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Influence of empathic design process on universally designed kitchen environments in an online project-based course

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Abstract
This paper explores how experiencing the empathic design (ED) process influences students' end products (kitchen designs) in terms of applying Human Factors/Ergonomics (HF/E) and Universal Design (UD) principles. Moreover, it investigates what interior design items students give importance to and how they are performed in their end products. Interior design students are divided into three experimental and one control group in an online project-based course. The experimental groups used three different ED techniques, namely: (A) communication directly with the stakeholder, (B) communication indirectly with the stakeholder by using communication tools, and (C) using the role-playing technique in redesigning the stakeholder's kitchen environment online. Three instructors assessed the groups' end products using importance-performance analysis (IPA). Groups who experienced ED techniques were concerned about fulfilling stakeholder's needs and paid great attention to finding UD solutions for all people's effortless use. IPA findings indicated that ED techniques having direct or indirect contact with the stakeholder provide more highly performed kitchen design items considered important in the design process. However, role-playing as an ED technique yields the imagination, and the designer's experience influences the design process. Design instructors should benefit from using the ED process in teaching UD in project-based courses as it helps the design students find more UD solutions for kitchen interiors.

Keywords Empathic design · Importance-performance analysis · Kitchen design · Online design course · Universal design

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Introduction

One of the most significant tasks of designers is to involve a broad range of stakeholders in the problem-solving process, such as children, people with diverse abilities, older adults, pregnant women, and people who are ill or injured. Everyone can experience a temporary disability (e.g., a broken leg or arm, a sprained wrist) or a permanent disability (e.g., paralysis, cerebral palsy, cancer) in their life and use assistive devices such as a wheelchair, crutches, walker, or sensorial devices. UD is an approach to designing environments or products that everyone (with or without disabilities) can use easily and independently. In addition, the UD approach pays attention to creating no special or adaptable design solutions (Center for Universal Design, 1997). The seven UD principles are (1) equitable use, (2) flexibility in use, (3) simple and intuitive use, (4) perceptible information, (5) tolerance for error, (6) low physical effort, and (7) size and space for approach and their twenty-nine guidelines established to bolster designing universal products or environments (Center for Universal Design, 1997). Designing products or environments that everyone can use independently and effortlessly is the responsibility of designers. Designers need to be self-aware and sensitive to the stakeholder (Sandman et al., 2020). Suppose this self-awareness responsibility is fostered among design students at their undergraduate level by being empathetic with the stakeholders. Then they are able to become very sensitive designers who rethink while designing products or environments on a professional level and aim to design for everyone. The research questions of the study are proposed as follows:

RQ1: To what extent does the ED process in online project-based course influence students'end products by applying HF/E and UD principles?
RQ2: What is the relationship between students' importance rate and their performance in their end products?
RQ3: Is there a difference between ED techniques to the extent of stakeholder involvement?

This study explores how experiencing the ED process influences students' end products (kitchen designs) while applying HF/E and UD principles. Also, it aims to determine what design items students give importance to in design solutions and how they are performed in their end products. Furthermore, it explores the design process with different approaches to the ED process.

Empathy in design education

Cambridge Dictionary (2019) defines empathy as"the ability to share someone else's feelings or experiences by imagining what it would be like to be in that person's situation"(Empathy, n.d.). Strayer (1987) states that empathy consists of cognitive and affective psychological components. Perceiving the other's thoughts is cognitive empathy. Enjoyment and sharing of the other's feelings constitute the affective aspect of empathy. Empathy develops by being affected by the perceived feelings (need or pain) of the other (Vreeke & van der Mark, 2003). Designers try to feel and sense the needs and/or pains of stakeholders by using empathic methods and techniques in empathic design process. "Empathy, the ability to feel and understand other's emotions and circumstances, is

considered a fundamental skill for designers to acquire an in-depth understanding of people (i.e., end-users and other stakeholders) so that products, services, environments, systems, and experiences meet human needs, expectations, and aspirations" (Tellez & Gonzalez-Tobon, 2019, p.909).

Empathy plays a vital role in the learning and teaching process in design education (Efilti & Gelmez, 2024). The ED approach can enlighten students in using UD, since empathizing makes the designer understand the needs and problems of any kind of stakeholders and strengthens the designer-stakeholder relationship. In ED, the designer tries to understand the needs, problems and expectations of the stakeholder by empathizing with him/her. Designers try to empathize with the stakeholder by experiencing ED techniques such as communicating directly, either the designer collaborates with the stakeholder or the stakeholder participates in the design process (Mattelmaki et al., 2014; Yesiltepe and Demirkan, 2023) or indirectly with the stakeholder through communication tools such as creating empathy map technique, storytelling technique, and personas, listening to lectures about empathy in design, watching the video of the stakeholder, and using the role-playing technique designers imagine themselves as actual stakeholders (Pallasmaa, 2015; Sandman et al., 2020). Besides, some scholars have claimed that there can be empathy without imagination, for example, when we infer someone's, feelings based on situational circumstances, as Morton (2017) stated. In its simplest form, not every instance of imagination is linked with empathy when what we imagine is not about other people's feelings. Morton (2017) highlights that our moods and emotions pressure our imaginations, so we do not imagine more than is necessary for our needs and purposes. Kouprie and Sleeswijk Visser (2009) described role-playing as taking stakeholder's perspective and assimilating his/her abilities.

Researchers have studied empathy as a teaching method in different disciplines, such as medical science, nursing, pedagogics, psychiatry, and others. In recent years, empathy-related studies in the design process have notably increased (Hutton & Maguire, 2021; Kocaoglu & Demirkan, 2019; Sandman et al., 2020; Surma-aho & Höltta-Otto, 2022; Tracey & Baaki, 2022; Yesiltepe and Demirkan, 2023). In addition, numerous experimental ED studies are carried out by design educators and the research findings indicated that design students' awareness of empathic understanding was raised, and designing with empathy was observed to design more accessible and easily usable products or environments for all people (Altay & Demirkan, 2014; Altay et al., 2016; McDonagh & Thomas, 2010; Memikoglu et al., 2021).

Some design educators have even integrated the concept of empathy into their curriculum, either in a workshop, a compulsory course, or a design elective course (Altay & Demirkan, 2014; Altay et al., 2016; McDonagh & Thomas, 2010). For example, Gagnon and Cote (2014) taught ED practices in five years (2007–2012) of workshop at University of Montreal School of Industrial Design, Canada. Design students are asked to implement the activities such as seeing, listening, telling and imagining related techniques to understand needs of stakeholders and designed final projects. Lorentzen and Hedvall (2018) used empathic modelling with role-playing technique/simulation to teach Universal Design for fifteen years, in Sweden. Sixteen design students experienced reducing hand and eye-sight simulation and designed model based on their experiences within one-day, co-designed with expert users and received expert users' and teachers' feedback as end assessment in one-week project course at University of Gavle in Sweden. In the Faculty of Industrial Design Engineering; Delft University of Technology, design education experts compared different data sources to study empathic cues. Industrial design engineering students were grouped and worked together to design propose product concept for children with autism.

Parents and teachers of the children evaluated the products. Researchers found that background information and direct contact with the stakeholder enhance the quality of the products of the students. In addition, having background information and indirect contact by gaining and video observation have a potential for empathizing with stakeholders (van Rijn et al., 2011).

