ITU A|Z • Vol 20 No 1 • March 2023 • 199-217

The role of usability in the technology acceptance of projection-based user-interfaces

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Received: December 2021 • Final Acceptance: November 2022

Abstract
This paper aims to discover the role of usability on the technology acceptance of projection-based user-interfaces in the kitchen context. VUX–Virtual User Experience; a system consisting of a hob, a hood and a dishwasher machine controlled by a projection-based user-interface, was chosen as the product. The Unified Theory of Acceptance and Use of Technology (UTAUT) model was chosen as the theoretical frame. A two-phase study was conducted with 30 participants based on the functional prototype. The first phase consisted of a structured user-test in a showroom kitchen environment in which participants were requested to complete pre-defined tasks. The second phase was a UTAUT questionnaire including 32 questions organized in 9 sections. Content analysis and statistical analysis were used to analyze qualitative and quantitative data from the UTAUT questionnaire. It has been found that although the projection-based user-interface has a great role on technology acceptance based on usability, most of the users defined their behavioral intention to use VUX by their attitude toward using technology, experience, and anxiety in the kitchen context. In terms of user-interface design, it has been found that the design characteristics of the user-interface, such as form of icons, color and shape, did not have a significant effect on the technology acceptance of VUX. In terms of usability, errors and safety concerns were found to be the most effective factors in the acceptance of technology by determining the usability of the system.

Keywords
Technology-acceptance, Usability, User-interface design, Projection-based user-interface.

doi: 10.58278/0.2023.2

1. Introduction

With the technological developments and advancements, the design and technology of user-interfaces is continuously progressing while providing new interaction typologies to users. Projection-based user-interface (PBUI) that is used in various applications such as projected keyboards, interactive tables etc., is a new technology that can provide a new interaction style to the user. Although they are computerized user-interfaces based on icons and menus, instead of being displayed on a screen; these elements are projected on a surface to be controlled by the users' hands or fingers.

However, the acceptance of new technologies by users is a problematic issue and is the subject of a large number of studies based on the concept of technology-acceptance research. Due to the facts stated above, the technology acceptance issues related with PBUI have attracted the academic interest of the authors.

A number of models such as UTAUT have been developed in order to better understand the process of acceptance of new technologies by users. In these models, usability is considered to be one of the primary factors which directly affects the acceptance of a new technology by prospective users. The number of studies focusing on the usability of consumer products having a PBUI is limited. Besides personal computer peripherals and home entertainment; the application areas of PBUIs are constantly increasing by including restaurants and exhibition designs (Roeber et al., 2003; Dalsgaard & Halskov, 2011).

Prior research has examined technological acceptability in various fields and sectors; including website designs, medical devices, smartphone applications and military systems (Wu et al., 2007).

Also, most of the research (Hiraki et al., 2019; Lin & Lin, 2013, Mewes et al., 2016; Huber, 2014) that study PBUIs focus on ergonomics-based issues of the technology. However, concerning a computerized user-interface usability is a key factor for the effective, satisfactory and error-free usage of any product. The user-interface is the medium where all interactions between the user and the product take place. It must provide the user sufficient information about the way the product works and its status to be able to operate the product intuitively. A badly designed user-interface will result in an ineffective and unsatisfactory usage along with errors.

Based on the facts stated above, the aims of this study have been identified as follows: the first aim is to investigate the factors that influence the acceptance of a product system with a PBUI in the context of kitchen appliances; the second aim is to explore the role of usability and their effects on the technology acceptance of PBUI and the third aim is to question whether the selected product will be preferred by the users in the future. Arçelik VUX (Virtual User-Experience), which is a concept product that is not commercialized yet, has been chosen as the product to be studied and explored for this study.

Therefore, regarding to the aims stated above, this research attempts to address the following research questions: (1) Which factors of UTAUT influence the user acceptance of PBUI systems; (2) What effect do PBUI features have on kitchen product acceptance; and (3) What is the role of usability issues on the technology acceptance of PBUI kitchen system.

The usability of a user-interface of any consumer product has an important role on its overall design quality. When users interact with a product, the lack of intuition in the interaction process can result in the product failing. In such cases, users may refuse to use the product (Oliveira & Baranauskas, 1998).

2. Technology acceptance

Technology acceptance research tries to explain cognitive and psychological factors required for the use of a new technology. Originating from the Theory of Reasoned Action (Fishbein & Azjen, 1975) in the field of psychology, there exist a considerable number of models that developed incrementally to explain the acceptance of a new technology by humans. Davis, considered to be the

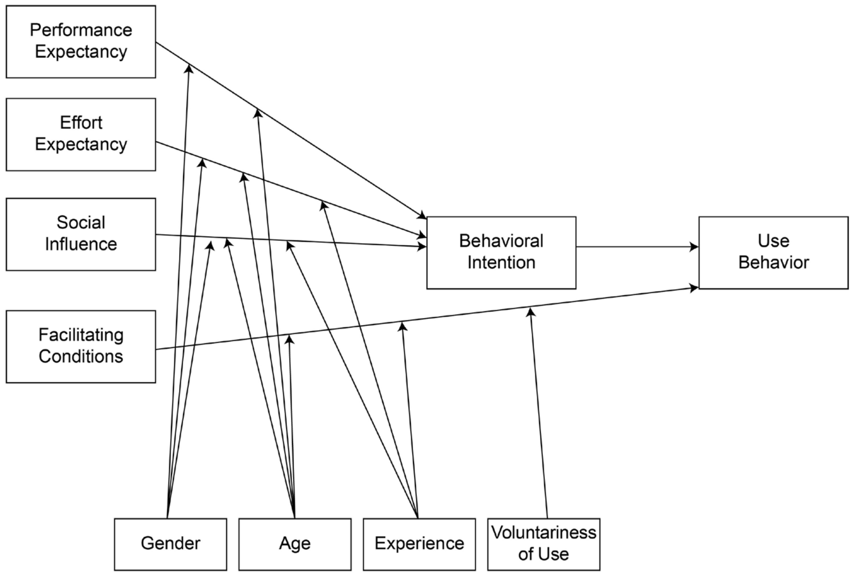

Figure 1. *The unified theory of acceptance and use of technology (Venkatesh et al., 2003).*

