slip-resistant					**.589**		
People have their attention focused on kitchen tasks rather than focusing on errors in the kitchen						.861	
Designing simple to make problems visible in residential kitchen						.509	
Functionality of kitchen use (e.g., no need for special support)							.670
Communication (e.g., elimination of door sill)							.510

4.1.3. Correlation Between Ease of Use and Poka-Yoke Concept

Pearson correlation was conducted to indicate the relationship between ease of use in the kitchen items and Poka-Yoke Concept in the residential kitchen environment items, in which Hypothesis 2 (H2) 'There is a significant correlation between the residential kitchen's ease of use and older adults' importance level of Poka-Yoke Concept was tested. According to the Pearson correlation test result, there was a statistically significant moderate positive correlation ($r = 0.553$, $p < 0.001$) between ease of use in the kitchen items and Poka-Yoke Concept in the residential kitchen environment items, showing values of ease of use in kitchen items increase, there is a corresponding increase in values of Poka-Yoke Concept in the residential kitchen environment item, and vice versa. Table 8 shows the correlation between ease of use in the kitchen and Poka-Yoke Concept in the residential kitchen environment items.

Table 8. Pearson correlation table for ease of use in the kitchen and Poka-Yoke Concept in the residential kitchen environment items.

		Ease of use in the kitchen	Poka-Yoke Concept in the residential kitchen environment
Ease of use in the kitchen	Pearson Correlation	1	.553**
	Sig. (2-tailed)		.000
	N	152	152
Poka-Yoke Concept in the residential kitchen environment	Pearson Correlation	.553**	1
	Sig. (2-tailed)	.000	
	N	152	152

**. Correlation is significant at the 0.01 level (2-tailed).

4.1.4. Difference Between the Importance Level of Ease of Use in the Kitchen and Poka-Yoke Concept

Lastly, one sample t-test was conducted to indicate the difference between the importance level of ease of use in the kitchen items and Poka-Yoke Concept in the residential kitchen environment items, in which Hypothesis 3 (H3) 'There is a statistically significant difference between importance level of ease of use in the kitchen and Poka-Yoke Concept in the residential kitchen design requirements.' was tested. According to the result of the one-sample t-test, there was a statistically significant difference between the importance level of ease of use in the kitchen items and Poka-

Yoke Concept in the residential kitchen environment items. The mean difference for ease of use in the kitchen item is 375.055 with a 95% confidence interval ranging from 36.725. For Poka-Yoke Concept in the residential kitchen environment items, the mean difference is 396.805, with a 95% confidence interval ranging from 38.888. These results indicate a statistically significant difference between the two groups' measured variables. Table 9 indicates one sample t-test results for ease of use in the kitchen and Poka-Yoke Concept in the residential kitchen environment items.

Table 9. One sample t-test table for ease of use in the kitchen and Poka-Yoke Concept in the residential kitchen environment items.

					Test Value = 0
					95% Confidence Interval of the Difference
	t	**df**	**Sig. (2-tailed)**	**Mean Difference**	**Lower**
Ease of use in the kitchen	94.912	151	0	375.055	36.725
Poka-Yoke Concept in the residential kitchen environment	98.9	151	0	396.805	38.888

4.2. STUDY DATA SET II FINDINGS

4.2.1. Descriptive Findings

In total, six designers participate in Study Data Set II. Regarding age, 33% (n=2) of the participants were the age 30. 17% (n= 1) of the participant was 29, while 16.7% (n=1) of the designer was 26. At the same time, 33% (n=2) of the participants were 32. According to the gender ratio, there is no equal distribution. While 67% (n=4) of the designers were female, 33% (n=2) were male.

Among the participants, 67%(n=4) were single, while 33%(n=2) were married. Regarding education level, 33% (n=2) of them had bachelor's degrees. Regarding profession, 67% (n=4) of the participants were interior architects, while 33% (n=2) were architects. Regarding graduate studies degrees, while 17% (n=1) of the participants had master's degrees, 50% (n=3) had a P.h.D. degree. Among the participants' residential kitchen age, 33% (n=2) of them were from 5 to 10, 33% (n=2) were from 15 to 20, 33% (n=2) were from 20 to 25.

Among participants, %100 (n=6) have no physical limitation. Lastly, %33 (n=2) of the participants smoke, %67 (n=14) do not smoke. Table 10 illustrates the descriptive statistics of the Study Data Set II findings.

Table 10. Descriptive table of designers' demographic data.

Characteristics	Number (n)	Percent (%)
Age		
30	2	33
29	1	17
26	1	17
32	2	33
Gender		
Female	4	67
Male	2	33
Marital Status		
Single	4	67
Married	2	33
Profession		
Architect	2	33
Interior Architect	4	67
Education Level		
Bachelor's degree	2	33
Master's degree	1	17
Ph.D. Degree	3	50.0
Age of the residential kitchen		
5-10	2	33
15-20	2	33
20-25	2	33
Physical Limitation		
No	6	100
Smoke Habit		
Yes	2	33
No	2	33

Adapted Heuristic evaluation consisted of four factors as follows: (i) Usage of color and lighting, (ii) Working Efficiency, (iii) Low Physical Effort, and (iv) Access to the workstations.

Firstly, regarding without GERT experience, the first factor is usage of color and lighting. The highest mean is the color difference between the counter and the accessible visual recognition item (M= 4.33, SD= 0.516) and the effortless usage of the lighting fixtures item (M= 433, SD= 0.816). The lowest mean values were the choice of color (M= 3.00, SD= 1.414) and the efficiency of the lighting fixture items (M= 3.00, SD= 1.549). The highest mean value that belongs to the GERT suit experience is the sufficiency of the storage capacity item (M= 4.00, SD= 1.095). The lowest mean value was the color choice of the kitchen elements (e.g., countertops and cabinets), which was satisfactory item (M= 2.50, SD= .548).

The second factor is the working efficiency. Without GERT suit experience, the item there is a short distance between the kitchen and the dining table, which has the highest mean value (M= 4.83, SD= 0.408), and working from the refrigerator to the sink, oven, and dining table did not require extra effort (M= 4.50, SD= 0.837). The lowest item under the second factor without great experience is the applied slip-resistant floor materials item (M=3.33, SD= 1.049). The highest mean value of the GERT suit experience is that there is a short distance between the kitchen and the dining table item (M= 4.67, SD= 0.516). The lowest mean value was that no extra effort was required to use the oven item (M= 2.17, SD= 1.169).

The third factor is the low physical effort. Without GERT suit experience, the highest mean value is there were enough upper and base cabinet items (M= 4.33, SD= 0.816), and the lowest is the cabinet design was adequate, eliminating the need to consider design errors in the upper and base cabinets item (M=3.00, SD= 0.894). The highest mean value of the GERT suit experience is if there was a design-related problem with the cabinets, the user recognized the error item (M= 4.33, SD= 0.516). The lowest mean values were the design of the base and upper cabinets did not affect the tempo of the kitchen tasks and accessing upper cabinets was easy (M= 1.83, SD= 0.408) and there were enough upper and base cabinets (M= 1.83, SD= 0.408).

The fourth factor is access to the workstations. The highest mean value is the storage capacity was adequate, eliminating the need to consider where to put kitchen items (M= 4.50, SD= 1.549). The lowest is the storage capacity and the countertop design were error-free (M=3.00, SD= 1.549). The highest mean value would belong to the GERT suit experience is the storage capacity was adequate, eliminating the need to consider where to put kitchen items (M=3.50, SD= 0.837), and the storage capacity and the countertop did not affect the tempo of the kitchen tasks item (M=2.17, SD= 0.983). Table 11 indicates the descriptive frequencies with mean values of with and without GERT suit experience result.

Table 11. Frequency table of with and without GERT suit experience.

	Without GERT Suit			With GERT Suit		
	Mean	**Mode**	**SD**	**Mean**	**Mode**	**SD**
Factor 1: Usage of color and lighting						
Reaching the lighting fixture was easy	4.00	4.00	1.095	2.67	2.00	1.033
The color difference between the counter and the cabinet was crucial for easy visual recognition	4.33	4.00	.516	3.67	3.50	1.211
The storage capacity was sufficient	4.17	4.50	.983	4.00	4.00	1.095
The color choice of the kitchen elements (e.g. countertops, and cabinets) was satisfactory	3.83	4.00	1.169	2.50	2.50	.548
The color choice was not distracting while performing kitchen tasks	3.83	4.00	1.269	3.33	3.00	.516
The choice of the color choice was rational	3.00	3.00	1.414	3.00	3.00	.894
The usage of the lighting fixture was efficient	3.00	3.00	1.549	2.33	2.00	.516
The lighting fixture was correctly used without error	3.83	4.00	1.472	2.83	3.00	1.169
The lighting fixture was used without instructions being needed	4.17	4.50	1.169	3.67	4.00	1.033
The lighting fixture was used effortlessly	4.33	4.50	.816	3.17	3.00	1.169
It was understandable that the lighting fixture was checked to be used properly	4.00	4.50	1.265	3.83	4.00	1.169
Factor 2: Working Efficiency						
Accessing the refrigerator was easy	3.67	4.00	1.366	2.67	2.50	1.211
The use of the sink was efficient	3.83	4.00	1.169	2.83	3.00	.753
No extra effort was required to use the oven	3.50	3.50	1.517	2.17	2.00	1.169
Kitchen appliances were simply located to fulfill the needs	4.00	4.00	.632	3.50	3.50	1.049
Using the refrigerator, sink and oven was adequate, eliminating the need to consider design errors for their usage	3.50	3.50	1.378	2.67	2.00	1.211
Using appliances and the storage areas fulfilled the needs during kitchen tasks	3.50	3.50	1.049	3.33	3.50	1.211
Slip-resistant floor materials were applied	3.33	3.50	1.366	3.17	3.00	1.329

Table 11. (continued).

Accessing the refrigerator, sink, and then accessing the countertops to the dining table was easy	4.17	4.50	.0983	2.67	2.50	1.366
There is a short distance between the kitchen and the dining table	4.83	5.00	.408	4.67	5.00	.516
Working from the refrigerator to the sink, oven, and dining table did not require extra effort	4.50	5.00	.837	2.33	2.00	1.506
The location of the dining table was adequate	4.17	4.50	1.169	3.17	3.00	1.169
Factor 3: Low Physical Effort						
Accessing upper cabinets was easy	3.33	3.00	.816	1.83	2.00	.408
There were enough upper and base cabinets	4.33	4.50	.816	3.67	4.00	1.033
No extra effort was required to reach the upper cabinets	3.50	3.50	1.049	2.33	2.00	1.366
Cabinets were simply designed to fulfill the needs	4.00	4.00	.894	3.00	3.00	.894
The cabinet design was adequate, eliminating the need to consider design errors in the upper and base cabinets	3.00	3.00	.894	2.67	3.00	.516
The countertop and the storage areas fulfilled the needs during kitchen tasks	3.83	4.00	.753	2.67	3.00	.516
Cabinet heights were appropriate	3.67	4.00	1.033	1.83	2.00	.753
The cabinets were used without errors	3.83	4.00	1.169	2.50	2.00	1.225
If there was a design-related problem with the cabinets, the user recognized the error	3.67	4.00	1.033	4.33	4.00	.516
The design of the base and upper cabinets did not affect the tempo of the kitchen tasks	3.83	4.00	.408	1.83	2.00	.408
The design of the base and upper cabinets was error-free	3.67	4.00	1.033	2.17	2.00	.753
Factor 4: Access to the workstations						
The countertop workspace was adequate to use	3.50	4.00	1.225	3.00	3.00	.894
There was sufficient storage capacity	3.83	4.00	.983	3.00	4.00	1.033
The countertop workspace did not require extra effort to use	3.67	3.50	1.211	2.00	2.00	1.095
The design of the countertop and the storage capacity were efficient	3.83	4.00	1.472	3.00	3.00	.894
The storage capacity was adequate, eliminating the need to consider where to put kitchen items	4.00	4.50	1.549	3.50	4.00	.837

Table 11. (continued).