Also, instructional designers (Tracey & Baaki, 2022) from the USA explored the relationship between online teaching of empathy and its implications for instructional graduate design students' actual design projects. Research, interview and observation were used as teaching methods in empathic design. Their results indicated that three of the nine teams designed meaningful design projects, and four of the nine projects indicate elements of a meaningful design. Experimental simulations with people of diverse abilities and elderly were conducted by undergraduate industrial design students in the course called 'Disability + Relevant Design' in USA. Design students designed products for people of varying abilities and through product analysis, educators found design awareness improvement of students (McDonagh & Thomas, 2010).

Besides, fourth-year students of Interior Architecture and Environmental Design Department and Architecture Department, Turkey joined workshop with aim to enhance the universal design awareness of students (Altay et al., 2016). Students experienced project-based learning by designing three-dimensional products (in full-day) on person-environment relationship and experience-based learning by role-playing/simulation technique. Students and instructors evaluated end products and researchers concluded that empathic design techniques enriched students' universal design awareness as the reflections on their design outcomes (Altay et al., 2016).

Architecture students were asked to apply Universal Design principles using empathic design methods with user groups to foster their interior design projects in the Department of Architecture Interior Design Class at Çukurova University, Turkey (Senyigit & Yılmaz, 2021). Observation, interview, and experience of user characteristics are used as methods in the process of empathic design. Students designed various interior projects for specific user groups such as children with autism, hearing-impaired adults, adolescents with Down syndrome, and children with cerebral palsy. Design instructors found that the empathic design approach resulted in universally designed products with enhanced design awareness and empathic understanding.

Universal kitchen design assessment

The kitchen is a challenging environment to simulate the activities to solve design problems. It is also one of the active environments in residential buildings that involves home-based activities of daily living and instrumental activities, such as cooking, preparing meals, and other kitchen activities. In addition, people can encounter several home accidents in the kitchen because of incorrect positioning of a cooker or electrical devices, unreachable wall cabinets, and incorrect spatial layout. Therefore, in recent years, the previous studies concentrated on the studies about universal kitchen design features for all people, especially people with diverse abilities and the elderly, to design safe, easy, and independently usable kitchens (Afacan & Demirkan, 2010; Demirkan & Olgunturk, 2014; Hartje, 2005; Kaczor et al., 2023). So, UD practices associated with kitchen interiors are significant and must be studied (Bonenberg et al., 2017).

In the UD literature, some design instructors developed assessment methods for evaluating UD solutions. Afacan and Demirkan (2010) developed a survey instrument with 87 items to comprise universal kitchen design features. The authors stated that requirements prioritization is needed to satisfy people with diverse abilities'needs, capabilities, and expectations in home design. Also, Demirkan and Olgunturk (2014) utilized a prioritization technique in developing a checklist in the architectural design process to respond to diverse stakeholders'needs for more independent living in their homes.

Previous studies demonstrated that ED in design education could design meaningful end products (Gagnon & Cote, 2014; Tracey & Baaki, 2022). In this respect, this study investigates how experiencing the ED process influences students'end products in applying HF/E and UD principles. This study also aims to determine what design items students give importance to and how they are performed in their end products. It is hypothesized that integrating ED approaches to the design process produces more universally designed end products with the correct application of HFE and UD principles. Also, it is hypothesized that a positive relationship exists between the importance students give to design items and their performance.

Methods

Participants

The participants were twelve second-year undergraduate interior design students (nine females and three males, $M_{age} = 23$ years) from the Department of Interior Architecture and Environmental Design, I.D. Bilkent University, at the beginning of the global pandemic in the 2020–2021 academic year. Students were randomly assigned into four groups (Groups A, B, C, and D) of three students, as three (A, B, and C) were experimental and one (D) was the control group. Participation in the study was voluntary. Since all participants previously had taken the courses'Human Factors (or Ergonomics)'and'Basic Design,'they had similar knowledge and experience in practicing UD, HF/E, and interior design principles.

The kitchen stakeholder is a retired woman, at 60, who is a right-handed person with a short stature (1.55 cm) and lives with her husband. She has a temporary physical limitation caused by a broken right arm because of a kitchen accident. She had fallen off a chair when she climbed to reach the kitchen wall cabinets. She encounters difficulties in efficiently using the kitchen, so she needs her kitchen to be redesigned.

Setting

The study was conducted in an online environment during the COVID-19 pandemic. All groups participated in design sessions that were conducted as Zoom meetings. The experiential environment was the stakeholder's kitchen that would be redesigned. It is on an apartment floor with an L-shaped counter, has a 16 m^2 floor area with a balcony of 3.5 m^2, and a ceiling height of 2.60 m.

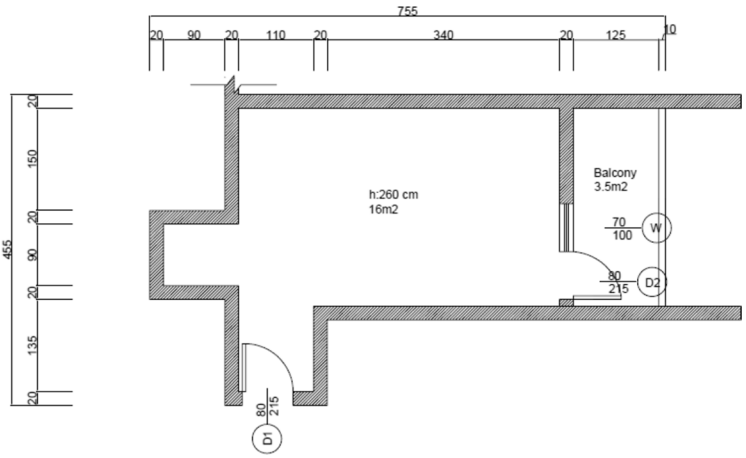
Instruments and data collection

The instruments of this study are the design brief (Fig. 1), kitchen survey (see Appendix), and design assessment sheet. The design brief describes the design problem, requirements,

Design Problem: You are given the real kitchen floor plan within a balcony in an apartment flat which was built in 2006 at Çankaya/Ankara. The apartment flat is 135 square meters on the second floor of a reinforced concrete residential building. The kitchen has a floor area 16 square meters, and its ceiling height is 2.60 meters. Besides, the balcony is 3.5 square meters.

You are required to design a universal kitchen in an apartment for a couple in their 60's.

There should be dining area within a kitchen and you can integrate balcony area into kitchen floor. Please consider cabinets and storage, counters or work surfaces, circulation, appliances sink and faucets, illumination, and materials in the light of human factors and universal design principles.



Requirements: You are asked to draw your design by freehand or digitally in 1/50 scale.

- Initial ideas, design statement.
- Research, concept information
- Plan and section (sketches)
- Sketch perspective(s)

Fig. 1 Design brief

the floor plan drawing, and the technical information about the stakeholder's kitchen environment with the stakeholder profile. Students were required to consider the needs of the stakeholder and all people (elderly, people with physical limitations, children) with temporary or permanent limitations. At the beginning of the first design sessions, each group had the design brief through email.