pioneer of the technology acceptance field, (1989) combined social behavior with technology acceptance from the disciplines of psychology and sociology. Dillon and Morris (1998) described technology acceptance as "observable willingness of using a specific product of information technology for a specific user group". Teo (2011) defines the concept of technology acceptance as "a person's desire to fulfill a task or achieve a goal using technology". Much work has been done to understand the factors that increase technology acceptance and willingness to use technology by information technology researchers and practitioners (Wang & Yang, 2005; Wu et al., 2007; Carlsson et al., 2006; Wong et al., 2013)

In order to evaluate the intention and use of a technology in relation to previous acceptance models, an extension of Technology Acceptance Model (TAM), named Unified Theory of Acceptance and Technology Use (UTAUT) has been proposed by Venkatesh et al. (2003). This model includes four main determiners that affect user acceptance with use behavior. Performance expectation, effort expectation, and social influence determine directly behavioral intention to use. Facilitating conditions determine use behavior as shown in Figure 1. Effect of individual differences on technology usage was also examined. The moderators were defined as gender, age, experience and voluntary use. This model differs from previous theories by the variance it covers. Previous theories can only explain 30-40% of the variance, whereas UTAUT can explain 70% (Venkatesh et al., 2003). In this way, it can form the basis for new theories.

There exist a wide range of research focusing on UTAUT in the literature such as, mobile applications and mobile technology (Chang, 2013; Ma et al., 2016; Okumus et al., 2018; Di Pietro et al., 2015; Palau-Saumell et al., 2019; Wu et al., 2007), transportation systems (Ooi et al., 2018; Ye et al., 2020; Adnan et al., 2018; Madigan et al., 2016; Rahman et al., 2017), medical device and software research (Chang, 2020; Garavand et al., 2019; Hennington & Janz ,2007; Lin et al., 2016; Singh & Mittal, 2020; Arfi et al., 2021,), technology applications in the education field (Abu-Al-Aish & Love, 2013; Chiu & Wang, 2008), sports technologies (Seol et al., 2017; Mahalil et al., 2020; Cavdar Aksoy et al., 2020) as well as military-based research (Tunnell IV, 2013).

Most of the research cited above attempts to explore how a product's physical properties affect people's adoption of technology, and it suggests that these attributes have an effect on people's expectations for performance, effort, self-efficacy, and anxiety.

However, the literature on the technology acceptance of products designed and developed for use in the home environment using the UTAUT model is very limited. Ficocelli and Nejat (2012) designed a voice-controlled auxiliary kitchen system for the elderly and evaluated the interface using the UTAUT model.

They proposed an enhanced UTAUT model that includes additional determinants which are perceived adaptability, perceived ease of use, perceived usefulness, and trust. Mayer et al. (2011) investigated the technology acceptance of smart products in the kitchen context with UTAUT. In terms of determinants their model was similar to the original UTAUT model and also they added new determiners such as importance, personal relevance, and innovativeness. With an extended version of Ficocelli and Nejat. (2012); Asghar et al. (2017) examined a remote assistance system with projection technology for the elderly. Another study focusing on kitchen activities was the study by Orso et al. (2017) which was examining the technology acceptance of a wearable smart device.

Intention is suggested as the primary factor influencing behavior, according to UTAUT and related models. New models have been generated including more moderators and determiners in the literature. On the other hand, although the UTAUT 2 model is more recent, it includes additional determiners such as hedonic motivation, price value, and habits that were not focused on in this study. For this reason, the authors preferred to utilize the UTAUT as the background of the study.

3. Usability and projection-based user-interfaces

International Standards Organization defines usability as: "the extent to which a system, product or service can be used by specified users to achieve specific goals with effectiveness, efficiency and satisfaction in a specified context of use" (ISO 9241-11, 2018).

As a concept that emerged from the needs of software industry as well as personal computer users, usability studies were initially focused on the problems of software user-interfaces developed for personal computers. Since the first use of the concept by Eason (1984) many researchers (Gould & Lewis, 1985; Norman, 1990; Shackel, 1991; Nielsen, 1993; Preece et al, 1994; Jordan, 1998; Constantine & Lockwood, 1999; Chen & Sherry, 2005; Seffah et al. 2006; Hornbæk, 2006; Rubin & Chisnell, 2008) explored and developed theoretical boundaries of the field. Most of the primary concepts, principles as well as research techniques were developed with the efforts made within the boundaries of these studies.