The countertop and storage areas fulfilled the needs during kitchen tasks	3.83	4.00	1.472	3.17	3.00	.753
The storage height was appropriate	3.83	3.50	.983	2.33	2.00	1.033
The countertop was used without errors	4.00	4.50	1.265	2.50	2.00	.837
If there was a design-related problem on the countertop, the user recognized the error	3.83	4.00	.753	4.17	4.00	.753
The storage capacity and the countertop did not affect the tempo of the kitchen tasks	3.67	4.00	1.366	2.17	2.00	.983
The storage capacity and the countertop design were error-free	3.00	3.00	1.549	2.00	2.00	.632

4.2.2. Difference Between with and without GERT Suit Experience

To explore the impact of the GERT suit on an error-proofed heuristic evaluation method, mean values were first calculated for four factors. Firstly, the mean value for color and lighting factor usage for those without GERT suit experience is higher (3.863) than those with GERT suit experience (3.181). Secondly, the mean value of the working efficiency factor without GERT suit experience is higher (3.909) than the one with GERT suit experience (3.015). Thirdly, the mean value of the low physical effort factor without GERT suit experience is higher (3.697) than that with GERT suit experience (2.621). Fourthly, the mean value of the low physical effort factor without GERT suit experience is higher (3.060) than that with GERT suit experience (2.833). Thus, the GERT suit enhanced the performance of heuristic evaluation by finding more usability problems for all four factors. Figure 33 illustrates mean values of with and without GERT suit experience according to four factors.

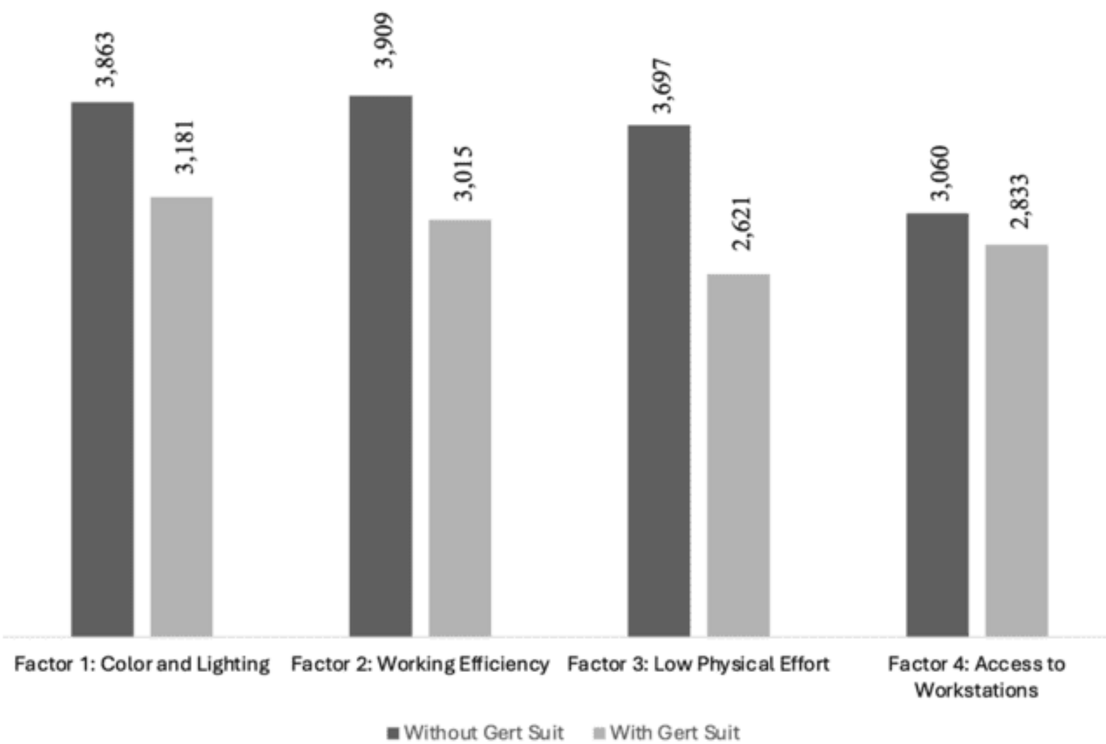

Figure 33. Mean values of the differences between with and without Gert suit experience according to four age-friendly residential kitchen factors.

Lastly, to explore the impact of GERT suit experience on designers with Poka-Yoke Concept items based on the heuristic evaluation method, one sample t-test was conducted to indicate the difference between with and without GERT suit experience in which Hypothesis 4 (H4) ' There is a statistical significance in terms of heuristic evaluation between designers while performing residential kitchen scenarios with and without GERT Suit was tested. According to the result of the one-sample t-test, there was a statistically significant difference between the with and without GERT suit experience in the selected residential kitchen environment.

The mean difference for Factor 1 is 3.863 with a 95% confidence interval ranging from 3.163 to 4.564 without the GERT suit, while the GERT suit experience mean difference is 3.181 with a 95% confidence interval ranging from 2.759 to 3.604. The mean difference in Factor 1 indicated that performance was slightly reduced when designers wore GERT suit.

The mean difference for Factor 2 is 3.909 with a 95% confidence interval ranging from 2.895 to 4.922 without the GERT suit, while the GERT suit while the GERT suit experience mean difference is 3.015 with a 95% confidence interval ranging from 2.085 to 3.944. The mean difference in Factor 2 indicated substantial improvement when designers wore GERT suit.

The mean difference for Factor 3 is 3.696 with a 95% confidence interval ranging from 2.971 to 4.422 without the GERT suit, while the GERT suit while the GERT suit experienced a mean difference of 2.621 with a 95% confidence interval ranging from 2.283 to 2.959. The mean difference in Factor 3 tasks still indicates improvement with the GERT suit; the difference is slightly reduced compared to the condition without the suit.

The mean difference for Factor 4 is 3.060 with a 95% confidence interval ranging from 2.170 to 3.950 without the GERT suit, while the GERT suit and the GERT suit experience mean difference is 2.833 with a 95% confidence interval ranging from 2.231 to 3.435. The mean difference in Factor 4 indicated a slight difference between with and without GERT suit experience. Table 12 indicates the one sample t-test results with and without GERT suit experience according to four factors.

Table 12. One sample t-test table for with and without GERT suit experience according to four age-friendly residential kitchen factors.

	Test Value=0					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
Without GERT Suit						
Factor 1: Usage of color and lighting	14.180	5	.000	3.863	3.163	4.564
Factor 2: Working Efficiency	9.917	5	.000	3.909	2.895	4.922
Factor 3: Low Physical Effort	13.095	5	.000	3.696	2.971	4.422
Factor 4: Access to the workstations	8.838	5	.000	3.060	2.170	3.950
With GERT Suit						
Factor 1: Usage of color and lighting	19.365	5	.000	3.181	2.759	3.604
Factor 2: Working Efficiency	8.337	5	.000	3.015	2.085	3.944
Factor 3: Low Physical Effort	19.923	5	.000	2.621	2.283	2.959
Factor 4: Access to the workstations	12.106	5	.000	2.833	2.231	3.435

Lastly, one sample t-test was conducted to indicate the difference between the with and without GERT suit experience. The mean difference for those with GERT suit experience is 3.63258, with a 95% confidence interval ranging from 2.9450 to 4.320. For those without GERT suit experience, the mean difference is 2.91288, with a 95% confidence interval ranging from 2.3769 to 3.4488. Thus, results indicated a lower performance improvement than when wearing the suit. Table 13 shows one sample t-test for with and without GERT suit experience.

Table 13. One sample t-test table for with and without GERT suit experience.

	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
With GERT Suit	13.582	5	.000	3.63258	2.9450	4.3201
Without GERT Suit	13.971	5	.000	2.91288	2.3769	3.4488

4.2.3. IOS (Inclusion of Others in the Self) Results

As mentioned in the methodology chapter, perceived closeness was measured by the Inclusion of Other in the Self (IOS) Scale. According to the IOS scale results, a mean difference existed between the experience with and without a GERT suit. The mean value of the with GERT suit experience is higher (6.67) than the without GERT suit experience (2.17). It was shown that the experience with the GERT suit indicated higher perceived closeness towards older adults. Thus, Hypothesis 5 (H5), ‘There is statistical evidence that the GERT suit enables designers to increase their empathy towards older adults' experience in residential kitchen environments,' was also supported. Figure 34 illustrates the mean values of inclusion of other in the self (IOS) scale.

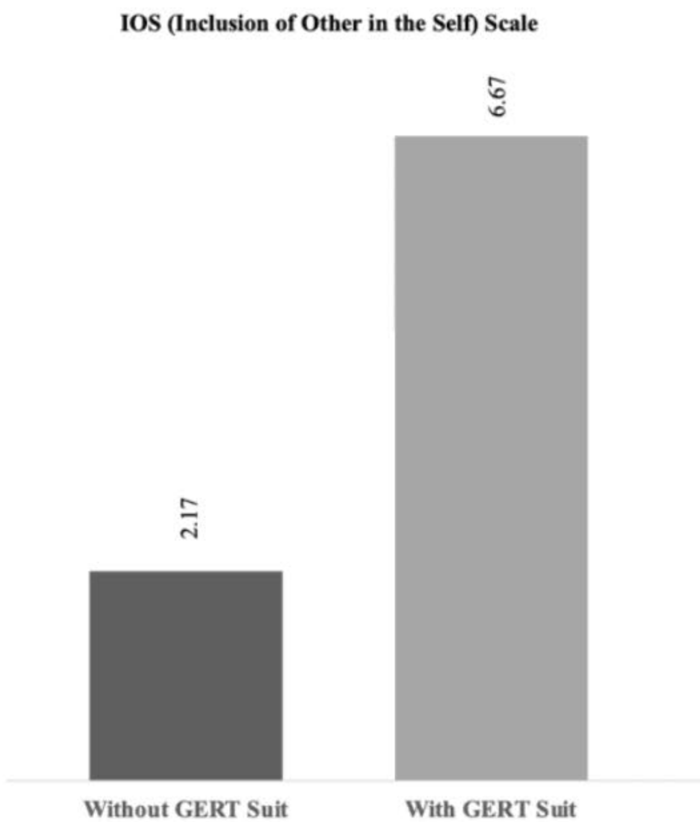

Figure 34. Mean values of inclusion of other in the self (IOS) scale.

Lastly, one sample t-test was conducted to indicate the difference between with and without GERT suit experience regarding IOS scale results. The mean difference for those with GERT suit experience is 2.167, with a 95% confidence interval ranging from 1.38 to 2.96. The mean difference for those without GERT suit experience is 6.667, with a 95% confidence interval ranging from 6.12 to 7.21. Thus, results indicated a lower performance improvement compared to when wearing the suit. Therefore, significantly different mean differences were seen in performance. As a result, the GERT suits decrease the performance of the designers. Table 14 shows One sample t-test with and without GERT suit experience according to the IOS scale.

Table 14. One sample t-test table for with and without GERT suit experience according to the IOS scale.