The second instrument was the kitchen survey, which included 47 items (adapted from Afacan & Demirkan, 2010). The kitchen survey aims to determine the needs of varied stakeholders in the kitchen environment. Therefore, participants were asked to rank the importance level on a five-point Likert scale (1 being least important and 5 most important) for each kitchen design item to use a kitchen environment efficiently. The kitchen survey was originally developed, involving eight kitchen design features and 87 items. In this

study, seven kitchen design features and 47 kitchen items remained to be assessed by the students since they do not have to deal with details of controls and appliances (including 40 items) in their end products. After the design sessions, the students must fill out the kitchen survey from the stakeholder's point of view (a person with a broken arm). The third instrument was the design assessment sheet, which consisted of 7 UD principles (Center for Universal Design, 1997) and 47 kitchen survey items (adapted from Afacan & Demirkan, 2010).

Procedure

This study consists of four main stages, as seen in Fig. 2. In the first stage, groups A, B, and C were asked to experience one ED technique online. Group A communicated directly with the stakeholder; Group B communicated indirectly with the stakeholder by using communication tools such as the empathy map technique, online lecture, and video of a stakeholder in a kitchen environment, and Group C practiced role-playing (preparing and eating food in their own kitchens) as an ED technique (Kouprie & Sleeswijk Visser, 2009). Group D (the control group) did not practice any ED technique as a learning method. Later, the second stage involved redesigning the stakeholder's kitchen environment online. Each group had to complete their kitchen designs in an independent Zoom session. The session lasted 2.5 h, and each group had to redesign the stakeholder's kitchen with the required space components. The design brief, photographs, and the online AutoCAD plan drawing of the stakeholder's kitchen were emailed to the groups. Each design session was recorded. After the design session, in the third stage, groups were asked to fill out the kitchen survey from the stakeholder's point of view. At the end of sessions, in the fourth and last stage, three instructors with at least five years of design studio experience in the Department of Interior Architecture and Environmental Design, at ID. Bilkent University assessed each group's end products by filling out the design assessment sheet.

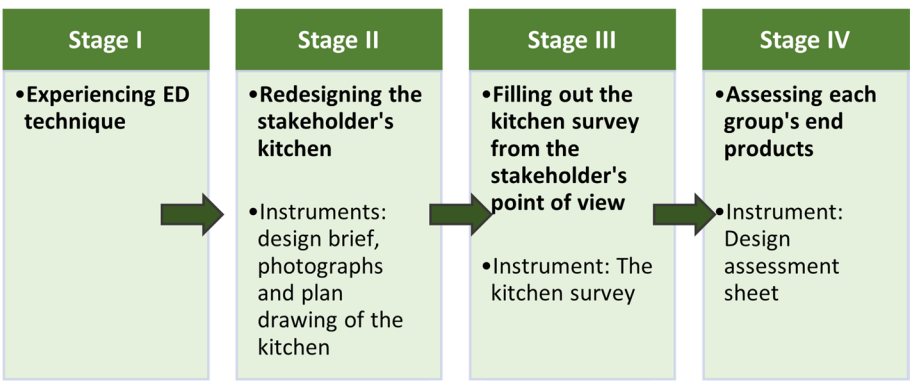


Fig. 2 Procedure of the study and the instruments used in each stage

Data analysis

End-product analyses are analyzed using qualitative and quantitative methods in four stages. The first stage was descriptive statistics analysis of the kitchen survey findings. Data obtained as each group's (n = 3) mean values from the kitchen survey instrument were analyzed statistically. The second stage was the analysis of the design assessment sheet instrument. Three experts evaluated each group's end products by rating each kitchen design item in the Design Assessment Sheet. The rating was done on a 5-point Likert scale (1 being very dissatisfied, 5 very satisfied). Inter-rater reliability of the three instructors'assessments was conducted using the Intraclass Correlation Coefficient (ICC), which was first developed by Fisher (1954). Since the number of instructors is fixed at three and each instructor assesses each item in this study, the two-way mixed model is selected (Koo & Li, 2016). The third stage was the Importance-Performance Analysis (IPA) of the kitchen survey instrument and design assessment sheet instrument's findings. IPA is the technique frequently used in distinct research areas that emphasize priorities on importance and performance dimensions, which originated with Martilla and James (1977). They defined it as"[a]n easily applied technique for measuring attribute importance and performance can further the development of effective marketing programs"(Martilla & James, 1977, p. 77). Also, IPA has been used in studies of housing accessibility (Afacan, 2019; Tasoz & Afacan, 2020). In this study, the important items are provided from the kitchen survey instrument the participants filled out. The performance items are obtained from the design assessment sheet instrument the three instructors filled out. All quantitative data is analyzed with the Statistical Package for Social Sciences (SPSS, version 21) software.

Findings

Students' end products analysis

All the groups had to submit a plan, a section, and some perspective drawings as the end products. Group A only submitted the orthographic drawings consisting of a plan and a section. Although perspective drawings were also requested, they could not deliver them within the given time. Group B submitted a plan, a section, and a digitally drawn perspective. Groups C and D (the control group) submitted a plan, a section, and a freehand-drawn perspective (Fig. 3).

Three instructors assessed each group's end products with checklist analysis using the Design Assessment Sheet. Table 1 presents each instructor's assessments of the groups related to the availability of seven UD Principles and 47 kitchen design items. The findings indicated that the groups'end products met stakeholder's needs. The inter-rater reliability test determined the degree of consistency in the instructors'assessment process.

Inter-rater reliability analysis

ICC assessments and their 95% confidence intervals were calculated using SPSS software with the selection of the two-way mixed model, mean of three raters measurement type, and consistency as the relationship definition. The findings of ICC values (average measures) for three instructors related to seven UD principles have a range from 0.75 to 0.889,