However, as a result of technological advancements, new user-interface technologies are developed and applied into consumer products. With the advancements in user-interface technologies a wide spectrum of research focused on the usability problems of user-interfaces found in smart products, smart phones, digital products etc. Researchers such as Sade et al., (1998); Keinonen, (1998), de Vet, (1993), Han et al., (2000); Freudenthal and Mook (2003); Connell et al., (2004); Wiklund et al. (2011); Liljegren, (2006); Rümelin and Butz, (2013) focused on the usability problems of smartphones, vending machines, ATM machines,' automobile infotainment systems and similar consumer products. As a new interaction type, PBUIs are based on projection technology. A two-dimensional user-interface is projected on a surface by a projector and the user is expected to control a device or product by interacting with the two-dimensional user-interface elements such as buttons, rotary knobs, keys etc. Although this user-interface technology is not new; it is still not fully commercialized in the market. Also the usability of a PBUI is not sufficiently explored and studied in the literature. Cao et al., (2007); Ko et al., (2010); Song et al., (2007) are among few researchers who studied different aspects of projection-based user-interfaces in mostly computer game environments. To our knowledge, only Lin and Lin (2013) studied PBUIs focusing on more basic ergonomic issues such as fingertip detection, fingertip tracking and gesture recognition. Therefore, usability research concerning PBUIs in home environments is an unstudied area of research.

In terms of products that are available in the market, there exist very few examples or systems that are based on PBUIs; however, most of them are uncommercialized. For example, in IKEA's "A Table for Living" concept for kitchens in 2025, the smart kitchen table has a projector (URL-1). The kitchen table serves as a guide with a projector, which may interact with other electrical devices on the table and recognize objects on the table. Users can remove the ingredient list and reflect it on the table which can be used as a stove. Another example is the Xperia Touch, a product released by Sony that can make daily tasks simpler (URL-2). The product is a portable desktop projection device that projects the user-interface to a surface or on a wall. Because it's a portable product, a family can play games at a table by turning on the projector. MIT researchers worked on creating a self-aware, digitally connected kitchen that could identify all of the activities taking place there using a PBUI (Bonanni et al., 2005).

4. Methodology

The methodology of this study consists of two main phases in order to answer research questions written in the introduction section. The first phase is a user test consisting of a semi-structured interview and an observational study focusing on usability. The second phase is a survey based on the UTAUT model focusing on technology acceptance.

4.1. Participants

A total of 30 participants (15 male and 15 female), consisting of engineers, technicians, designers and other office staff, selected on a voluntary basis, contributed to the study. The age distribution of male participants varied between 24 years and 46 years (average= 31.5, SD = 5.604420024). The age distribution of female participants was between 23 years and 49 years (average = 30.4, SD = 7.64198927). 14 participants are younger than 29 years, 13 participants are between 30-39 years and 3 participants are older than 40 years. All the participants were novel users to PBUIs and have never used or tested before. The product could not be transported anywhere for study. Also this product was a working prototype and was not available for consumers to test and use. Therefore, due these facts stated in the preceding statements, the study was conducted in the Arçelik Campus with Arçelik staff who did not work in a project related to and did not have knowledge about the product.

4.2. Product

The product that is investigated and analyzed in the study is a kitchen system that is controlled by a PBUI system, designed and built by Arçelik to operate a hob, a hood and a dishwasher. A projector that is placed in the front side of the hood projects a two-dimensional user-interface which includes buttons, keys and other controls to the kitchen counter. The user-interface is also customizable by allowing the user to locate the user-interface to the front side, left side or right side of the hob. This customization also causes the re-arrangement of the user-interface elements. The hob, the hood and the dishwasher do not have their own separate user-interface and can be only operated by the same

Figure 2. *Product group used for the study.*

Figure 3. *Projection-based user-interface used for the study.*

PBUI, The elements on the user-interface are activated and controlled by the user's hand gestures. Touching the user-interface is not required for the operation of the product. The dishwasher and the hob have separate On/Off buttons. For the observational study a working and fully-functional prototype of VUX has been used. In order to establish a realistic usage environment, the prototype has been located as a modular part of the showroom kitchen.

4.3. User test

In order to refine and fine-tune the user test a pilot study was conducted with 10 participants. After the completion of the pilot study the main user test has been conducted with 30 participants. At the beginning of each test, participants were informed about the study subject and a warm up interview including demographic data was conducted to the participants. During the warm-up interview a short video about the specifications and functionalities of the PBUI was also shown to the participants. Participants were questioned regarding their initial impressions after the film had finished playing. The warm-up interview was followed by the user-test. The showroom located in the Arçelik campus was used as the user-test environment. To obtain an isolated study environment, the showroom was closed during the user-tests to other participants or any people who were not related with the study.

For data collection purposes an observation form was used to collect data from each user test. The form included standard usability data such as: total task time, pass / fail, negative actions, number of negative actions, frequency of negative actions, observations, verbal expressions. As shown in Table 1, 4 main headings and sub-steps consisted of the user-test. Verbal data resulting from the user test has been analyzed using content analysis based on the principle concepts of UTAUT.

Table 1. *Interview questions and tasks.*

Warm-up interview questions	User test Tasks
1. Personal Information: Can you briefly introduce yourself (such as your age, education, occupation, marital status.) 2. Cooking: How often do you cook? Who cooks at home? 3. Kitchen plan: Which white goods do you have in your kitchen? How are their placements? 4. Hob usage: What kind of hob do you use? What features do you like and dislike? How long do you use your hob on average and how often do you operate your hob and hood together? 5. Have you ever used projection user-interface products? If so, which ones? After that, an introduction video of chosen product/user user-interface was shown to participants.	TASKS RELATED TO GENERAL SYSTEM 1 Activate the system 2 Control functions 2.1 Activate hood menu 2.2 Activate the hob 2.3 Activate dishwasher menu 3 Set the system menu 3.1 Change the menu position 3.2 Adjust volume 3.3 Adjust light intensity 3.4 Activation of child lock TASKS RELATED TO HOOD 4 Activate the hood 4.1 Set power 4.2 Turn the light on TASKS RELATED TO HOB 5 Boil egg 5.1 Place the pot 5.2 Adjust temperature 5.3 Adjust time 6 Brew tea 6.1 Place the teapot 6.2 Adjust temperature 6.3 Adjust time TASKS RELATED TO DISHWASHER 7 Select a program 8 Set functions 9 Run the dishwasher 10 Cancel the operation