	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
With GERT Suit	7.050	5	.001	2.167	1.38	2.96
Without GERT Suit	31.623	5	.000	6.667	6.12	7.21

CHAPTER V

DISCUSSION

This thesis investigated whether the Poka-Yoke Concept was explored as an extended criterion in a residential kitchen environment through the aging experience. The first research question identifies the most important requirements for age-friendly residential kitchen design for older adults (**RQ1:** What are the most important requirements for age-friendly residential kitchen design for older adults?). The results indicated that the most important requirements for age-friendly residential kitchen design are improving lighting, effectiveness of workstations, and reducing the physical effort in the kitchen.

The findings of this research question align with previous research that pointed to the significance of lighting (Demirkan & Olguntürk, 2014) and the low physical effort (Maguire et al., 2014) in the residential kitchen for older adults. The hypothesis proposed that the lighting fixtures' design, the effectiveness of the workstations (e.g., easy usage of the countertop), and designing a kitchen to minimize the effort were the most important kitchen design factors (**H1:** The most important age-friendly residential kitchen design requirements for older adults are related with to five main factors which are the usage of usage of color and lighting, access to the workstations, less effort and working efficiency). Thus, the study's findings are aligned with this hypothesis.

Age-friendly residential kitchen design requirements consisted of three headings as follows: (i) physical design elements for custom integrated residential kitchen, (ii) ease of use in the kitchen, and (iii) Poka-Yoke Concept in the residential kitchen environment. In the second and third research questions, the difference and the correlation between the ease of use in the kitchen and Poka-Yoke Concept in the residential kitchen environment was examined (**RQ2:** Is there any statistically significant correlation between ease of use in the kitchen and Poka-Yoke Concept among kitchen environment design requirements? **RQ3:** Is there any statistically significant difference between the importance level of ease of use in the kitchen and Poka-Yoke Concept among residential kitchen design requirements?). Unfortunately, no study has examined the ease of use in the residential kitchen and the Poka-Yoke Concept. Although there are no previous studies that examine these two aspects, the findings of these research questions are aligned with the hypotheses. Consequently, both hypotheses (**H2:** There is a significant correlation between the residential kitchen's ease of use and older adults' importance level of the Poka-Yoke Concept, and **H3:** There is a statistically significant difference between the importance level of ease of use in the kitchen and Poka-Yoke Concept in the residential kitchen design requirements) was accepted.

In terms of aging experience in residential kitchen environments, the study's second data set investigated the effectiveness of heuristic evaluation to find out the difference between the experience with and without GERT suit (**RQ4:** Is there any statistical difference in terms of heuristic evaluation between designers while performing residential kitchen scenarios with and without GERT Suit?). The hypothesis proposed that there is a difference between the two experiences due to the aging experience creates a difference because it enables designers to empathize with older adults (**H4:** There is a statistical significance in terms of heuristic evaluation between designers while performing residential kitchen scenarios with and without GERT Suit). Therefore, H4 is accepted. Previous studies have also found that wearing and not wearing a GERT suit while performing the same task creates a difference in the airport environment (Caglayan & Afacan, 2021). Moreover, Sari et al. (2022b) stated that wearing an aging simulation suit makes nursing students more emphatic. This finding is aligned with previous studies.

Since the heuristic evaluation includes the Poka-Yoke Concept's items, finding usability problems is easy (**RQ5:** Does assessing the Poka-Yoke Concept as an extended usability criterion assist in finding more usability problems?). An aging simulation suit, known as an emphatic tool, helps designers to empathize with older adults (**RQ5:** Does GERT suit enable designers to increase their empathy towards older adults' experience in residential kitchen environments?). H6 suggested that the empathic tool increases designers' empathy towards older adults (**H5:** There is statistical evidence that the GERT suit enables designers to increase their empathy towards older adults' experience in residential kitchen environments. Previous studies by Caglayan & Afacan (2021), Laurentius et al. (2022), Bennett et al. (2022), and Sari et al. (2022a) stated that the

GERT suit enables people to improve their empathy toward older adults. Thus, H6 is accepted. Table 15 illustrates the tested hypotheses chart of the thesis.

Table 15. Tested hypotheses chart of the thesis.

Hypotheses	Decision	Consisted	Inconsisted
H1: The most requirements for age-friendly residential kitchen design for older adults are related to five main factors: eliminating errors, using of usage of color and lighting, access to the workstations, less effort, and working efficiency.	Accepted	Demirkan & Olguntürk (2014), Maguire et al. (2014)	
H2: There is a significant correlation between the residential kitchen's ease of use and older adults' level of importance in the Poka-Yoke Concept.	Accepted		
H3: There is a statistically significant difference between the importance level of ease of use in the kitchen and Poka-Yoke Concept in the residential kitchen design requirements.	Accepted		
H4: There is a statistical significance in terms of heuristic evaluation between designers while performing residential kitchen scenarios with and without GERT Suit	Accepted	Caglayan & Afacan (2021), Sari et al. (2022a)	
H5: There is statistical evidence that the GERT suit enables designers to increase their empathy towards older adults' experience in residential kitchen environments	Accepted	Caglayan & Afacan (2021), Sari et al. (2022b), Laurentius et al. (2022), Bennett et al. (2022)	

CHAPTER VI

CONCLUSION

In conclusion, this thesis aimed to investigate the extension of the latest usability criterion by adding a Poka-Yoke Concept to improve older adults' life quality to make designers empathize with older adults' needs in a residential kitchen environment to design more age-friendly residential kitchens with the aging experience. The thesis used two study data sets to explore the Poka-Yoke Concept as an extended usability criterion. In Study Data Set I, the importance level of age-friendly residential kitchen design requirements was tested to explore the most important kitchen factors that older adults give importance to while performing daily kitchen tasks. This data set showed that using usage of color and lighting, having access to the workstations, putting less effort into working efficiency, and being more efficient were the most critical requirements for age-friendly residential kitchen design.

Furthermore, in addition to the most important age-friendly residential kitchen requirements, there is a relationship between the kitchen's ease of the kitchen's Poka-Yoke Concept in the kitchen. Thus, these results underline the significance of Poka-

Yoke Concept criterion in residential kitchens for finding more usability problems to enhance and design more usable residential kitchens for older adults.

According to Study Data Set I factors, in Study Data Set II, heuristic evaluation was used to find usability problems by the six designers by performing kitchen tasks according to the scenario that contains age-friendly residential kitchen design factors that include results of Study Data Set I. In Study Data Set II, aging simulation findings indicated that designers empathize with older adults' needs in the residential environments after wearing aging simulation suits. Designers need hard-to-reach upper cabinets rather than base cabinets. Although they reached base cabinets, the operation of oven buttons and refrigerator opening was complex for designers, and they wore GERT suits due to the lower working efficiency, high physical effort, and hard to access to the workstations. Thus, the results underline the significance of the emphatic tool in exploring the Poka-Yoke Concept as an extended usability criterion with the aging experience of the six designers.

In general, this study advances designers and our knowledge of the crucial factors and the practical examination of these factors by experiencing aging. It demonstrates the significance of understanding older adults with essential factors to design more usable residential kitchens for older adults with empathy.

In conclusion, this thesis offers valuable insights into kitchen design and the importance of empathizing with older residential kitchen users and understanding the essential age-friendly residential kitchen factors to improve older adults' physical activities while performing daily task tasks by adding Poka-Yoke Concept as an extended usability criterion.

6.1. Limitations of the Study

This thesis provides an overview of Poka-Yoke Concept as an extended usability criterion to improve older adults' physical performance in their residential kitchen environment. However, it is crucial to acknowledge certain limitations that may have influenced the results. Firstly, half of the sample size in the Study Data Set I simple size was limited to the Hacettepe Hospital's Department. Consequently, the non-homogeneity of the sampling frame may have been considered as a limitation. To address this, future research with a homogenous sampling frame is recommended. Moreover, when necessary, the questionnaire was read aloud to older adults who could not fill it out. Thus, in the Study Data Set I, these are the study's limitations.

Secondly, in Study Data Set II’s, the experiment area with the GERT suit is the Bilkent University 34th Graduate Housing's residential kitchen, which is limited to six square meters. Thus, the experiment area was limited to only one residential kitchen area with a simple kitchen design. To consider this, future studies may focus on different types of residential kitchens with different layouts and designs to compare the effect of the different kitchen types on performance with the Gert suit.

Moreover, in Study Data Set II, the sampling size is limited to six designers. Although the number of participants is adequate to test the designers' physical performance by emphasizing older adults, the sampling size may have limitations for a deeper understanding of the different physical performances of the professions.

In Study Data Set II, exploring the Poka-Yoke Concept as an extended usability criterion in residential kitchen environments with designers using aging simulation is limited to using GERT suit. This one type of aging simulation may have a limitation for comparison.

Despite these limitations, this research provides a valuable starting point for extending the Poka-Yoke Concept as an extended usability criterion to improve the usability of the residential kitchen environment for older adults. By addressing these limitations in future studies, researchers and designers can enhance the validity, generalizability, and insights of the results, providing more usable solutions for residential kitchen environments to help older adults improve their needs by designing and analyzing usable kitchen environments.

6.2. Further Research

Several areas of research can be considered to Poka-Yoke Concept as an extended criterion in the residential kitchen environment through the aging experience, several areas of research can be considered. One potential for further research is comparing studies with aging simulation suit. This comparison study may have included different kinds of kitchen layouts with different kitchen working triangle distances to find usability problems. The comparison may have created different, detailed insights while performing kitchen tasks with an aging simulation suit. This would impact how usability problems are linked to different kitchen types.

Another direction for future research is a comparative analysis of the aging simulation suits. This is an opportunity to try different types of aging simulation suits and make a comparison to find out usability problems. By involving different kinds of suits, further studies can develop an idea of the effectiveness of aging simulation suits. Although involving designers who have experience in the design field is crucial, future studies may include design students when they are in undergraduate programs to learn emphatic design in a practical way. Wearing an aging simulation suit by design, students may improve their empathy by experiencing aging to learn design for different ages by understanding their physical needs in specific areas.

Furthermore, bathrooms are as crucial as kitchens, so further studies may focus on the tasks with aging simulation suits to give importance to physical limitations in bathroom design. Thus, empathizing with older adults' needs in bathroom designers may have changed designers' vision.

Additionally, since Poka-Yoke Concept is not a usual working concept in built environments, for further studies, researchers may focus on the assessing of the Poka-Yoke Concept to detect, minimize, and eliminate the design errors before the practice so older users have more usable environments.

Pursuing further research into these suggested aspects may improve age-friendly designs and enhance the quality of life of their residents. This knowledge can inform interior architects, architects, researchers, and caregivers to strengthen age-friendly residential designs.

REFERENCES

Abran, A., Khelifi, A., & Suryn, W. (2003). *Usability Meanings and Interpretations in ISO Standards*.

Adilawati, L., Aini, Q., & Nuryasin, N. (2023). Usability Analysis of MSME Business Accounting Applications Based on User Retention Using ISO 9241-11. *INTENSIF: Jurnal Ilmiah Penelitian Dan Penerapan Teknologi Sistem Informasi*, *7*(1), Article 1. https://doi.org/10.29407/intensif.v7i1.18879

Afacan, Y. (2017). Sustainable library buildings: green design needs and interior architecture students' ideas for special collection rooms. *The Journal of Academic Librarianship*, *43*(5), 375-383.

Afacan, Y., & Erbug, C. (2009). An interdisciplinary heuristic evaluation method for universal building design. *Applied Ergonomics*, *40*(4), 731–744. https://doi.org/10.1016/j.apergo.2008.07.002

Age-friendly kitchens | Search | Elicit. (n.d.). Retrieved July 5, 2023, from https://elicit.org/search?q=age+friendly+kitchens&token=01H4K9WFA62A8549HVNP2K6V92&paper=59300f997765e39bfcd437c77f62b58bc5ed1927&column=title

Aging and health. (n.d.). Retrieved July 24, 2023, from https://www.who.int/news-room/fact-sheets/detail/ageing-and-health

Akbal, Y., Köse, B. G., Pekmezci, H., & Çuvalci, B. (202). *COVID-19 Pandemi Sürecinde Meşguliyet Terapisi ile Yaşlı Bakım Teknikeri Öğrencilerinde Yaşlı Farkındalığı: Bir Fenomenolojik Çalışma*.