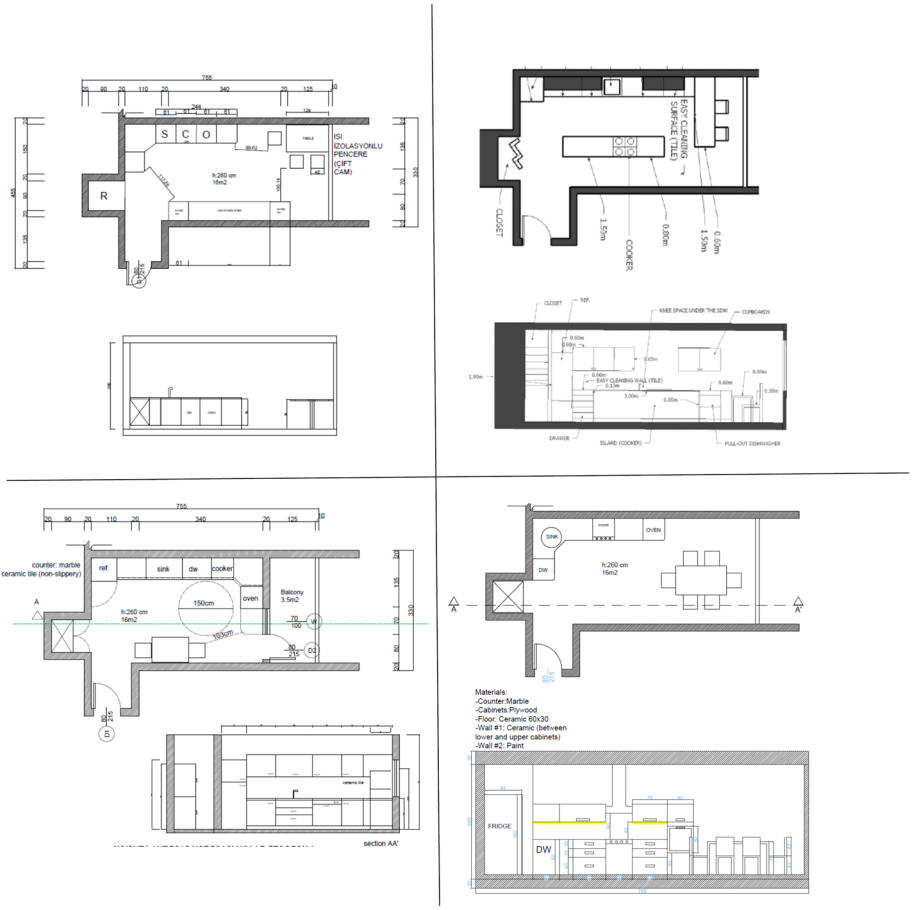


Fig. 3 Floor plan and section drawings (Group A, B, C and D, left to right)

Table 1 Three instructors' assessments of the groups

		Groups			
		Group A	Group B	Group C	Group D
Seven UD Principles (The Center for Universal Design, 1997)	**Instructor 1**	6	5	5	6
	Instructor 2	6	6	6	6
	Instructor 3	4	5	5	5
Forty-seven kitchen design items (adapted from Afacan & Demirkan, 2010)	**Instructor 1**	33	28	35	35
	Instructor 2	27	27	37	39
	Instructor 3	22	20	29	31

listed as for Group A = 0.808, Group B = 0.750, Group C = 0.750, and group D = 0.889 based on 95% confidence interval with a *p-value* ≤ 0.05. Since all values are greater than 0.75, there is high inter-rater reliability and an agreement between the three instructors'

assessments (Koo & Li, 2016). Moreover, the findings of ICC values (average measures) for three instructors on 47 kitchen design items are for Group A = 0.839, Group B = 0.817, Group C = 0.824, and Group D = 0.805 based on a 95% confidence interval with a *p-value* ≤ 0.05 with a range from 0.805 to 0.839. The findings indicated good inter-rater reliability, which refers to a high degree of agreement between three instructors since all values are greater than (0.8).

Importance-performance analysis (IPA)

In this study, IPA quadrants are developed and interpreted according to the traditional importance-performance grid introduced by Martilla and James (1977). Figures 4–7 present the IPA graphs of groups. Median values are taken into consideration.

First, Fig. 4 presents the IPA graph of **Group A** on the four quadrants. According to the IPA findings for Group A, thirteen items 2, 6, 7, 9, 17, 18, 21, 22, 23, 24, 28, 30 and 37 are in Quadrant 1. All the items in Quadrant 1 (Keep Up the Good Work) are considered high in performance and importance. Group A had adequate clear spaces as passages and circulation spaces and provided an adequate clear floor area for a dining kitchen by integrating the balcony with the kitchen area. They also eliminated all the wall cabinets to prevent accidents falling. In addition, they designed a special counter surface for electrical appliances and considered not locating the appliances next to the sink or cooktop because

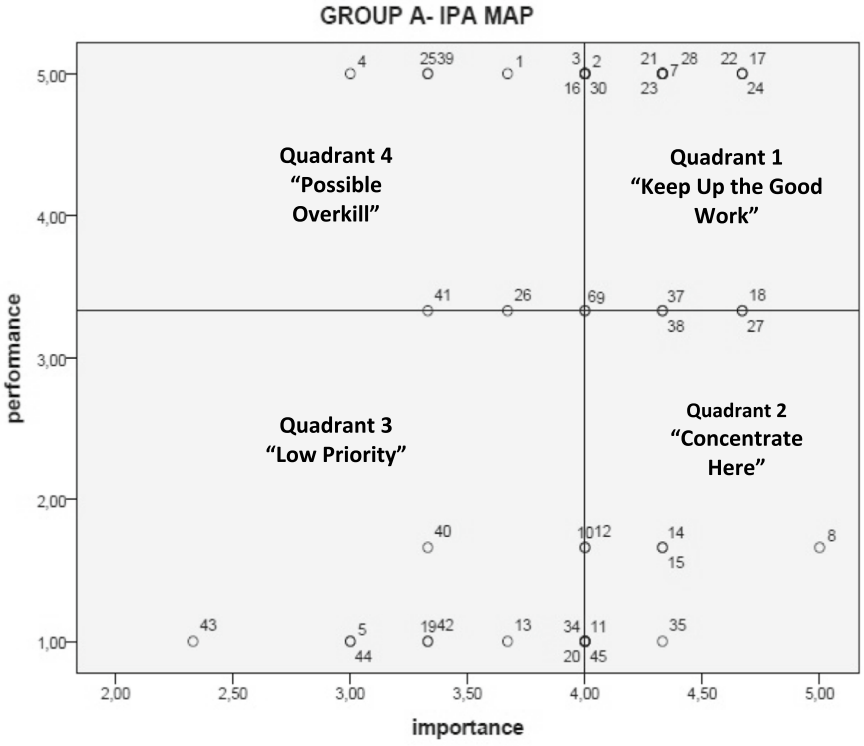


Fig. 4 The IPA Graph with Four Quadrants of Group A

of safety issues. Moreover, they corrected the existing work sequence of use (the order of activities involved in preparing food). They provided an appropriate free space in front of the refrigerator, cooktop, oven, sink, and dishwasher for an easy approach and efficient use of all equipment. Quadrant 2 indicates high importance and low performance. Also, it means'Concentrate Here.'This quadrant has ten items, namely 8, 10, 11, 12, 14, 15, 27, 35, 38, and 45. The nine items, 5, 13,19, 20, 34, 40, 42, 43, and 44, are considered in Quadrant 3 (Low Priority), which also means low importance was given by Group A. The last Quadrant 4 (Possible Overkill) means low importance and high performance. The items in this quadrant are 1, 3, 4, 16, 25, 26, 39, and 41. Group A included a 152 cm diameter for wheelchair stakeholders' easy turn. Also, they suggested a work triangle with no obstacles between the refrigerator, sink, and cooktop. They also designed the kitchen counter and table with smooth edges. Also, they provided the appropriate counter depth and suggested adequate natural light and LED (light-emitting diode) devices over the working surface mounted under the shelves.