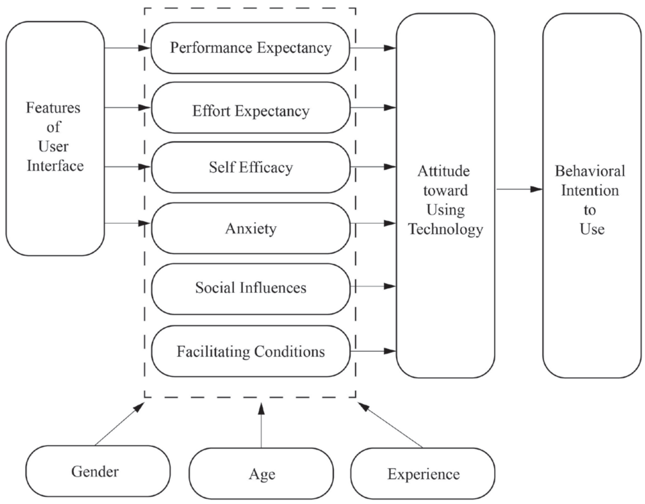

Figure 4. *Proposed research model.*

4.4. Survey (UTAUT)

In the second phase, participants responded to a questionnaire based on the UTAUT model. Selected questions on personal information and kitchen experience were asked to the participants in the first section of the questionnaire. The second part of the questionnaire contained 9 question categories related to the technology acceptance model. The total number of 32 questions were rated based on a 1 to 5 Likert-scale rating.

As emphasized by Nielsen (1994), UTAUT can be employed to gather data regarding a user's attitudes and beliefs towards the usage of technology. Some moderators of the original UTAUT model; gender, experience and age were added to this study.

On the other hand, Venkatesh et al. (2003), discussed the inclusion of the effects of anxiety and self-efficacy in the UTAUT model and reformulated the model by defining these two factors as indirect determinants. However, in contrast to Venkatesh et al. (2003) according to Çınar (2019) these indirect determiners can be examined directly within the kitchen context.

In contrast to the original UTAUT model, use behavior was not the end variable. For the purposes of this study, the user's anticipated usage of the product in the future is considered to be an important factor; therefore, as illustrated in Figure 4, the end variable was altered to behavioral intention. It is aimed to understand whether the features of the user-interface of a product affects new product's acceptance. Users' suggestions for improving the user interface will be taken into consideration while the product is currently in the development stage.

For the purposes of this study the survey included experience as a moderator. On the other hand, in the context of this study the authors defined the term "experience" as "technology experience". Technology experience relates the participant's familiarity with the product's technology and functionalities. The hob's use was selected as the factor that would determine the experience.

Gas hob users are referred to as inexperienced users. Participants who previously used products, which have PBUIs, were defined as experienced users. Scores on the questionnaire between 1 and 4 were used to determine experience level. As in the original UTAUT model, gender and age are hypothesized as moderators for the technology acceptance of PBUI based products

5. Findings

5.1. Findings of the user test

The initial impressions of participants on the product were as follows: "I have never seen a user-interface on the hob like this before. It is very innovative", "Sometimes it's hard to cook in the kitchen. I think I can cook more easily if this product is commercially available. I'm pleased I had the opportunity to try such a product", "I like to see the status of the hob and dishwasher on my VUX paired phone".

All participants attempted to obtain information at the start of the user test by first selecting the "Info" icon in an effort to better comprehend the system and the user-interface they were using for the first time.

Although some of the operational failures were related to the fact that the product was a functional prototype, participants' impressions about their experience were positive. The child camera feature was defined as "favorite feature" by most of the participants. The first impression of a participant who was a parent as well who saw the camera at first glance was as follows: "My wife will love this product just because of the child camera feature."

Although the product is operating based on gesture recognition; some participants thought the system was operating based on touch-screen technology. As a result, they said that the surface on which VUX is projected will need a special liquid for cleaning purposes. They also stressed that, with the exception of one participant, they would prefer to use the user-interface through touch since the physical contact it provides makes them feel safer, even though the controls could be engaged without touching. On the other hand, it would be useful if the counter is unclean for those who wished to utilize it without touching it.

In terms of visual appeal, participants found the user-interface quite "stylish". Participants also appreciated aspects like the hob's ability to set the time, the dishwasher's ability to show how to wash dishes, and the user interface's interchangeability for child safety. Positive and negative appraisals by the participants are shown in Table 2.

Concerning the total task completion times, the longest time for the participants to complete the tasks is 19.03 min., the shortest time was 11.29 min. and an average of 14.7 minutes. The success levels of the participants in user tests were recorded in a standard observation form.

Also, it was discovered that the prominent usage problems generally focused on the understandability of the icons as user-interface control elements. The majority of these problems were encountered during learning the interaction typology, and it was noted that as the test progressed, fewer issues were encountered.