Anacker, K. B., Carswell, A. T., Kirby, S. D., & Tremblay, K. R. (2018). *Introduction to Housing*. University of Georgia Press.

Arthana, I. K. R., Pradnyana, I. M. A., & Dantes, G. R. (2019). Usability testing on website wadaya based on ISO 9241-11. *Journal of Physics: Conference Series*, *1165*(1), 012012. https://doi.org/10.1088/1742-6596/1165/1/012012

Arun, Ö. (2014). 'Que Vadis' Türkiye? 2050'ye Doğru Yaşlanan Türkiye'yi Bekleyen Riskler. *Selçuk Üniversitesi Sosyal Bilimler Enstitüsü Dergisi*, *32*, Article 32. https://dergipark.org.tr/en/pub/susbed/issue/61812/924668

Attaianese, E., & Duca, G. (2012). Human factors and ergonomic principles in building design for life and work activities: an applied methodology. *Theoretical Issues in Ergonomics Science*, *13*(2), 187-202.

Balaji, A., Sathyasri, B., Vanaja, S., Manasa, M. N., Malavega, M., & Maheswari, S. (2020). Smart Kitchen Wardrobe System Based on IoT. *2020 International Conference on Smart Electronics and Communication (ICOSEC)*, 865–871. https://doi.org/10.1109/ICOSEC49089.2020.9215459

Barnum, C. M. (2010, October 29). *Usability Testing Essentials: Ready, Set...Test!* https://www.semanticscholar.org/paper/Usability-Testing-Essentials%3A-Ready%2C-Set...Test!-Barnum/5d7facb3b2f88004c6ec5ca31dc89a14a5e3dc57

Bastien, J. M. C. (2010). Usability testing: A review of the method's methodological and technical aspects. *International Journal of Medical Informatics*, *79*(4), e18–e23. https://doi.org/10.1016/j.ijmedinf.2008.12.004

Beecher, M. A. (2001). Promoting the “Unit Idea”: Manufactured Kitchen Cabinets (1900-1950). *APT Bulletin: The Journal of Preservation Technology*, *32*(2/3), 27–37. https://doi.org/10.2307/1504736

Bevan, N., Carter, J., & Harker, S. (2015). ISO 9241-11 Revised: What Have We Learnt About Usability Since 1998? In M. Kurosu (Ed.), *Human-Computer Interaction: Design and Evaluation* (pp. 143–151). Springer International Publishing. https://doi.org/10.1007/978-3-319-20901-2_13

Bhatia, A., & Singla, S.K. (2019). Ergonomic Evaluation and Customized Design of Kitchen. *International Journal of Innovative Technology and Exploring Engineering*.

Bonenberg, A., Branowski, B., Kurczewski, P., Lewandowska, A., Sydor, M., Torzyński, D., & Zabłocki, M. (2019). Designing for human use: Examples of kitchen interiors for persons with disability and elderly people. *Human Factors and Ergonomics in Manufacturing & Service Industries*, *29*(2), 177–186. https://doi.org/10.1002/hfm.20772
https://doi.org/10.1002/hfm.20772

Bowden, A., Chang, H.-C. (Rita), Wilson, V., & Traynor, V. (2021). The impact of ageing simulation education on healthcare professionals to promote person-centred care towards older people: A literature review. *Nurse Education in Practice*, *53*, 103077. https://doi.org/10.1016/j.nepr.2021.103077

Braileanu, P. I. (2017). Design of a Modular Kitchen Furniture. *Journal of Industrial Design and Engineering Graphics*, *12*(2), Article 2. http://www.sorging.ro/jideg/index.php/jideg/article/view/105

Büker, M. B., Şavkin, R., & Büker, N. (2023). Yaşlı Kullanıcı Gözüyle Konut İç Mekan Güvenliği. *Yaşlı Sorunları Araştırma Dergisi*, *16*(1), 1–8. https://doi.org/10.46414/yasad.1191128

Caglayan, I., & Afacan, Y. (2021). Simulation-based service walkthrough (SBSW) to assess airport environment performance. *Archnet-IJAR: International Journal of Architectural Research*, *15*(3), 905–924. https://doi.org/10.1108/ARCH-12-2020-0300

Cajander, Å., Eriksson, E., & Gulliksen, J. (2010). Towards a Usability Coaching Method for Institutionalizing Usability in Organisations. In P. Forbrig, F. Paternó, & A. Mark Pejtersen (Eds.), *Human-Computer Interaction* (Vol. 332, pp. 86–97). Springer Berlin Heidelberg. https://doi.org/10.1007/978-3-642-15231-3_10

Campbell, K. (2004). *Usability Testing* (usability-testing). IGI Global. https://www.igi-global.com/gateway/chapter/www.igi-global.com/gateway/chapter/8971

Castro, L. M. (2023). Introductory Chapter: Why Usability Matters. In *Updates on Software Usability*. IntechOpen. https://doi.org/10.5772/intechopen.109241

Charytonowicz, J. (2018). *Advances in Human Factors and Sustainable Infrastructure*. AHFE International (USA).

Charytonowicz, J., & Latala, D. (2011). Evolution of Domestic Kitchen. In C. Stephanidis (Ed.), *Universal Access in Human-Computer Interaction. Context Diversity* (pp. 348–357). Springer. https://doi.org/10.1007/978-3-642-21666-4_38

Chen, X., Beveridge, A. J., & Fu, P. P. (2018). Put yourself in others' age: How age simulation facilitates inter-generational cooperation. *Academy of Management Proceedings*. https://doi.org/10.5465/AMBPP.2018.249

Cheng, F.-T. (2004). *Concrete Countertops: Design, Forms, and Finishes for the New Kitchen and Bath*. Taunton Press.

Carrol, J. M. (1999). Five reasons for scenario-based design. *Proceedings of the 32nd Annual Hawaii International Conference on Systems Sciences. 1999. HICSS-32. Abstracts and CD-ROM of Full Papers*, 11. https://doi.org/10.1109/HICSS.1999.772890

Carroll, J. M., Rosson, M. B., Chin, G., & Koenemann, J. (1999). Requirements development in scenario-based design. *IEEE Transactions on Software Engineering*, *24*(12), 1156–1170. https://doi.org/10.1109/32.738344

DeMaio, J., Worth, R., & Curtin, D. (1997). *Darkrooms in Kitchens*.

Demirkan, H., & Olguntürk, N. (2014). A priority-based 'design for all' approach to guide home designers for independent living. *Architectural Science Review*, *57*(2), 90–104. https://doi.org/10.1080/00038628.2013.832141

Design, cognition & behaviour: Usability in the built environment. (2023, June 30). https://www.tandfonline.com/doi/epdf/10.1080/21650349.2016.1143080?needAccess=true&role=button

Depp, C. A., & Jeste, D. V. (2006). Definitions and predictors of successful aging: a comprehensive review of larger quantitative studies. *The American Journal of Geriatric Psychiatry*, *14*(1), 6-20.

Dubey, S. K. (2012). Analytical Comparison of Usability Measurement Methods. *International Journal of Computer Applications*, *39*.

Dudek-Burlikowska, M., & Szewieczek, D. (2009). The Poka-Yoke method as an improving quality tool of operations in the process. *Journal of Achievements in Materials and Manufacturing Engineering*, *36*(1).

Dutsinma, F. L. I., Pal, D., Funilkul, S., & Chan, J. H. (2022). A Systematic Review of Voice Assistant Usability: An ISO 9241–11 Approach. *SN Computer Science*, *3*(4), 267. https://doi.org/10.1007/s42979-022-01172-3

Ergonomic Evaluation and Customized Design of Kitchen. (2019). *International Journal of Innovative Technology and Exploring Engineering*, *8*(9S), Article 9S. https://doi.org/10.35940/ijitee.I1166.0789S19

Estrada, G., & Lloveras, J. (2008). *Application of Moka Methodology to Capture Knowledge in Design for Poka-Yoke Assembly*.

Fisher, M. (1999). Process improvement by poka-yoke. *Work Study*, *48*(7), 264–266. https://doi.org/10.1108/00438029910294153

Flores, G. E., Bates, S. T., Caporaso, J. G., Lauber, C. L., Leff, J. W., Knight, R., & Fierer, N. (2013). Diversity, distribution and sources of bacteria in residential kitchens: Bacterial diversity of residential kitchens. *Environmental Microbiology*, *15*(2), 588–596. https://doi.org/10.1111/1462-2920.12036

Folmer, E., & Bosch, J. (2002). Architecting for usability: A questionnaire. *Journal of Systems and Software*, *70*(1–2), Article 1–2. https://doi.org/10.1016/S0164-1212(02)00159-0

Frederick, C. (1913). *Christine Frederick, The New Housekeeping, Efficiency Studies in Home Management, 1913, excerpts*.

Galford, G., & Peek, G. (2021). Secluion and surveillance within the home: The role of privacy in housing design. *Housing and Society*, *49*(1), 95–106. https://doi.org/10.1080/08882746.2021.1914534

Granić, A., Nakić, J., & Marangunić, N. (2020). Scenario-based Group Usability Testing as a Mixed Methods Approach to the Evaluation of Three-Dimensional Virtual Learning Environments. *Journal of Educational Computing Research*, *58*(3), 616–639. https://doi.org/10.1177/0735633119859918

Granic, A., Sayer, A. A., & Robinson, S. M. (2019). Dietary patterns, skeletal muscle health, and sarcopenia in older adults. *Nutrients*, *11*(4), 745.

Green, D., & Pearson, Micheal. (2006). *Development of a Web Site Usability Instrument Based on ISO 9241-11*.

https://www.tandfonline.com/doi/epdf/10.1080/08874417.2006.11645940?needAccess=true&role=button

Grout, J. (2007). *Mistakeproofing the Design of Health Care Processes*.

Go, K., & Carroll, J. M. (2004). *Scenario-Based Task Analysis*.

Gonzalez-Holland, E., Whitmer, D., Moralez, L., & Mouloua, M. (2017). Examination of the Use of Nielsen's 10 Usability Heuristics & Outlooks for the Future. *Proceedings of the Human Factors and Ergonomics Society Annual Meeting*, *61*(1), 1472–1475. https://doi.org/10.1177/1541931213601853

Gulati, A., & Dubey. (2012). Critical Analysis on Usability Evaluation Techniques. *International Journal of Engineering Science and Technology*, *4*.

Goldman, K. H., & Bendoly, L. (2003). Investigating Heuristic Evaluation: A Case Study.