According to the IPA findings for **Group B** (Fig. 5), seventeen items 2, 3, 4, 9, 14, 15, 16, 18, 21, 22, 23, 24, 27, 29, 32, 33, and 46 are in Quadrant 1 (Keep up the Good Work). Group B suggested the right work sequence (sink-main counter-cooktop-counter) and proposed appropriate counter-frontal lengths at the refrigerator's opening side, to the cooktop's right, and at the main counter. They also proposed a knee space under the sink and pull-out dishwasher, considering the sitting elbow height of a wheelchair user concerning the anthropometric data table. Also, they provided free space in front of the refrigerator,

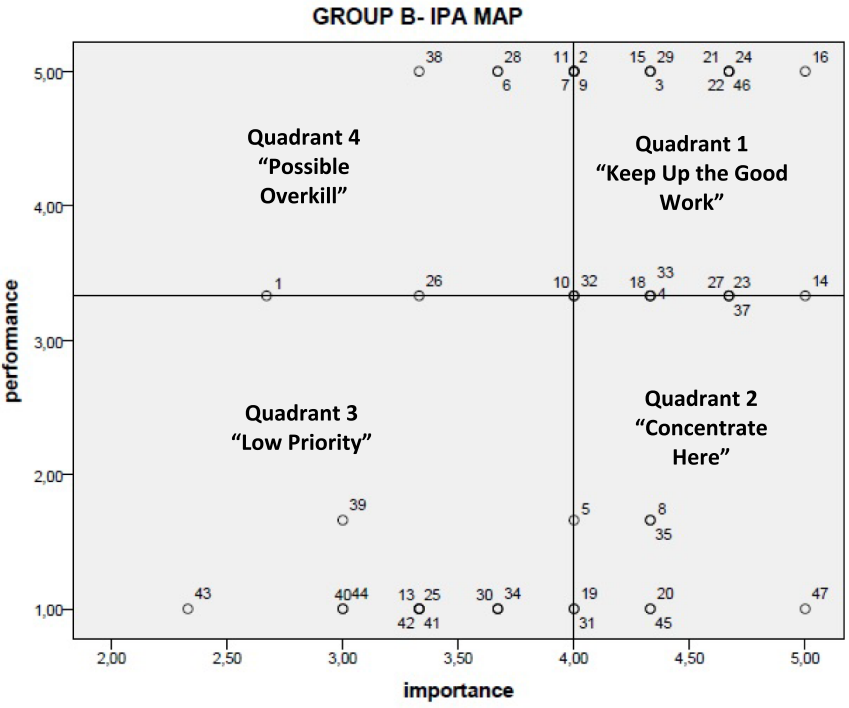


Fig. 5 The IPA Graph with Four Quadrants of Group B

cooktop, sink, and dishwasher. Group B suggested easy-care floor material. Quadrant 2 (Concentrate Here) has nine items: 5, 8, 19, 20, 31, 35, 37, 45, and 47. Group B suggested high wall cabinets that were not reachable for the stakeholder. The ten items in Quadrant 3 (Low Priority) are items 13, 25, 30, 34, 39, 40, 41, 42, 43, and 44. Group B did not suggest lighting equipment to illuminate the working surfaces or above the cooktop and did not propose adequate natural light in the kitchen. Also, they did not propose a color contrast between the floor and counter material and a heat-resistant countertop material.

The items in Quadrant 4 (Possible Overkill) are 1, 6, 7, 10, 11, 26, 28 and 38. Group B focused on the idea of the separation of the circulation and working zone areas. They proposed an island kitchen layout, even though they knew there was no sufficient floor area, but they defined a circular space for a wheelchair to make a 180-degree or 360-degree turn. Therefore, they suggested integrating the balcony with the kitchen area to provide an adequate floor area for an enclosed kitchen with an island counter layout.

According to the IPA findings for **Group C** (Fig. 6), in Quadrant 1 (Keep up the Good Work), there are four items: 1, 2, 3, and 14. Group C provided the right total length of the work triangle, which must be no more than 7 m on all three sides. In their one-wall kitchen, the sides of the work triangle between the refrigerator, sink, and cooktop were all on the same line. Also, they proposed adequate space requirements for a wheelchair to ensure accessibility and circulation in the kitchen. Group C designed the right work sequence of use in the kitchen in consideration of a right-handed person. In Quadrant 2 (Concentrate Here), there are nine items: 4, 8, 10, 17, 23, 29, 37, 41, and 42. Group C noticed the need for more storage units and designed wall cabinets higher than 190 cm, which were unreachable to the stakeholder. Quadrant 3 (Low priority) indicates low importance and low satisfaction. This quadrant has sixteen items: 7, 9, 11, 13, 15, 19, 25, 26, 27, 28, 30, 34, 35,

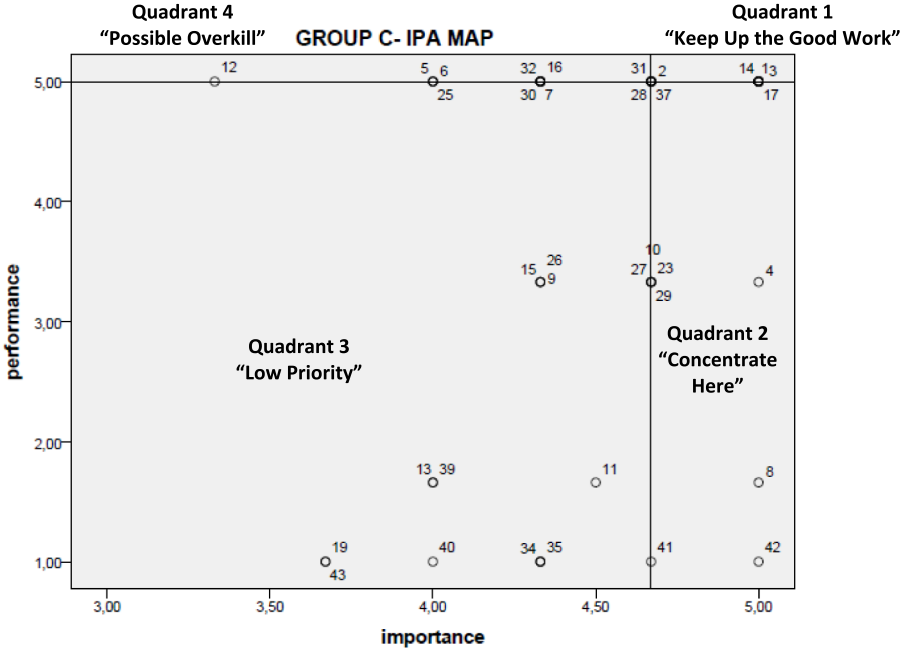


Fig. 6 The IPA Graph with Four Quadrants of Group C

39, 40, and 43. Group C did not suggest lighting equipment but proposed marble as a heat-resistant countertop material and ceramic tiles as slip-resistant and easy-care floor material. Quadrant 4 (Possible Overkill) has six items: 5, 6, 12, 16, 31, and 32. Group C located the oven height at the stakeholder's eye level, provided adequate clear space at three sides of the dining table, and suggested an adjustable dining table; they also suggested an efficient corner cabinet and close access to the dishwasher and the counter.