Problems that are observed during the user test, problem frequency (PF), problem severity rating (PSR) and the interpretation of usability problems are shown in Table 3. Problem frequency has been calculated based on how many participants faced the same problem. A problem that is faced by 1-10 participants were defined as a "low frequency problem", a problem that is faced by 11-20 participants were defined as a "high frequency problem" and a problem that is faced by 21-30 participants were defined as a "very high frequency problem". These usability problems are grouped into 9 usability problem types based on the similarity of the problem observed. 5 types of usability problems were the most frequent occurring problems as follows: operation technique cannot be understood by the user, the button is not properly designed, the buttons are located very closely, the technology of the user-interface is not clearly understood, the user-interface is not properly organized. On the other hand, 3 usability problems cause low frequency rates during the user-test: the warning is not properly designed, hob color (warning) is not properly

Table 2. *Users' positive and negative appraisals about the features of VUX.*

Positive Appraisals	Negative Appraisals
- Easy to use. - No physical buttons. This makes it easy to clean. - Timer and baby cameras such as extra features - Innovative - Multi-product control can be provided from selected area - Hob automatically senses pots. - Ability to use the hob with pots in different sizes - Ability to change the location of the control user-interfaces	- Slow response/feedback - Some of the icons are not understood - Excessive function, unnecessary function - Large design, requires large space - Perception that it will be expensive - Time setting indicator is small. - Menu positioning can be accidentally changed - Proximity of hob to dishwasher

Table 3. *Usability problems of VUX.*

PC	USABILITY PROBLEMS DETECTED	PF	PSR	INTERPRETATION OF THE PROBLEM
1	The on/off button of the hood and the on/off button of the VUX system is confused	High	2	The button is not properly designed
2	The function of VUX navigation button cannot be interpreted by the user	Very high	2	The button is not properly designed
3	The VUX user-interface is perceived as a touch-operated control panel	Very high	1	The technology of the user-interface is not clearly understood
4	The user cannot find the setup function menu	High	1	The button is not properly designed
5	The user accidentally activates the child lock button instead of the child camera button and locks the system.	Very high	3	The buttons are located very closely
6	The child lock button is confused with the child camera button	High	2	The buttons is not properly designed
7	The activation of setup function button cannot be interpreted by the user	Very high	2	Operation technique cannot be understood by the user
8	The user cannot make the correct selection of functions	Low	3	The buttons are located very closely
9	Accidental activation of the auto mode	Low	2	The button is not properly designed
10	Flashing system on/off button cannot be interpreted by the user	Low	3	The button is not properly designed
11	The limits of the heating areas on the hob are not properly perceived	High	1	İnnovative forms cannot be easily understood
12	The case that hob buttons are separately grouped together creates confusion in users mind	Very high	3	The user-interface is not properly organized
13	(-) and (+) icons on the hob are to small to use	High	2	The button is not properly designed
14	The flashing light at the end of timer cannot be understood	Low	3	The warning is not properly designed.
15	The flashing light that indicates the correct placement of pans etc on the hob cannot be interpreted by the user	low	2	The warning is not properly designed.
16	The warning that signals the over heated hob surface cannot be interpreted	Low	3	The warning is not properly designed.
17	"Over heated surface" disappear as the system is turned off	Low	3	Hob color (warning) is not properly designed
18	Accidental activation of the dishwasher	Very high	3	The buttons are located very closely
19	The user fails to exit from the device function menu	Low	2	There is no separate exit button
20	The user cannot the correct button to stop the dishwasher	Very high	3	The button is not properly designed

a) Navigation Icon b) Hob control icon c) Selected hob icon

Figure 5. *Examples of similarity of the icons causing a confusion on participants.*

designed, and there is no separate exit button.

Table 3 shows that the design of the user-interface elements individually as well as the general organization of the user-interface and operation principles have strong roles on the usability of the PBUI. Participants' expectations for performance and effort have an impact on how usable they feel. Some users have also noted problems that may result from technology of the product. Most of these problems were based on basic visual qualities related to product's legibility and understandability. These basic visual qualities were visibility, brightness, and contrast etc. These problems also may have an important role on the usability of the product.

Instead of taking the quickest route, the users in the scenarios followed alternative steps to get at the aimed objectives. These informal operational sequences that are not part of planned design may constitute a basis to increase the product's usage and its acceptance. For example; when a participant was requested to turn off the whole system, he/she first turned off the hob and later turned off the whole system. However, the shortest action was to turn off the whole system without turning off the components. Features like icon alert control and timing adjustment are included in the third and fourth scenarios' steps, which some customers have never used before. In these situations, the participant was questioned about how to perform the desired task. Due to their failure to complete the assigned work, several users were hesitant to follow this scenario.

The majority of participants misunderstood what the navigation icon meant (P2). Some even describe this symbol as the icon that activates the selection function for the hob to be used or as an icon connected to the hob control. An example of the similarity of the icons causing a confusion on participants is shown in Figure 5.

Different gestures such as, holding and dragging the menu, touching two different icons at the same time, and tapping and releasing the navigation icon, were observed during tasks based on rearranging the menu. As the user-test progressed, participants become more adapted to the meanings of the icons (P7). Also, participants felt it was not easy to access the system configuration menu. Some participants attempted to activate the setup menu by touching the info icon on the user-interface. After at least three attempts, it has been figured out how to open the settings menu by simultaneously touching two separate icons. Some participants entered the settings menu and unintentionally turned on the child lock.

When compared with other devices the number of problems resulting from tasks based on the hood were lower. In order to predict how to use the PBUI participants tried to make an analogy with touch screen technology that they are familiar with in their daily lives. Few participants attempted to use the PBUI's projection feature, in other words operating the user-interface without physically touching the surface. They quickly became familiar with the slider tool on the hob user-interface because they are used to using it on phones or tablet computers like the Apple iPad every day. Due to the close proximity of the power adjustment slider and the hood menu icon, issues with accidental power setting changes and on/off switching have been noted.