Harna, T. G., Syaifurrahman, E., & Sunardi. (2022). User Experience Evaluation of Building Materials Application Using Usability Testing Based on ISO 9241–11 Standard and The USE Questionnaire. *2022 10th International Conference on Cyber and IT Service Management (CITSM)*, 1–6. https://doi.org/10.1109/CITSM56380.2022.9935903

Harte, R., Glynn, L., Rodríguez-Molinero, A., Baker, P. M., Scharf, T., Quinlan, L. R., & ÓLaighin, G. (2017). A Human-Centered Design Methodology to Enhance the Usability, Human Factors, and User Experience of Connected Health Systems: A Three-Phase Methodology. *JMIR Human Factors*, *4*(1), e5443. https://doi.org/10.2196/humanfactors.5443

Hartje, S. C. (2005). Universal Design Features and Product Characteristics for Kitchens. *Housing and Society*, *32*(2), 101–118. https://doi.org/10.1080/08882746.2005.11430644

Hass, C. (2019). *A Practical Guide to Usability Testing*. 107–124. https://doi.org/10.1007/978-3-319-96906-0_6

Holbrook, H. (1990). A scenario-based methodology for conducting requirements elicitation. *ACM SIGSOFT Software Engineering Notes*, *15*(1), 95–104. https://doi.org/10.1145/382294.382725

Hong, Y., Goldberg, D., Dahlke, D. V., Ory, M. G., Cargill, J. S., Coughlin, R., Hernandez, E., Kellstedt, D. K., & Peres, S. C. (2014). Testing Usability and Acceptability of a Web Application to Promote Physical Activity (iCanFit) Among Older Adults. *JMIR Human Factors*, *1*(1). https://doi.org/10.2196/humanfactors.3787

Hori, M., Kihara, Y., & Kato, T. (2011). Investigation of Indirect Oral Operation Method for Think Aloud Usability Testing. In M. Kurosu (Ed.), *Human Centered Design* (Vol. 6776, pp. 38–46). Springer Berlin Heidelberg. https://doi.org/10.1007/978-3-642-21753-1_5

Hrovatin, J., Prekrat, S., Oblak, L., & Ravnik, D. (2015). Ergonomic suitability of kitchen furniture regarding height accessibility. *Collegium Antropologicum*, *39*(1), 185–191.

Hrovatin, J., Širok, K., Jevšnik, S., Oblak, L., & Berginc, J. (2012). Adaptability of Kitchen Furniture for Elderly People in Terms of Safety. *Drvna Industrija*, 113–120. https://doi.org/10.5552/drind.2012.1128

Hrovatin, J., & Vižintin, J. (2013). *35-40_Kitchen furniture for elderly people*.

Human factors and ergonomic principles in building design for life and work activities: An applied methodology. (n.d.). Retrieved July 14, 2023, from https://www.tandfonline.com/doi/epdf/10.1080/1463922X.2010.504286?needAccess=true&role=button

Hussain, A., Nadeem, A., & Ikram, M. T. (2015). Review on formalizing use cases and scenarios: Scenario based testing. *2015 International Conference on Emerging Technologies (ICET)*, 1–6. https://doi.org/10.1109/ICET.2015.7389203

Ibrahim, N. I., & Davies, S. (2012). Aging: Physical difficulties and safety in cooking tasks. *Work*, *41*, 5152–5159. https://doi.org/10.3233/WOR-2012-0804-5152

ISO/IEC. (1998). *ISO 9241-11:1998*. ISO. Retrieved July 12, 2023, from https://www.iso.org/standard/16883.html

ISO/IEC. (2018). *ISO 9241-11:2018*. ISO. https://www.iso.org/standard/63500.html

Jimenez, C., Lozada, P., & Rosas, P. (2016). Usability heuristics: A systematic review. *2016 IEEE 11th Colombian Computing Conference (CCC)*, 1–8. https://doi.org/10.1109/ColumbianCC.2016.7750805

Jokela, T., Iivari, N., Matero, J., & Karukka, M. (2003). The standard of user-centered design and the standard definition of usability: Analyzing ISO 13407 against ISO 9241-11. *Proceedings of the Latin American Conference on Human-Computer Interaction*, 53–60. https://doi.org/10.1145/944519.944525

Kalisch, B. J. (1973). What is empathy?. *The American journal of nursing*, 1548-1552.

Kors, S. (2013). General design principles involved a major kitchen adaptation for disabled and elderly people. *British Journal of Therapy and Rehabilitation*, *3*(6), 310–316. https://doi.org/10.12968/bjtr.1996.3.6.14810

Kosonen, R., Koskela, H., & Saarinen, P. (2006). Thermal plumes of kitchen appliances: Cooking mode. *Energy and buildings*, *38*(10), 1141-1148.

Kuoppamäki, S., Tuncer, S., Eriksson, S., & McMillan, D. (2021). Designing Kitchen Technologies for Ageing in Place: A Video Study of Older Adults’ Cooking at Home. *Proceedings of the ACM on Interactive, Mobile, Wearable and Ubiquitous Technologies*, *5*(2), 1–19. https://doi.org/10.1145/3463516

Kumar, B. A., Goundar, M. S., & Chand, S. S. (2020). A framework for heuristic evaluation of mobile learning applications. *Education and Information Technologies*, *25*, 3189-3204.

Kurhade, A. J. (2015). *ON "Poka-Yoke: Technique to Prevent Defects ."* https://www.semanticscholar.org/paper/ON-%E2%80%9C-POKA-YOKE-%3A-TECHNIQUE-TO-PREVENT-DEFECTS-%E2%80%9D-Kurhade/fc54094186fcf821d0fb8a46d715c93bc6827e59

Lam, M. C., Lim, S. M., & Tan, S. Y. (2023). User Evaluation on a Mobile Augmented Reality Game-based Application as a Learning Tool for Biology. *TEM Journal*, *12*(1).

Laurentius, T., Quandel, J., Bollheimer, L. C., Leonhardt, S., Ngo, C., & Lüken, M. (2022). Spatiotemporal gait parameters in young individuals wearing an age simulation suit compared to healthy older individuals. *European Review of Aging and Physical Activity*, *19*(1), 29. https://doi.org/10.1186/s11556-022-00298-w

Lavallière, M., D'Ambrosio, L., Gennis, A., Burstein, A., Godfrey, K. M., Waerstad, H., Puleo, R. M., Lauenroth, A., & Coughlin, J. F. (2017). Walking a mile in another's shoes: The impact of wearing an Age Suit. *Gerontology & Geriatrics Education*, *38*(2), 171–187. https://doi.org/10.1080/02701960.2015.1079706

Lazarevic, M., Mandic, J., Sremčev, N., Vukelic, D., & Debevec, M. (2019). *A Systematic Literature Review of Poka-Yoke and Novel Approach to Theoretical Aspects*. 454–467. https://doi.org/10.5545/sv-jme.2019.6056

Lee, C.-H. J., Bonanni, L., Espinosa, J. H., Lieberman, H., & Selker, T. (2006). Augmenting kitchen appliances with a shared context using knowledge about daily events. *Proceedings of the 11th International Conference on Intelligent User Interfaces*, 348–350. https://doi.org/10.1145/1111449.1111533

Lewis, J. R. (2014). Psychometric evaluation of an after-scenario questionnaire for computer usability studies: The ASQ. *ACM SIGCHI Bulletin*, *23*(1), 78–81. https://doi.org/10.1145/122672.122692

Liu, J. J., & MacGregor, J. F. (2006). Estimation and monitoring of product aesthetics: Application to manufacturing of gineered stone" countertops. *Machine Vision and Applications*, *16*(6), 374–383. https://doi.org/10.1007/s00138-005-0009-8

Lixia, C., & Bo, M. (2010). How to Apply Error Proofing to Realize Full Process Quality Control of Products in Chinese Enterprises Successfully. *2010 3rd International Conference on Information Management, Innovation Management and Industrial Engineering*, 75–78. https://doi.org/10.1109/ICIII.2010.496

Maguire, M., Nicolle, C., Marshall, R., Sims, R., Lawton, C., Peace, S., & Percival, J. (2011). *A study of the age-friendliness of kitchens*.

Maguire, M., Peace, S., Nicolle, C., Marshall, R., Sims, R., Percival, J., & Lawton, C. (2014). *Kitchen living in later life: Exploring ergonomic problems, coping strategies and design solutions*. https://repository.lboro.ac.uk/articles/journal_contribution/Kitchen_living_in_later_life_Exploring_ergonomic_problems_coping_strategies_and_design_solutions/9346364/1

Malega, P. (2018). Poka–Yoke–solution to human errors in the production process. *The International Journal of Business Management and Technology*, *2*(5), 207-213.

Middleton, P. (2001). Lean Software Development: Two Case Studies. *Software Quality Journal*, *9*(4), 241–252. https://doi.org/10.1023/A:1013754402981

Mihalache, O. A., Møretrø, T., Borda, D., Dumitraşcu, L., Neagu, C., Nguyen-The, C., Maître, I., Didier, P., Teixeira, P., Junqueira, L. O. L., Truninger, M., Izsó, T., Kasza, G., Skuland, S. E., Langsrud, S., & Nicolau, A. I. (2021). Data on European kitchen layouts belonging to vulnerable consumers (elderly peo young families with children or pregnant women) and risk-takers (young single men). *Data in Brief*, *38*, 107362. https://doi.org/10.1016/j.dib.2021.107362

Mosca, E. I. (2023). Design for All: Strategy to Achieve Inclusive and Healthier Environments. In S. Capolongo, M. Botta, & A. Rebecchi (Eds.), *Therapeutic Landscape Design: Methods, Design Strategies and New Scientific Approaches* (pp. 113–125). Springer International Publishing. https://doi.org/10.1007/978-3-031-09439-2_11

Mosca, E. I., & Capolongo, S. (2018). Towards a Universal Design Evaluation for Assessing the Performance of the Built Environment. *Studies in Health Technology and Informatics*, *256*, 771–779.

Mosca, E. I., & Capolongo, S. (2020). Universal Design-Based Framework to Assess Usability and Inclusion of Buildings. In O. Gervasi, B. Murgante, S. Misra, C. Garau, I. Blečić, D. Taniar, B. O. Apduhan, A. M. A. C. Rocha, E. Tarantino, C. M. Torre, & Y. Karaca (Eds.), *Computational Science and Its Applications – ICCSA 2020* (pp. 316–331). Springer International Publishing. https://doi.org/10.1007/978-3-030-58814-4_22

Moody, D., & Vineyard, M. (2007). The Evolution of Domestic Kitchen Design: Influence of the Social Determinants of Health During the Industrial Revolution. *IDEC 2007*, 471.

Moslehian, A., Warner, E., & Andrews, F. (2023). The impacts of kitchen and dining spatial design on cooking and eating experience in residential buildings: A scoping review. *Journal of Housing and the Built Environment*. https://doi.org/10.1007/s10901-023-10027-z

Muller, M. J., Matheson, L., Page, C., & Gallup, R. (1998). Methods & tools: participatory heuristic evaluation. *interactions*, *5*(5), 13-18.

Nassar, V. (2012). Common criterion for usability review. *Work*, *41*, 1053–1057. https://doi.org/10.3233/WOR-2012-0282-1053

Nielsen, J. (1994). *Usability Engineering*. Elsevier.

Older adult women find food preparation easier with specialized kitchen tools—ProQuest. (n.d.). Retrieved July 3, 2023, from https://www.proquest.com/openview/e21f77a9589726fc866db2513a2d8c83/1?pq-origsite=gscholar&cbl=49142

Ollár, A., Granath, K., Femenías, P., & Rahe, U. (2022). Is there a need for new kitchen design? Assessing the adaptative capacity of space to enable circularity in multiresidential buildings. *Frontiers of Architectural Research*, *11*(5), 891–916. https://doi.org/10.1016/j.foar.2022.03.009

Overhill, H. (2014). Apple Pie Proxemics: Edward T. Hall in the Kitchen Work Triangle. *Design Issues*, *30*(2), 67–82. https://doi.org/10.1162/DESI_a_00263

Özalp, B. T. (2020). Determination of Domestic Kitchen Characteristics for Elderly Turkish Women: A Comprehensive Ergonomics Approach. *Open Journal of Safety Science and Technology*, *10*(02), 53–67. https://doi.org/10.4236/ojsst.2020.102005

Parrott, K. R., Beamish, J. O., & Emmel, J. M. (2005). Rethinking Guidelines for Kitchen Storage. *Housing and Society*, *32*(2), 43–61. https://doi.org/10.1080/08882746.2005.11430521

Pins, D., & Paul, D. (2022). *Towards a Framework for Supporting User Satisfaction of Conversational Agents according to the Usability Norm DIN EN ISO 9241-11*.