According to the IPA findings for **Group D** (Fig. 7), in Quadrant 1 (Keep up the Good Work), there are seven items: 2, 8, 21, 24, 29, 33, and 35. Group D integrated the balcony with the kitchen area to provide an adequate floor area for a wheelchair. The other groups provided adequate floor area in the kitchen for a wheelchair to make a 180-degree or 360-degree turn. They also suggested wall cabinet heights considering the stakeholder's short stature. Also, they located the dishwasher and oven according to the'sitting vertical grip reach (103 cm)'dimension considering the anthropometric data table. Group D provided the right sequence of use as refrigerator counter-sink- main counter-cooktop counter from left to right since the stakeholder is right-handed. Also, they located the dishwasher near the sink, which is preferable for the water supply and drainage system. Quadrant 2 (Concentrate Here) indicates high importance and low satisfaction. Group D gave high importance to items 3, 17, 18, 24, 26, 27, 28, 37, 38, 39, 40, 42, and 46. Group D only provided an adequate illumination level over the working surfaces mounted under the cabinets. Also, they recommended ceramic tiles as slip-resistant floor material, marble as a heat-resistant countertop material, plywood for cabinets, and ceramic tiles as slip-resistant material for the walls. Quadrant 3 (Low Priority) means low importance and performance

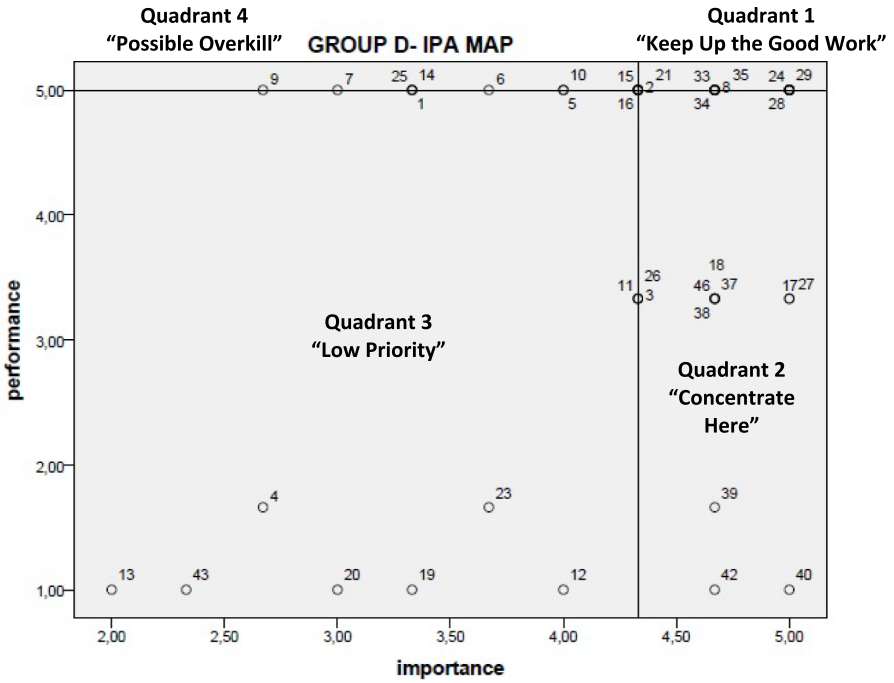


Fig. 7 The IPA Graph with Four Quadrants of Group D

for Group D. Group D gave low importance to eleven items: 1, 4, 5, 11, 12, 13, 16, 19, 20, 23, and 43. According to the literature, Group D located the sink in a corner, which is preferable. They also provided knee space under the sink and cooktop and suggested a pull-out dishwasher. In addition, they located the oven and microwave oven at eye level for the efficient use of people with diverse abilities. Quadrant 4 (Possible Overkill) means Group D indicated high performance but gave low importance to the seven items 6, 7, 9, 10, 14, 15 and 25.

Importance-performance analysis (IPA) of the groups

In the IPA, most items are located in Quadrant 1 (Keep up the Good Work) in Groups A and B, as seen in Table 2. These groups communicated directly or indirectly with the stakeholder. For Group C, who had practiced the role-playing technique, most items are in Quadrant 3 (Low Priority). As the control group, Group D had the highest number of items in Quadrant 2 (Concentrate Here).

The interaction of groups and kitchen design features

A two-way unrelated analysis of variance test showed that only significant effects are obtained for the interaction of groups and kitchen design features ($F\ (18, 129) = 2.32$, $p = 0.004$, partial $\eta^2 = 0.24$, medium effect). It was determined that there is no significant difference among groups A, B, C, and D and 47 design items. Since groups and kitchen design features interact, each group's performance level in design is analyzed according to the preferred quadrants. Figure 8 demonstrates each group's IPA analysis findings of kitchen design features in the quadrants.

The design features estimated to be in Quadrant 1 (Keep up the Good Work) involve the high importance and highly performed kitchen design features. As seen in Fig. 8 for Group A, sink and faucets ($M = 1.50$, $SD = 0.71$), cabinets and storage areas ($M = 1.80$, $SD = 0.63$), features; for Group B, counters and worksurfaces ($M = 1.44$, $SD = 0.73$), and circulation ($M = 1.80$, $SD = 1.30$); for Group C, circulation ($M = 1.80$, $SD = 1.30$); and Group D, appliances ($M = 1.57$, $SD = 0.56$) have high importance and highly performed kitchen design features.

The design features estimated to be in Quadrant 2 (Concentrate Here) involve high-importance and low-performance kitchen design features. As seen in Fig. 8 for Group A, counters and worksurfaces ($M = 2.00$, $SD = 1.33$), and appliances ($M = 2.17$, $SD = 1.67$); for Group B, materials ($M = 2.20$, $SD = 0.84$), and appliances ($M = 2.20$, SD

Table 2 Number of items and their percentages of the groups within each IPA quadrant

	Group A		Group B		Group C		Group D	
	Items	%	Items	%	Items	%	Items	%
Quadrant 1 (Keep up the Good Work)	13	32.50	17	38.64	4	11.43	7	18.42
Quadrant 2 (Concentrate Here)	10	25.00	9	20.45	9	25.72	13	34.21
Quadrant 3 (Low Priority)	9	22.50	10	22.73	16	45.71	11	28.95
Quadrant 4 (Possible Overkill)	8	20.00	8	18.18	6	17.14	7	18.42
Total items	40	100.00	44	100.00	35	100.00	38	100.00

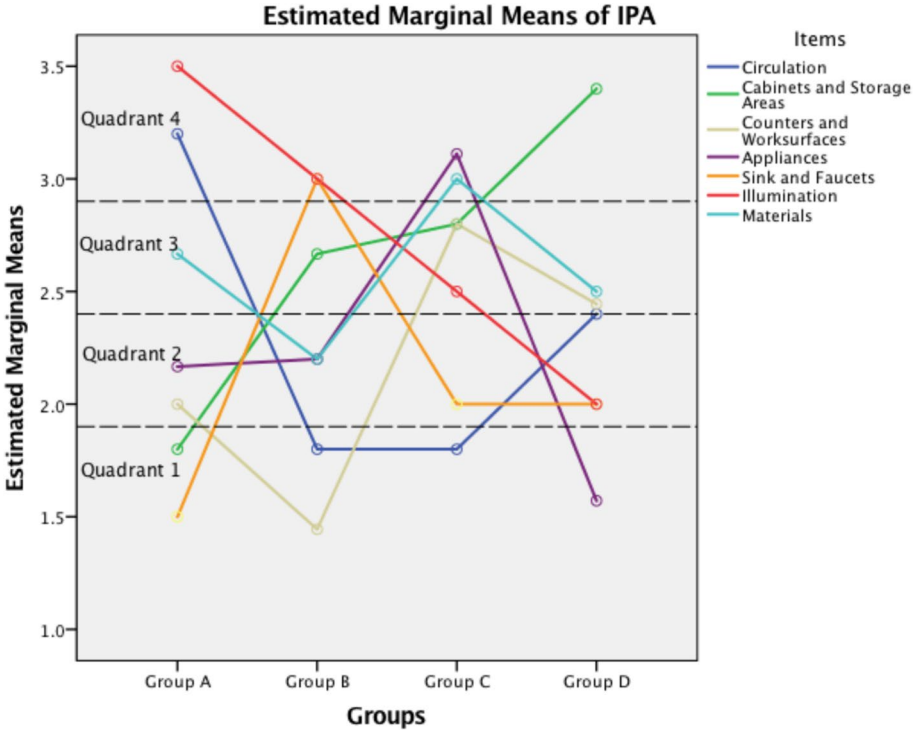


Fig. 8 Estimated IPA values of groups with the interaction of kitchen design features

= 1.23); for Group C, and sink and faucets (M = 2.00, SD = 0.01); and for Group D, sink and faucets (M = 2.00, SD = 0.01), illumination (M = 2.00, SD = 0.01), and circulation (M = 2.40, SD = 0.89) kitchen design features have high importance, but lowly performed kitchen design features.