Problems based on visibility of the icons concerning the dishwasher programs and interpretation of the functions have been observed during the user-test. The majority of the participants accidentally activated the "run" icon and the "function" icon because of the closeness of both icons. Additionally, some participants were unable to finish the stop and cancel activities. Vertical positioning the menu, in other words projecting the menu on the surface vertically, caused problems of confusion in reading and visual discrimination of menu icons because of limited projection space (P19).

5.2. Findings of the Survey

As a result of the questionnaire, the relationship between user-interface features and product acceptance was confirmed and during the evaluation process, prominent determiners and moderators were determined. According to the UTAUT model, 32 questions were divided into 9 sections. The section with the highest average score out of 5 points was attitude toward use with 3,975, and the section with the lowest average score was social impact with 2,9. The average scores of the other sections are as follows; effort expectancy with 3,733, self-efficacy with 3,721, behavioral intention to use with 3,666; facilitating conditions with 3,566, performance expectancy with 3,502, user-interface features with 3,475, anxiety with 3,01.

The results of regression analysis on user-interface features and other variables with moderators are given in Table 4. First regression results show a significant correlation between user interface features and expected effort of 27%. Other variables do not have a statistically significant influence, but might be mentioned as follows: 2% between user-interface and anxiety, 0.7% between user-interface and performance expectation, and 0.6% between user-interface characteristics and self-efficacy. In addition, user-interface had no significant effect on anxiety, self-efficacy, or performance expectations.

Table 4. *Results of regression analysis.*

Dependent Variables	Independent Variables + Moderators	Beta	R^2
Performance Expectancy	Interface Features	,083	,007
Effort Expectancy	Interface Features	,523	,273
Anxiety	Interface Features	,147	,022
Self Efficacy	Interface Features	(-),079	,006
Attitude toward use	Performance Expectancy	,271	,194
	Effort Expectancy	,208	
	Anxiety	(-),082	
	Self Efficacy	(-),135	
	Social Influence	(-),054	
	Facilitating Conditions	,296	
	Age	(-),071	
	Gender	(-),093	
	Experience	(-),249	
Behavioral intention to use	Performance Expectancy	(-),049	,603
	Effort Expectancy	,191	
	Anxiety	,417	
	Self Efficacy	(-),175	
	Facilitating Conditions	,252	
	Experience	(-),582	
	Age	(-),286	
	Gender	,026	
	Attitude toward use	,326	
Behavioral intention to use	Age	(-),297	,685
	Experience	(-),516	
	Attitude toward use	,495	
	Anxiety	(-),462	
Behavioral intention to use	**Experience**	**(-),482**	
	Attitude toward use	**,531**	,603
	Anxiety	**(-),368**	

Correlation is significant at the 0.05 level (2-tailed)

Second regression revealed that independent factors (performance expectation, effort expectation, facilitating conditions, anxiety, social influence, self-efficacy) and moderators (age, gender, experience) have no significant effect on attitude toward the usage of a PBUI. This finding suggests that attitude toward use might be considered an independent variable in the proposed model.

In the last part of the regression analysis, the researchers performed multiple regressions to explore the relation between determiners and moderators on behavioral intention to use. According to Table 4, the attitude toward use as has the highest influence on the behavioral intention to use. Functions of the PBUI have positive effects on attitude. Anxiety and experience also noteworthy effects on behavioral intention. This study's research model predicted that anxiety would have a negative effect on behavioral intent. Although the original UTAUT model eliminates anxiety components, both questionnaire findings and participant comments match the study model's predictions for the kitchen scenario.

The original UTAUT model suggests that determinants have a strong effect on behavioral intention to use. According to the findings of our second regression analysis it can be claimed that the original UTAUT determinants' impact on the behavioral intention to use a new technology is negligible. Although most of the users

Table 5. *Themes, codes and categories used in the content analysis.*

Theme	Participants' Verbal Expressions	Codes	Categories
Concerns about kitchen experience	*"My wife is better at cooking than I am. She chooses the products to be taken into the kitchen. "*	my wife	Social influence
	"The gas stove feels like it heats better and faster."	faster	Performance expectancy
	"My product at home is easy to use"	easy to use	Effort expectancy
	"My electric hob works very simply, I would choose it again"	simple, choose	Effort expectancy, Behavioral intention to use
	"It is difficult to find recipes. This can slow me down."	difficult, slow	Effort expectancy, Performance expectancy
	"I live with my cat. Considering that, I buy products that are not scratched."	cat	Social influence
	"My house is narrow, I cannot buy large items. If my house was bigger, I would like to have a dishwasher.	would like	Behavioral intention to use
	"My hob is very old. I don't like grills and knobs at all."	don't like, grill, knob	Attitude, Interface features
	"My hood is very old and sounds loud. That's why I don't use it."	loud, don't use	Performance expectancy, Behavioral intention to use
Concerns about VUX before the user test	*"It's nice that the functions don't appear at first glance."*	the functions don't appear	Interface features
	"Is it difficult to press the interface?"	difficult	Effort expectancy
	"Is it a product that you get used to when you use it?	get used to	Effort expectancy
	"I am very excited to use this product."	excited	Attitude
	"I feel like it's a complex product."	complex	Effort expectancy
	"Is there a child lock feature? My wife wants to buy this product just for this feature."	my wife	Social influence
	"I am familiar with computer programs. Will I be able to use this easily?	familiar, easily	Self-efficacy, Effort expectancy
	"Is the system detection slow or fast?"	slow or fast	Performance expectancy
	"Are we going to have fun?"	have fun	Attitude
Concerns about VUX' s usability after user test	*"Although it is a product that I am not familiar with, I think I used it easily."*	easily	Effort expectancy
	"I am not sure if the product is safe for cooking."	safe	Anxiety
	"I would like to run the product I want with a voice command."	voice command	Interface features
	"Using this interface in a restricted area is useful."	useful	Performance expectancy
	"The voice control feature can provide ease of command and enable even a child to use this product."	voice control, ease of command	Interface features, Effort expectancy
	"I wasn't sure if I should long touch the interface during use or just press it once."	wasn't sure, long touch,	Anxiety, Interface features
	"I prefer VUX after the technology has improved a bit."	prefer	Behavioral intention
	"I need to learn to use this product."	learn	Self-efficacy
	"The product is running slowly."	slowly	Performance expectancy
	"Gesture control feature can be added."	gesture control	Interface features
	"Doesn't seem to save time."	save time	Performance expectancy
	"Especially for the elderly, the interface brightness is a challenge for vision."	brightness, challenge	Interface features, Effort expectancy