Plonka, F. E. (1997). Developing a lean and agile work force. *Human Factors and Ergonomics in Manufacturing & Service Industries*, *7*(1), 11–20. https://doi.org/10.1002/(SICI)1520-6564(199724)7:1<11::AID-HFM2>3.0.CO;2-J

Pourtahmasi, K., Tarmian, A., & Mojarradi, M. (2007). Glued laminated panels as kitchen countertops. *DRVNA INDUSTRIJA*.

Rasila, H., Rothe, P., & Kerosuo, H. (2010). Dimensions of usability assessment in built environments. *Journal of Facilities Management*, *8*(2), Article 2. https://doi.org/10.1108/14725961011041189

Rubin, J. (1994, April 29). *Handbook of Usability Testing: How to Plan, Design, and Conduct Effective Tests*. https://www.semanticscholar.org/paper/Handbook-of-Usability-Testing%3A-How-to-Plan%2C-Design%2C-Rubin/1e08dc098a2c5842a2159db3dbfc5c2fbb7b0e32

Salvini, V. R., Pandolfelli, V. C., & Spinelli, D. (2018). Mechanical properties of porous ceramics. *Recent Adv. Porous Ceram*, *34*, 171-199.

Sari, D., Karabilgin Öztürkçü, Ö. S., Baysal, E., Taşkiran, N., & Özgül, S. (2022a). The Effect of Role-Playing and Aged Simulation Suit on Empathy and Positive Attitude towards the Older-People. *Tıp Eğitimi Dünyası*, *21*(64), 62–74. https://doi.org/10.25282/ted.1069645

Sari, D., KarabiLgiN Öztürkçü, Ö. S., Baysal, E., Taşkiran, N., & Özgül, S. (2022b). The Effect of Role-Playing and Aged Simulation Suit on Empathy and Positive Attitude towards the Older-People. *Tıp Eğitimi Dünyası*, *21*(64), 62–74. https://doi.org/10.25282/ted.1069645

Saurin, T. A., Ribeiro, J. L. D., & Vidor, G. (2012). A framework for assessing poka-yoke devices. *Journal of Manufacturing Systems*, *31*(3), 358–366. https://doi.org/10.1016/j.jmsy.2012.04.001

Schulz, R., Smaradottir, B., Prinz, A., & Hara, T. (2020). User-Centered Design of a Scenario-Based Serious Game: Game-Based Teaching of Future Healthcare. *IEEE Transactions on Games*, *12*(4), 376–385. https://doi.org/10.1109/TG.2020.3033437

Sebesi, S. B., Groza, H. L., Ianoşi, A., Dimitrova, A., & Mândru, D. (2016). Specific issues of the design for the elderly. *IOP Conference Series: Materials Science and Engineering*, *147*(1), 012049. https://doi.org/10.1088/1757-899X/147/1/012049

Sebesi, S., Groza, H., Ianosi, A., Dimitrova, A., & Mandru, D. (2016). Specific issues of the design for the elderly. *IOP Conference Series: Materials Science and Engineering*, *147*, 012049. https://doi.org/10.1088/1757-899X/147/1/012049

Shanklin, R., Kortum, P., & Acemyan, C. Z. (2020, December). Adaptation of heuristic evaluations for the physical environment. In *Proceedings of the Human Factors and Ergonomics Society Annual Meeting* (Vol. 64, No. 1, pp. 1135-1139). Sage CA: Los Angeles, CA: SAGE Publications.

Shinde, A., Deore, G., Navsariwala, K. P., Tabassum, H., & Wani, M. (2022). We are all aging, and here's why. *AGING MEDICINE*, *5*(3), 211–231. https://doi.org/10.1002/agm2.12223

Siio, I., Hamada, R., & Mima, N. (2007). Kitchen of the Future and Applications. In J. A. Jacko (Ed.), *Human-Computer Interaction. Interaction Platforms and Techniques* (pp. 946–955). Springer. https://doi.org/10.1007/978-3-540-73107-8_104

Sobouti, H., & Ghasemi, A. (2016). The Evolution of the Cookhouse to the Kitchen. *Turkish Online Journal thaf Design, Art and Communication*, *6*(JLYSPCL), 605–613. https://doi.org/10.7456/1060JSE/027

Sullivan, P. (1989). Beyond a narrow conception of usability testing. *IEEE Transactions on Professional Communication*, *32*(4), 256–264. https://doi.org/10.1109/47.44537

Sundaram, R., & Rukmangadhan, S. (2016). Optimizing Kitchen Experience. *Proceedings of the 8th Indian Conference on Human-Computer Interaction*, 147–156. https://doi.org/10.1145/3014362.3014380

Surmann, A., Käsmayr, A., & Reinmann, R. (2017). The Evolution of Kitchen Design: A Yearning for a Modern Stone Age Cave. In N. van der Meulen & J. Wiesel (Eds.), *Culinary Turn* (pp. 47–56). Transcript Verlag. https://www.jstor.org/stable/j.ctv1wxt0c.7

Syafrizal, R.I.H., Ermatita, M.A.F., Pacu P., Lovinta H. A., & Monterico A. (2022). Using ISO 9241-11 To Identify How E-Commerce Companies Applied UX Guidelines. *Inform : Jurnal Ilmiah Bidang Teknologi Informasi Dan Komunikasi*, *7*(1), 9–15. https://doi.org/10.25139/inform.v7i1.4443

Sydora, C., & Stroulia, E. (2020). Rule-based compliance checking and generative design for building interiors using BIM. *Automation in Construction*, *120*, 103368. https://doi.org/10.1016/j.autcon.2020.103368

Taha. (2010). Perceived Kitchen Environment among Malaysian Elderly. *American Journal of Engineering and Applied Sciences*, *3*(2), 270–276. https://doi.org/10.3844/ajeassp.2010.270.276

Tanaka, T. (2001). Environment friendly revolution in home appliances. *Proceedings of the 13th International Symposium on Power Semiconductor Devices & ICs. IPSD '01 (IEEE Cat. No.01CH37216)*, 91–95. https://doi.org/10.1109/ISPSD.2001.934565

Tao, R., Watanabe, M., Paskevicius, A., & Ono, K. (2018). *Exploring the New Kitchen Layout in China by Analyzing The Cooking Route and Cuisine Culture*.

Taşoz, Ş. M., & Afacan, Y. (2022). Simulated physical ageing: A prioritized persona-based model for accessible interiors in senior housing environments. *Indoor and Built Environment*, *31*(8), 2115-2133.

Tarboush, R. M., & Erçin, Ç. (2021). User's Need in Architectural Spaces Development, Existing Kitchen Design in Northern Cyprus. *European Journal of Sustainable Development*, *10*(2), Article 2. https://doi.org/10.14207/ejsd.2021.v10n2p13

Timm, I. J., Spaderna, H., Rodermund, S. C., Lohr, C., Buettner, R., & Berndt, J. O. (2020). Designing a Randomized Trial with an Age Simulation Suit—Representing People with Health Impairments. *Healthcare*, *9*(1), 27. https://doi.org/10.3390/healthcare9010027

Vieweg, J., Panzer, S., & Schaefer, S. (2023). Effects of age simulation and age on motor sequence learning: Interaction of age-related cognitive and motor decline. *Human Movement Science*, *87*, 103025. https://doi.org/10.1016/j.humov.2022.103025

Vieweg, J., & Schaefer, S. (2020). How an Age Simulation Suit affects Motor and Cognitive Performance and Self-perception in Younger Adults. *Experimental Aging Research*, *46*(4), 273–290. https://doi.org/10.1080/0361073X.2020.1766299

Vincent, C. J., & Blandford, A. (2015). Usability standards meet scenario-based design: Challenges and opportunities. *Journal of Biomedical Informatics*, *53*, 243–250. https://doi.org/10.1016/j.jbi.2014.11.008

Virzi, R. A. (1992). Refining the Test Phase of Usability Evaluation: How Many Subjects Is Enough? *Human Factors*, *34*(4), 457–468. https://doi.org/10.1177/001872089203400407

Viyanon, W., & Sasananan, S. (2018). Usability and performance of the leap motion controller and oculus rift for interior decoration. *2018 International Conference on Information and Computer Technologies (ICICT)*, 47–51. https://doi.org/10.1109/INFOCT.2018.8356839

Walley, J. E. (1957). The Kitchen of to-Day and to-Morrow. *Journal of the Royal Society of Arts*, *105*(4996). https://www.proquest.com/docview/1307296859/citation/31265FDB11C949EBPQ/1

Wang, X., He, Y., & Zhang, H. (2023). How to Influence Behavioral Intention Toward Age-Friendly Home Modifications in Urban Older People Aged 70+. *Gerontology and Geriatric Medicine*. https://doi.org/10.1177/23337214231152697

Watchorn, V., Hitch, D., Tucker, R., Frawley, P., Aedy, K., & Grant, C. (2022). Evaluating universal design of built environments: An empirical study of stakeholder practice and perceptions. *Journal of Housing and the Built Environment*. https://doi.org/10.1007/s10901-022-09981-x

Wilson, M. (1947). *Considerations in Planning Kitchen Cabinets* [dataset]. https://doi.org/10.4016/28851.01

Xiaolei, C., Jun, S., & Bing, L. (2014). *Customer preferences for kitchen cabinets in China using conjoint analysis*.

Yazıcıoğlu, D. A. (2010). A statistical data analysis for increasing the kitchen design performance. *A|Z ITU JOURNAL OF THE FACULTY OF ARCHITECTURE*, *11*(1), Article 1. https://www.az.itu.edu.tr/index.php/jfa/article/view/483

Yeşiltepe, M. *Building empathy in interior architecture education: exploring empathic design and its reflections* (Doctoral dissertation, Bilkent University).

Yu, Y., & Sung, T. J. (2023). A value-based view of the smart PSS adoption: a study of smart kitchen appliances. *Service Business*, *17*(2), 499-527.

Zafirovska, D. (2023). Influence of Space Organisation on Kitchen Design From 2012—2022 in North Macedonia. *South East European Journal of Architecture and Design*, *9*(1), 1–4. https://doi.org/10.3889/seejad.2023.10067

Zhang, A. (2014). Quality improvement through Poka–Yoke: from engineering design to information system design. *International Journal of Six Sigma and Competitive Advantage*, *8*(2), 147-159.

APPENDIX A

ETHICS COMMITTEE APPROVALS

Bilkent Üniversitesi
Akademik İşler Rektör Yardımcılığı

Tarih : 6 Eylül 2023

Gönderilen : Gülçin Aydıngün

Danışman : Yasemin Afacan

Gönderen : H. Altay Güvenir
İnsan Araştırmaları Etik Kurulu Başkanı

Konu : *"Exploring ..."* çalışması etik kurul onayı [redacted]

Üniversitemiz İnsan Araştırmaları Etik Kurulu, 6 Eylül 2023 tarihli görüşme sonucu, *"Exploring poka-yoke concept (error-proofing) as an extended usability criteria in the kitchen design through aging experience"* isimli çalışmanız kapsamında yapmayı önerdiğiniz etkinlik için etik onay vermiş bulunmaktadır. Onay, ekte verilmiş olan çalışma önerisi, çalışma yürütücüleri ve bilgilendirme formu için geçerlidir.

Bu onay, yapmayı önerdiğiniz çalışmanın genel bilim etiği açısından bir değerlendirmedir. Çalışmanızda, kurulumuzun değerlendirmesi dışında kalabilen özel etik ve yasal sınırlamalara uymakla ayrıca yükümlüsünüz.