The design features estimated to be in Quadrant 3 (Low Priority) involve low importance and lowly performed kitchen design features. As seen in Fig. 8 for Group A, materials (M = 2.67, SD = 0.58); for Group B, cabinets and storage areas (M = 2.67, SD = 1.41); for Group C, counters and worksurfaces (M = 2.80, SD = 0.84), cabinets and storage areas (M = 2.80, SD = 0.92), and illumination (M = 2.50, SD = 0.58); and Group D, counters and worksurfaces (M = 2.44, SD = 1.01), and materials (M = 2.50, SD = 0.71) have low importance and lowly performed kitchen design features.

The design features estimated to be in Quadrant 4 (Possible Overkill) involve low importance but highly performed kitchen design features. As seen in Fig. 8, for Group A, circulation (M = 3.20, SD = 1.30), and illumination (M = 3.50, SD = 0.58); for Group B, sink and faucets (M = 3.00, SD = 1.41), and illumination (M = 3.00, SD = 0.01); for Group C, materials (M = 3.00, SD = 0.01) and appliances (M = 3.11, SD = 0.60); for Group D, cabinets and storage areas (M = 3.40, SD = 0.97) have low importance, but highly performed kitchen design features.

Discussion

The IPA findings indicated that Group B, who had indirect contact with the stakeholder while accumulating knowledge about the needs and expectations of the stakeholder through an online lecture and video of the stakeholder and experienced the empathy map technique, had practiced the highest number of kitchen design items (17/44) in Quadrant 1 (Keep up the Good Work). This means that Group B had given high importance and performed these UD kitchen items well. Similar to van Rijn et al. (2011) findings, having background information and video observation have the potential for empathizing with stakeholders and promoting universal design. Also, Group A, who had direct contact with the stakeholder while observing and interviewing, had practiced the highest number of design items (13/40) in Quadrant 1 (Keep up the Good Work). In Groups A and B, many practiced design items were highly important in parallel with the previous ED research studies. Building direct contact with stakeholders by observation and interview enhanced design awareness and empathic understanding and had a positive impact on the quality of students' products (Lorentzen & Hedvall, 2018; Senyigit & Yılmaz, 2021; Tracey & Baaki, 2022; van Rijn et al., 2011).

However, Group C, using the role-playing technique, had practiced the highest number of design items (16/35) in Quadrant 3 (Low Priority). This means they thought these kitchen design items were unimportant and performed poorly. This finding shows that Group C is different from Groups A and B as Pallasmaa (2015) stated that the designer imagines oneself as the actual stakeholder in role-playing. It is reflected in the design process. Group C viewed the design obstacles and problems of the stakeholder from their perspective. Moreover, it supports Morton (2017), who claimed that the designer's experience is also reflected in the designer's approach to the ED process. According to the instructors' evaluation, Group C provided more UD principles and kitchen design items than other experimental groups (5, 6, 7 out of 7 UD principles and 35, 37, 29 out of 47 kitchen design items for each of the three instructors). The role-playing technique enhanced cognitive knowledge and affective relationships with the stakeholder (Altay, 2014; Altay & Demirkan, 2014), and students learned from their experiences, they considered their own knowledge and experience in thinking about universal design solutions and this situation reflected on their design awareness positively (Altay et al., 2016; Gagnon & Cote, 2014; Kocaoglu & Demirkan, 2019; Lorentzen & Hedvall, 2018; McDonagh & Thomas, 2010).

Group D (control group), who did not have any contact or knowledge about the stakeholder, practiced the highest number of design items (13/38) in Quadrant 2 (Concentrate Here). Although they thought these design features were important, they could have performed better. The highest number of design items in Quadrant 2 was expected since they needed to have contact with the stakeholder or accumulate knowledge about the stakeholder. Consequently, the research findings of Kouprie and Sleeswijk Visser (2009) indicated that design students'awareness of empathic understanding was raised. This study recognized that designing with empathy produces more accessible and easily usable products or environments for all.

The findings of this study contribute to the design education discipline in empathic ways of designing with project-based and activity-based learning methods. The comparative analysis with a control group indicated the advantages of the ED process in the design of universally designed end products. The results of this study may be beneficial for both design instructors and design students. The design instructors could introduce the ED approach and demonstrate the techniques by emphasizing their importance, as suggested

in the previous literature (Altay, 2017; Altay & Demirkan, 2014). ED could be used as an alternate teaching approach and could be integrated as assignments in UD courses, design studios, or workshops (Nicolle & Maguire, 2003). Design instructors should benefit from using the ED process to teach UD in project-based courses. They can enable students to understand the obstacles and design problems that people with disabilities can encounter in their daily life activities through ED techniques. Rather than passive learning, students are more active in ED techniques through direct contact with stakeholders, research, and simulation of people with diverse abilities activities. Active learning strategies can strengthen students' learning in both cognitive and affective domains (Altay et al., 2016). In addition, students can learn much from their experience. This study will also help students to find more UD solutions for kitchen interiors. By criticizing and rating the importance of kitchen items through others' perspectives, students can enhance their empathy and design awareness of people with diverse abilities' problems. In architectural education, limited experimental and observational studies in interior architectural design education literature investigate the differences between ED techniques and their impacts on students' end products with importance-performance analysis. This study's learning and design outcomes will guide design students, design educators, or researchers.

Conclusion

This study explored the impact of the empathic design process on universally designed kitchen environments in an online project-based course. Furthermore, it researched what kitchen design items students give importance to and how they are performed in their end products. Design students experienced different ED techniques and redesigned the stakeholder's kitchen environment online. After the design sessions, the students ranked the importance level of each kitchen design item on a scale of 1–5 from the perspective of the stakeholder (who has a broken arm). At the end of the experiment, three instructors assessed each group's end products by checklist analysis, rating each kitchen design item on a 5-point Likert scale. They evaluated whether students provided the seven UD Principles and 47 kitchen design items in their end products.