said that the PBUI would improve their performance in the kitchen with minimum effort, the survey results presented a different data. In contrast to the original UTAUT model, performance expectation was found to have no significant effect on behavioral intention. As an evaluation of answers to open ended questions, it is stated that participants made much more comments on performance and effort expectancy compared to other moderators.

Our findings show that the social effect associated with performance expectation may not have a significant effect on behavioral intention. The original UTAUT model's proposal was refuted by both the survey results and the participants' comments. According to the original UTAUT, facilitating conditions have an effective role in product acceptance. It was found that the facilitating conditions were not significantly related to the behavioral intention to use by both the survey results and the comments of the participants. The majority of novice participants did not require additional instruction and reported that the PBUI was simple to use.

The findings of our survey supports the assumptions of the original UTAUT model in term of importance degree of self-efficacy. It was observed that the participants' self-efficacy did not affect the behavioral intention to use. It is observed by the authors that younger participants showed a higher degree of self-efficacy performance in user tests than older participants. The original UTAUT model suggested that age and gender had a significant influence on behavioral intention to use.

However, our questionnaire results contrasted with the suggestions of the original model in the context of PBUI. Female participants have more behavioral intentions to use and found the PBUI more usable.

Three main themes, their codes and categories were identified to conduct the content analysis of verbal data. These themes are concerns about kitchen experience (21 codes), concerns about VUX before the user test (20 codes) and concerns about VUX's usability after user test (30 codes). Examples from the content analysis data are shown in Table 5. The codes that resulted from verbal expressions of the participants have been categorized in categories that are UTAUT factors.

The content analysis of the verbal data revealed that male participants were more focused on the advantages of using a usable product, as they were more result-oriented and more easily adapted to new technologies; whereas female participants were more affected by social influences in other words can be more easily affected by other users. Performance expectancy was a more significant determiner for male participants whereas effort expectancy and social influence were more dominant determiners for female participants. On the other hand, in real-life situations, some external factors may affect users' willingness to use. For example; people living in rental houses may not be able to change the kitchen layout without the owner's knowledge or relocate the fixed products in the house. Another factor is the size of the kitchen. The dimensions of the area are important in the selection of the products to be purchased. Therefore, there may be users who do not wish to utilize an unsuitable product. Thus, the UTAUT model was not adequately validated, and the original UTAUT model does not accurately depict product acceptability in the kitchen setting with the selected factors. Summary of findings are shown separately in Table 6. Validated hypotheses are H2, H6, H7, H8 and H9.

Participants chose from 18 different given keywords to describe the PBUI in the last part of the questionnaire,

Table 6. *Summary of findings.*

Hypothesis	Dependent Variables	Independent Variables	Moderators	Explaination
H1	Performance expectancy	Interface features	None	Nonsignificant effect
H2	Effort expectancy	Interface features	None	Strong effect
H3	Anxiety	Interface features	None	Nonsignificant effect
H4	Self efficacy	Interface features	None	Nonsignificant effect
H5	Attitude toward using technology	Performance expectancy, effort expectancy,anxiety, self efficacy, social influence,facilitating conditions	Age,Gender, Experience	Nonsignificant effect
H6	Behavioral intention to use	Performance expectancy, effort expectancy,anxiety, self efficacy, social influence,facilitating conditions	Age,Gender, Experience	Anxiety,experience,age and attitude toward using technology affect strongly.Age has no significant effect.
H7	Behavioral intention to use	Anxiety,attitude toward using technology	Age,experie nce	Anxiety,experience and attitude toward using technology effect strongly. Age has no significant effect.
H8	Behavioral intention to use	Anxiety,attitude toward using technology	Experience	Attitude has the strongest effect on behavioral intention to use. Experience and anxiety have a stronger effect.
H9	Behavioral intention to use	Usability	None	Usability has a significant effect on behavioral intention to use