Kovid-19 salgını nedeniyle konulmuş olan kısıtlamaların yürürlükte olduğu süre içinde, tüm komite toplantıları elektronik ortamda yapılmaktadır; aşağıda isimleri bulunan Bilkent Üniversitesi Etik Kurulu Üyeleri adına bu yazıyı imzalama yetkisi kurul başkanındadır.

Etik Kurul Üyeleri:

Ünvan / İsim	**Bölüm / Uzmanlık**	
Prof.Dr. H. Altay Güvenir	Bilgisayar Mühendisliği	Başkan
Prof.Dr. Haldun Özaktaş	Elektrik ve Elektronik Müh.	Üye
Doç.Dr. Işık Yuluğ	Moleküler Biyoloji ve Genetik	Üye
Dr. Öğr. Üyesi Burcu Ayşen Ürgen	Psikoloji	Üye
Dr. Öğr. Üyesi A.Barış Özbilen	Hukuk	Yedek Üye
Dr. Öğr. Üyesi Didem Özkul McGeoch	İletişim ve Tasarımı	Yedek Üye
Dr. Öğr. Üyesi A.Barış Özbilen	Hukuk	Yedek Üye

Kurul karar/toplantı No: 2023_09_06_01

Bilkent Üniversitesi, 06800 Bilkent, Ankara • Telefon: (312) 290 12 13 • (312) 290 12 14 • Faks: (312) 266 41 52

Bilkent Üniversitesi

Akademik İşler Rektör Yardımcılığı

Tarih	: 3 Nisan 2024
Gönderilen	: Gülçin Aydıngün
Danışman	: Yasemin Afacan
Gönderen	: H. Altay Güvenir İnsan Araştırmaları Etik Kurulu Başkanı
Konu	: *"Exploring ..."* çalışması etik kurul onayı

[redacted]

Üniversitemiz İnsan Araştırmaları Etik Kurulu, 3 Nisan 2024 tarihli görüşme sonucu, *"Exploring the poka-yoke concept (error-proofing) as an extended usability criterion for kitchen design through the aging experience"* isimli çalışmanız kapsamında yapmayı önerdiğiniz etkinlik için etik onay vermiş bulunmaktadır. Onay, ekte verilmiş olan çalışma önerisi, çalışma yürütücüleri ve bilgilendirme formu için geçerlidir.

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Kovid-19 salgını nedeniyle konulmuş olan kısıtlamaların yürürlükte olduğu süre içinde, tüm komite toplantıları elektronik ortamda yapılmaktadır; aşağıda isimleri bulunan Bilkent Üniversitesi Etik Kurulu Üyeleri adına bu yazıyı imzalama yetkisi kurul başkanındadır.

Etik Kurul Üyeleri:

Ünvan / İsim	**Bölüm / Uzmanlık**	
Prof.Dr. H. Altay Güvenir	Bilgisayar Mühendisliği	Başkan
Prof.Dr. Haldun Özaktaş	Elektrik ve Elektronik Müh.	Üye
Doç.Dr. Işık Yuluğ	Moleküler Biyoloji ve Genetik	Üye
Dr. Öğr. Üyesi Burcu Ayşen Ürgen	Psikoloji	Üye
Dr. Öğr. Üyesi A.Barış Özbilen	Hukuk	Üye
Prof. Dr. Özgür Ulusoy	Bilgisayar Mühendisliği	Yedek Üye
Dr. Öğr. Üyesi A.Barış Özçelik	Hukuk	Yedek Üye

Kurul karar/toplantı No: 2024_04_03_02 Başvuru No: 535

APPENDIX B

ADAPTED AGE-FRIENDLY RESIDENTIAL KITCHEN DESIGN REQUIREMENTS QUESTIONNAIRE IN STUDY DATA SET I IN ENGLISH

Importance ratings of age- friendly residential kitchen design requirements and Poka-Yoke Concept approaches for older adults

We invite you to take part in our questionnaire on assessing importance level of Usable Kitchen Factors for older adults. Your valuable input helps us gather information to conduct further phase of the study. Thank you for your time and participation in advance.

A. Demographic Information:

A1. Age

a) 60-65 b) 65-70 c) 70-75 d) 75-80 e) 80+

A2. Gender

a) Female b) Male c) Prefer not to say.

A3. Marital Status

a) Single b) Married c) Divorced d) Widow

A4. Education Level

a) Primary school b) Middle School c) High school d) Bachelor' degree e) Master's Degree f) Ph.D Degree

A5. What is the age of your residential kitchen?

a) 0-5 b) 5-10 c) 10-15 d) 15-20 e) 20-25 f) 25-30 g) 30+

A6. Do you have any physical limitation, if you have any physical limitation please tick the related box.

a) No b) Sight c) Hearing d) Mobility

Please rate your importance level for each item of residential kitchen design requirements.

	1 Very Unimportant	2 Unimportant	3 Neutral	4 Important	5 Very Important
Physical design elements for custom integrated residential kitchen					
B1. Functionality of kitchen use (e.g., no need for special support)					
B2. Communication (e.g., elimination of door sill)					
B3. Working triangle (e.g., distances of appliances to workstations)					
B4. Existence of rest seat/ width of the rest seat					
B5. Height of the wall cabinet					
B6. Safety (e.g., placement of the breakable items on lower shelves)					
B7. Storage capacity					
B8. Storage height					
B9. Washing station (e.g., usability of kitchen sink)					
B10. Cooking station (e.g., usability of oven, microwave, and cooker)					
B11. Cooling station (e.g., placement and adequate space for refrigerator)					
Ease of use in the kitchen					
B12. To move easily in kitchen					
B13. Adequate illumination					
B14. To have color contrast between sink and counter					

B15. Main counter to be used easily					
B16. Task lighting on top of the counters					
B17. To have color contrast between counter and cabinets					
B18. Cabinet handles to be used easily					
B19. Cabinets to have pullout shelves					
B20. To have illumination inside of kitchen cabinets					
B21. Floor to be slip-resistant					
B22. To have short distance between the kitchen and the dining table					
B23. To have enough electrical outlets					
Poka-Yoke Concept in the residential kitchen environment					
B24. Elimination of errors in kitchen during design process					
B25. Prevention of errors in kitchen during design process					
B26. Detection of errors in kitchen during design process					
B27. Problems should be controlled during kitchen design process					
B28. Designing simple to make problems visible in residential kitchen					
B29. People have their attention focus on kitchen tasks rather than focusing on errors in the kitchen					
B30. Using visual controls, so no problem are hidden (e.g., using sensors and labels to detect errors)					

APPENDIX C

ADAPTED AGE-FRIENDLY RESIDENTIAL KITCHEN DESIGN REQUIREMENTS QUESTIONNAIRE IN STUDY DATA SET I IN TURKISH

Kullanılabilir Mutfak Ölçeklerinin ve Hata Önleme Faktörlerinin Yaşlı Bireyler için Önem Değerlendirmesi

Sizi kullanılabilir mutfak ölçeklerinin ve hata önleme faktörlerinin yaşlı bireyler için önemini test ettiğimiz anketimize katılmaya davet ediyoruz. Anketimizde kullanılabilirlik, mutfağın kullanıcılar tarafından etkili, verimli ve hataların önlenmesindeki önem derecesini ölçmek istiyoruz. Sizin değerli katkınız, daha sonraki aşamalarda yapacağımız çalışma için bilgi toplamamıza yardımcı olacaktır.

Katılımınız için teşekkür ederiz.

A. Kişisel Bilgiler:

A1. Yaşınız

a) 60-65 b) 65-70 c) 70-75 d) 75-80 e) 80+

A2. Cinsiyetiniz

a) Kadın b) Erkek c) Belirtmek istemiyorum

A3. Medeni Durum

a) Bekar b) Evli c) Boşanmış d) Dul

A4. Eğitim Durumunuz

a) İlkokul b) Ortaokul c) Lise d) Lisans e) Yüksek Lisans f) Doktora

A5. Evinizdeki mutfağın yaşı

a) 0-5 b) 5-10 c) 10-15 d) 15-20 e) 20-25 f) 25-30 g) 30+

A6. Herhangi bir fiziksel engeliniz var mı? Eğer varsa lütfen uygun şıkkı işaretleyiniz.

a) Yok b) Görme c) Duyma d) Ortopedik

Lütfen aşağıdaki listelenmiş olan mutfak tasarımı ve kullanılabilirliği ile ilgili değerlendirme ölçütlerinin size göre önem sıralamasını belirtiniz.

	1 Hiç önemi yok	2 Önemi yok	3 Ne Önemli ne önemsiz	4 Önemli	5 Çok önemli
Özel entegre mutfak için tercih edilen tasarım gereksinimleri					
B1. Mutfak kullanımının işlevselliği (örn. özel destek ihtiyacı olmaması)					
B2. Communication (örn. kapı eşiğinin ortadan kaldırılması)					
B3. Çalışma üçgeni (örn. buzdolabın, lavabonun ve ocağın birbirine olan uzaklığı)					
B4. Dinlenme alanının mevcudiyeti /dinlenme alanının genişliği					
B5. Üst dolapların yüksekliği					
B6. Güvenlik (örn. tabakların ve bardakların alt dolaplarda muhafaza edilmesi)					
B7. Depolama kapasitesi					
B8. Depolama kapasitesinin yüksekliği					
B9. Yıkama alanı (örn. lavabonun kullanılabilir olması)					
B10. Pişirme alanı (örn. ocağın, fırının ve mikrodalganın kullanılabilirliği)					
B11. Soğutma alanı (örn. Buzdolabının yerleşim yerinin yeterli ve uygun olması)					
Mutfakta kullanım kolaylığı					
B12. Mutfakta kolay hareket etme					
B13. Yeterli aydınlatma					
B14. Lavabo ve mutfak tezgahının farklı renklerde olması					
B15. Ana çalışma tezgah alanının kolay kullanılması					
B16. Tezgahın üstünde çalışma ışığının olması					

B17. Mutfak dolaplarının ve mutfak tezgahının farklı renklerde olması					
B18. Kolayca kullanılabilen dolap kulpları					
B19. Dolaplarda çekmece tipi rafların bulunması					
B20. Mutfak dolaplarının içinde aydınlatma bulunması					
B21. Zeminin kaymaz özellikte olması					
B22. Mutfak ile yemek masası arasında kısa mesafe olması					
B23. Yeterli miktarda elektrik prizinin bulunması					
Mutfak ortamında hata önleme eylemleri					
B24. Ortaya çıkabilecek hataların mutfak tasarımı sürecinde azaltılması					
B25. Ortaya çıkabilecek hataların mutfak tasarımı sürecinde önlenmesi					
B26. Ortaya çıkabilecek hataların mutfak tasarımı sürecinde tespit edilmesi					
B27. Ortaya çıkabilecek hataların mutfak tasarımı sürecinde kontrol edilmesi					
B28. Tasarım problemlerinin fark edilebilir olması için, mutfak tasarımının sade olması					
B29. İnsanlar mutfaktaki hatalar yerine, mutfakta ilgilendikleri işlere odaklanmalı					
B30. Problemleri tespit etmek için görsel uyarıcılar kullanmak (örn. sensörler ve etiketler)					

APPENDIX D

ADAPTED HEURISTIC EVALUATION QUESTIONNAIRE IN STUDY DATA SET II

We invite you to participate in our questionnaire assessing the Poka-Yoke Concept as an extended usability criterion. Your valuable input helps us gather information to conduct further study phases. Thank you in advance for your time and participation.