This study's findings underlined the ED process's positive impact on proposing UD solutions with the correct application of HF/E principles in students'design projects. A summary of the overall findings of the study is as follows: (1) Instructors' evaluation indicated that experiencing ED techniques was found effective in making drawings in accordance with UD principles and availability of kitchen design items. Integrating ED approaches in the design process made students think more comprehensively. Therefore, students provided more UD solutions with the correct application of HFE and UD principles. (2) IPA findings indicated a positive relationship exists between the importance students give to design items and their performance. Students gave high importance to these UD kitchen items and performed them well. Creating direct or indirect contact with the stakeholder provides more highly performed kitchen design items that are considered important in the design process. (3) Difference between ED techniques and the extent of stakeholder involvement was found. According to the instructors' evaluation, Group C, who experienced role-playing techniques, provided more UD principles and kitchen design items. The design results of this research demonstrated that using empathy in the design process improves university students' empathic ability (both cognitive and affective components) and encourages them to design universal, intuitive and

meaningful products/environments. Design students needed to contact or accumulate knowledge about the stakeholder with enhanced empathic understanding. It is very significant for design students to learn universal design, internalize its principles, and design accordingly in their educational life to become designers of equal and universal designs in the future.

Limitations and future study

This study had some limitations since it was conducted during the COVID-19 pandemic period. First, since the study was conducted online, the time for the experiment was limited. Role-playing technique experimentation, co-designing time, observation time, and interview time with the stakeholder could be longer. Second, a small number of students participated voluntarily since universities were closed. If the same studies are conducted in a studio environment, more students will be present to participate. Third, collaborative designing using Zoom was difficult for the students, and production time (a day) was limited. In future studies, students can work more effectively face-to-face in a studio environment with adequate time, as mentioned in the previous research (Altay et al., 2016; Lorentzen & Hedvall, 2018). Fourth, the students experienced only one physical disability (a broken arm) and one activity (preparing and eating food in their own kitchens) as role-playing techniques in their kitchen environment. In future studies, students can conduct multiple daily activities both in the home environment and/or built environment. Therefore, they can try to understand more design problems experienced by more individuals. They are also able to experience different types of disabilities such as visual, mobility, hearing-impaired, or aging so that they will be able to deal with the higher expectations, needs, and demands of the stakeholder. Fifth, this study was conducted with only undergraduate students from the Department of Interior Architecture and Environmental Design. Participants from different design disciplines would respond differently under IPA, thereby leading to differing design outcomes. Therefore, undergraduate/graduate students of interior architecture, architecture, urban design, and industrial engineering can experience together this type of experiment. Lastly, the evaluation of end products were done by cheklist analysis. For future studies, design instructors can evaluate students' end products by giving them face-to-face design critiques, or used other assesment methods.

Appendix. The Kitchen Survey (Adapted from Afacan & Demirkan, 2010) This survey lists the design features for a kitchen. Please rate your **(from a broken arm person's point of view)** importance level for each feature on a scale of 1–5 (1 being the least important and 5 the most important) and mark the appropriate boxes to identify how important each of the following features is in working successfully within a kitchen environment.

Age:
Gender: Female ☐ Male ☐

Category 1. Circulation	Least Important 1	2	3	4	Most Important 5
1. Ease of moving/maneuvering in the kitchen	☐	☐	☐	☐	☐
2. An adequate clear floor area if more than one person using the kitchen	☐	☐	☐	☐	☐
3. An uninterrupted clear floor area in the work triangle between the refrigerator, sink and cooker	☐	☐	☐	☐	☐
4. Non-exhausting walking distances (the work triangle) between the refrigerator, sink and cooking surface	☐ ☐	☐ ☐	☐ ☐	☐ ☐	☐ ☐
5. An adequate clearance at three sides of the dining table	☐	☐	☐	☐	☐
Category 2. Cabinets and storage areas					
6. Close access to the cabinets	☐	☐	☐	☐	☐
7. Ease of reach to the low portions of the base cabinets	☐	☐	☐	☐	☐
8. Ease of reach to the high portions of the wall cabinets	☐	☐	☐	☐	☐
9. Ease of use of the rear portions of the base cabinets	☐	☐	☐	☐	☐
10. Ease of use the rear portions of the wall cabinets	☐	☐	☐	☐	☐
11. Cabinets having pull-out shelves	☐	☐	☐	☐	☐
12. Effective and efficient use of corner cabinets by 360◦ rotating mechanisms/lazy-susan units/moon swing-out shelves	☐	☐	☐	☐	☐
13. Removable base cabinet doors	☐	☐	☐	☐	☐
14. Use of the cabinet door handles with low effort	☐	☐	☐	☐	☐
15. Use of the drawers and its contents without uncomfortable postures	☐	☐	☐	☐	☐
Category 3. Counters/ work surfaces					
16. Close access to the counter	☐	☐	☐	☐	☐
17. An appropriate counter height	☐	☐	☐	☐	☐
18. Use of the whole surface of the counter without uncomfortable postures	☐	☐	☐	☐	☐
19. Counters at various heights	☐	☐	☐	☐	☐

	Least Important 1	2	3	4	Most Important 5
20. Pull-out work surfaces	☐	☐	☐	☐	☐
21. An appropriate counter space on at least one side of the refrigerator	☐	☐	☐	☐	☐
22. An appropriate counter space on at least one side of the cooking surface	☐	☐	☐	☐	☐
23. An appropriate counter space on at least one side of the same level as the rack	☐	☐	☐	☐	☐
24. An appropriate counter space on at least one side of the sink	☐	☐	☐	☐	☐
25. Rounded edges on the counter	☐	☐	☐	☐	☐
Category 4. Appliances					
26. Close access to the refrigerator	☐	☐	☐	☐	☐
27. Ease of reach to all the essential elements of the refrigerator from preferred positions	☐	☐	☐	☐	☐
28. Close access to cooktop	☐	☐	☐	☐	☐
29. Ease of reach to all the essential elements of the cooktop from preferred positions	☐	☐	☐	☐	☐
30. Close access to the oven	☐	☐	☐	☐	☐
31. Ease of reach to all the essential elements of the oven from preferred positions	☐	☐	☐	☐	☐
32. Close access to dishwasher	☐	☐	☐	☐	☐
33. Ease of reach to all the essential elements of the dishwasher from preferred positions	☐	☐	☐	☐	☐
34. Close access to the hood	☐	☐	☐	☐	☐
35. Ease of reach to all the essential elements of the hood from preferred positions	☐	☐	☐	☐	☐
Category 5. Sink and faucets					
36. Close access to the sink	☐	☐	☐	☐	☐
37. Use of the sink without uncomfortable postures	☐	☐	☐	☐	☐
38. Ease of reach to the faucets from preferred positions	☐	☐	☐	☐	☐
Category 6. Illumination					
39. Adequate natural light in the kitchen	☐	☐	☐	☐	☐
40. Adequate artificial light in the kitchen	☐	☐	☐	☐	☐
41. Adequate illumination levels over the working surfaces	☐	☐	☐	☐	☐
42. Adequate illumination levels above the cooktop	☐	☐	☐	☐	☐
Category 7. Materials					
43. A colour contrast between floor and counter material	☐	☐	☐	☐	☐
44. A heat-resistant countertop material	☐	☐	☐	☐	☐
45. A durable floor material	☐	☐	☐	☐	☐
46. An easy-care floor material	☐	☐	☐	☐	☐
47. A slip-resistant floor material	☐	☐	☐	☐	☐

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Declarations

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