A. Demographic Information:

A1. Age: ……

A2. Gender
a) Female b) Male c) Prefer not to say

A3. Marital Status
a) Single b) Married c) Divorced d) Widow

A4. Education Level
a) Bachelor' degree b) Master's Degree c) Ph.D. Degree

A5. What is the age of your residential kitchen?
a) 0-5 b) 5-10 c) 10-15 d) 15-20 e) 20-25 f) 25-30 g) 30+

A6. Do you have any physical limitations, if you have any physical limitations, please tick the related box.
a) No b) Sight c) Hearing d) Mobility

A7. What is your profession?
a) Architect b) Interior Architect c) Landscape Architect d) Industrial Designer

A8. Do you smoke?
a) Yes b) No

HEURISTIC EVALUATION

Participant number:

Factors	Type of the Scenario	Heuristic Number	Definition of the heuristic	Heuristic Evaluation (Kitchen Performance) (1: strongly disagree, 2: disagree, 3: neutral, 4: agree, 5: strongly agree)	Comments	Difficulty (Physical Performance) (1: very difficult, 2: difficult, 3: ok, 4: easy, 5: very easy)
		H1	Reaching the lighting fixture was easy.	1 2 3 4 5 ☐ ☐ ☐ ☐ ☐		
		H2	The color difference between the counter and the cabinet was crucial for easy visual recognition.	1 2 3 4 5 ☐ ☐ ☐ ☐ ☐		
		H3	The storage capacity was sufficient.	1 2 3 4 5 ☐ ☐ ☐ ☐ ☐		
		H4	The color choice of the kitchen elements (e.g. countertops,and cabinets) was satisfactory.	1 2 3 4 5 ☐ ☐ ☐ ☐ ☐		
Usage of Color and Lighting	Exploring kitchen to realize the importance of color and lighting	H5	The color choice was not distracting while perfroming kitchen tasks.	1 2 3 4 5 ☐ ☐ ☐ ☐ ☐		
		H6	The choice of the color choice was rational.	1 2 3 4 5 ☐ ☐ ☐ ☐ ☐		1 2 3 4 5 ☐ ☐ ☐ ☐ ☐
		H7	The usage of the lighting fixture was efficient.	1 2 3 4 5 ☐ ☐ ☐ ☐ ☐		
		H8	The lighting fixture was correctly used without error.	1 2 3 4 5 ☐ ☐ ☐ ☐ ☐		
		H9	The lighting fixture was used without instructions being needed.	1 2 3 4 5 ☐ ☐ ☐ ☐ ☐		
		H10	The lighting fixture was used effortlessly.	1 2 3 4 5 ☐ ☐ ☐ ☐ ☐		
		H11	It was understandable that the lighting fixture was checked to be used properly.	1 2 3 4 5 ☐ ☐ ☐ ☐ ☐		

Working Efficiency	Usage of the kitchen work triangle	H1	Accessing the refrigerator was easy.	1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐		1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
		H2	The use of the sink was efficient.	1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐		
		H3	No extra effort was required to use the oven.	1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐		
		H4	Kitchen appliances were simply located to fulfill the needs.	1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐		
		H5	Using the refrigerator, sink and oven was adequate, eliminating the need to consider design errors for their usage.	1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐		
		H6	Using appliances and the storage areas fulfilled the needs during kitchen tasks.	1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐		
		H7	Slip-resistant floor materials were applied.	1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐		
		H8	Accessing the refrigerator, sink, and then accesing countertops to the dining	1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐		
		H9	There is a short distance between the kitchen and the dining table.	1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐		
		H10	Working from the refrigerator to the sink, oven and the dining table did not require extra effort.	1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐		
		H11	The location of the dining table was adequate.	1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐		

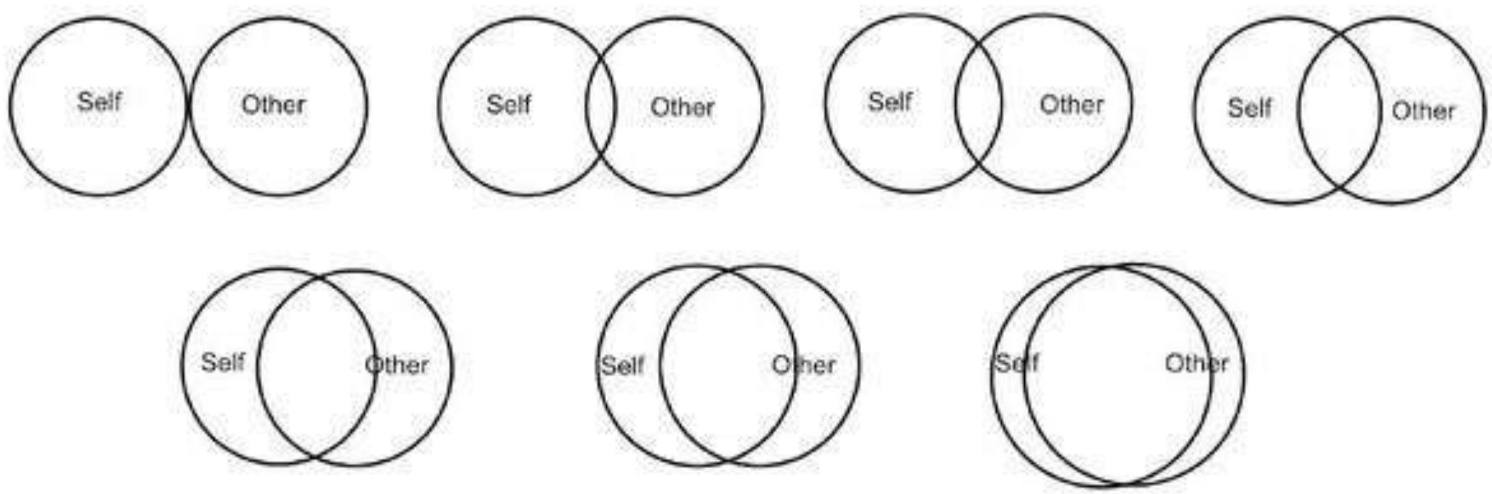
Low Physical Effort	Accessing upper and base cabinets	H1	Accessing upper cabinets was easy.	1 2 3 4 5 ☐ ☐ ☐ ☐ ☐		1 2 3 4 5 ☐ ☐ ☐ ☐ ☐
		H2	There were enough upper and base cabinets.	1 2 3 4 5 ☐ ☐ ☐ ☐ ☐		
		H3	No extra effort was required to reach the upper cabinets.	1 2 3 4 5 ☐ ☐ ☐ ☐ ☐		
		H4	Cabinets were simply designed to fulfill the needs.	1 2 3 4 5 ☐ ☐ ☐ ☐ ☐		
		H5	The cabinet design was adequate, eliminating the need to consider design errors in the upper and base cabinets.	1 2 3 4 5 ☐ ☐ ☐ ☐ ☐		
		H6	The countertop and the storage areas fulfilled the needs during kitchen tasks.	1 2 3 4 5 ☐ ☐ ☐ ☐ ☐		
		H7	Cabinet heights were appropriate.	1 2 3 4 5 ☐ ☐ ☐ ☐ ☐		
		H8	The cabinets were used without errors.	1 2 3 4 5 ☐ ☐ ☐ ☐ ☐		
		H9	If there was a design-related problem with the cabinets, the user recognized the error.	1 2 3 4 5 ☐ ☐ ☐ ☐ ☐		
		H10	The design of the base and upper cabinets did not affect the tempo of the kitchen tasks.	1 2 3 4 5 ☐ ☐ ☐ ☐ ☐		
		H11	The design of the base and upper cabinets was error-free.	1 2 3 4 5 ☐ ☐ ☐ ☐ ☐		

Access to the workstations	Working efficiently on countertop and storage areas	H1	The countertop workspace was adequate to use.	1 2 3 4 5		1 2 3 4 5
		H2	There was sufficient storage capacity.	1 2 3 4 5		
		H3	The countertop workspace did not require extra effort for use.	1 2 3 4 5		
		H4	The design of the countertop and the storage capacity was efficient.	1 2 3 4 5		
		H5	The storage capacity was adequate, eliminating the need to consider where to put kitchen items.	1 2 3 4 5		
		H6	The countertop and storage areas fulfilled the needs during kitchen tasks.	1 2 3 4 5		
		H7	The storage height was appropriate.	1 2 3 4 5		
		H8	The countertop was used without errors.	1 2 3 4 5		
		H9	If there was a design-related problem on the countertop, the user recognized the error.	1 2 3 4 5		
		H10	The storage capacity and the countertop did not affect the tempo of the kitchen tasks.	1 2 3 4 5		
		H11	The storage capacity and the countertop design were error-free.	1 2 3 4 5		

APPENDIX E

IOS (INCLUSION OF OTHERS IN THE SELF) SCALE

According to your performance and answers in residential kitchen task performance, how much do you empathize with older users.



APPENDIX F

PHOTOS OF THE GRADUATE HOUSING

RESIDENTIAL KITCHEN ENVIRONMENT

Figure F.1. Bilkent University Graduate 34th Housing (photo taken by the author, 2024).

Figure F.2. Bilkent University Graduate Housing's exterior entrance photo taken by the author, 2024).

Figure F.3. Bilkent University Graduate Housing’s interior entrance (photo taken by the author, 2024).

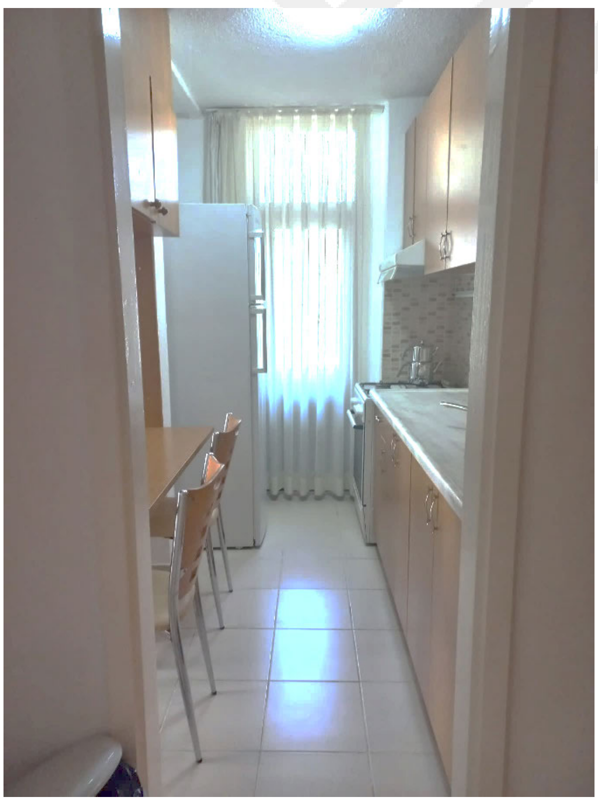


Figure F.4. Graduate housing’s kitchen area (photo taken by the author, 2024).

Figure F.5. Graduate housing’s kitchen area (photo taken by the author, 2024).

Figure F.6. Graduate housing’s dining table (photo taken by the author, 2024).

Figure F.7. Graduate housing's kitchen area (photo taken by the author, 2024).

Figure F.8. Graduate housing's kitchen area (photo taken by the author, 2024).

Figure F.9. Graduate housing’s kitchen area (photo taken by the author, 2024).

Figure F.10. Participant I while performing kitchen task (photo taken by the author, 2024).

Figure F.11. Participant I while performing kitchen task (photo taken by the author, 2024).

Figure F.12. Participant III while performing kitchen task (photo taken by the author, 2024).

Figure F.13. Participant I while performing kitchen task (photo taken by the author, 2024)