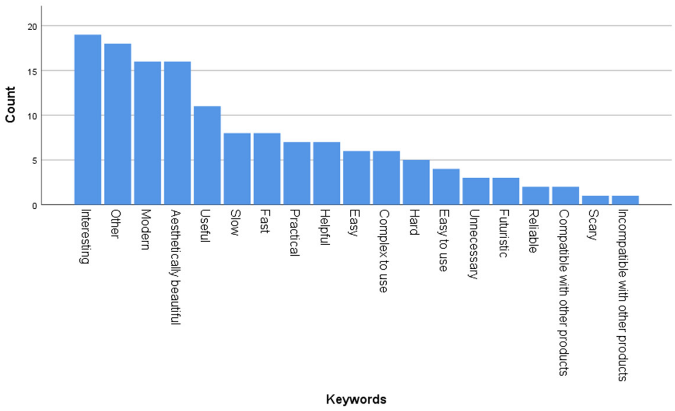

Figure 6. *Keywords selected by participants.*

and 1 "other" section that they could write additional keywords shown in Figure 6. Positive keywords were chosen more. Most selected ones are; interesting (with 13,3%), modern (with 11,2%), aesthetically beautiful (with 11,2%) and useful (with 7,7%). Also, fast (with 5,6%), practical (with 4,9%), and helpful (with 4,9%) are noteworthy. On the other hand, most selected negative keywords are; slow (with 5,6%), complex to use (with 4,2%), hard (with 3,5%), unnecessary (with 2,1%). Some keywords like; beautiful in terms of space saving, aesthetically improvable, insecure, technological, neither complicated nor simple to use, debatable necessity, a digital product, has many options, hygienic, surprising, unknown, not practical, different size, innovative were related to product features written under other section.

5.3. Discussion

This study provided valuable findings about factors which have a role in the acceptance of a product system to be used in the kitchen environment, which can be controlled from the PBUI, by using methodology based on user tests and surveys. The findings of the user-test have been used as a source to explore the usability problems and to enhance the PBUI designs. The findings of the survey provided a base to understand the relationship between UTAUT and PBUI.

Based on our findings, it can be argued that different variables can affect a product's acceptance. According to the results of the content analysis, the majority of participants' comments concern performance and effort expectations. Prior to using the product, they expressed their concerns regarding their attitude toward its use and their interface expectations. Additionally, according to the findings of the content analysis, social influence can be considered an effective factor in user preferences for kitchen products.

Negative thoughts and concerns influence the behavioral intention of participants. The results of the questionnaire showed that the user-interface design elements can affect users' effort expectancies.

Although participants noted that using the PBUI would improve the user performance, the results of the survey showed that, unlike the original UTAUT model, the expectations in performance issues do not have a significant impact on intended use. In other words, it can be said that the user's performance may not have a significant effect on the behavioral intention.

According to the questionnaire results we can argue that anxiety has a meaningful effect on behavioral intention to use the new product in the kitchen.

In contrast to the model of Venkatesh et al. (2003), reliability and safety issues are crucial and strongly related to anxiety. In the UTAUT model, facilitating conditions were considered as a direct determiner for usage. In addition, the model of Venkatesh et al. (2003) did not include attitudes toward technology use, but this study showed that it can be a determiner of technology acceptance.

In the previous technology acceptance models, TRA, TPB, and TAM, attitude was identified as one of the determinants of behavioral intention In parallel with the recommended UTAUT model, the results of the questionnaire supports the majority of the correlation between product acceptance in the kitchen and attitude toward using technology, anxiety, and experience. On the other hand, we can argue that the primary UTAUT determinants may have no meaningful effect on attitudes toward using a kitchen system with a PBUI. Anxiety and self-efficacy were not integrated in the UTAUT model of Venkatesh et al. (2003). Also, age, gender, experience, and voluntariness were moderators in their model. While the proposed model did not include the voluntariness variable, it was discovered that only experience had a significant impact on behavioral intention to use the PBUI kitchen system. Less anxiety and effort were observed by experienced users.

Young tech savvy users had more difficulty performing tasks than inexperienced users as well as older users. The reason for this may be that young people are used to the user-interface of touch screen technology-based devices such as smartphones and tablets, so they move quickly and want to get quick results. They expected that the system learning time and system feedback time to be fast. In addition, elderly and inexperienced users were more willing to learn how to use the product by reading the warnings next to the icons. The effect of age and experience factors were observed in the relationship between learnability and technology acceptance.

This study shows that there can be a relation between usability and behavioral intention to use and we can predict that improved usability can result with an increased technology acceptance and use. In terms of user-interface qualities, we found some positive features such as; child camera, time setting function, the visual representation of the dishwasher's current state, the ability to change the location of user-interface (vertical or horizontal), child lock, and having no tangible buttons. On the other hand, slow response, incomprehensible icon design and unnecessary functions were features that negatively affected PBUI's technology acceptance. Also, our findings showed that visual aesthetic qualities can play a strong role in the system usability as well as the technology acceptance of the system.

On the other hand, this study had some important limitations. The first limitation was the difficulty to transport the VUX system in order to test it with real potential users. Because of this technical limitation the study was conducted in Arçelik Çayırova Campus where the product was located and installed. The second limitation was the difficulty of inviting and carrying real users to Arçelik Çayırova Campus due to its location. Therefore, the participants have been Arçelik employees instead of real potential users. The number of participants is the third limitation of the study. As a result of the first two limitations stated above, the size of the sample was limited to 30 participants. Accordingly, increasing the number of participants may result in other usability problems and their effects of technology acceptance. Also methodologically the product is only tested in one session with participants. Therefore, learnability and experienced user-performance could not be measured and evaluated.

6. Conclusion

Concerning the research questions indicated in the Introduction Section; this section presents the results and the conclusions based on the research question.

Research question 1: Which factors of UTAUT influence the user acceptance of PBUI systems?

The most significant factors of UTAUT that influence the user acceptance of a PBUI are experience, attitude and anxiety. Performance expectancy and effort expectancy can be considered as the secondary UTAUT factors that influence the user acceptance of a PBUI system.

Research question 2: What effect do PBUI features have on kitchen product acceptance?

Although the usability and user-interface characteristics were the focus of this study, it was seen that they had no direct effect on behavioral intention to use in PBUI kitchen systems. The results of the survey showed that, the characteristics of the user interface as well as its usability are related to the anticipated level of effort.

The results of the study showed that the design quality of user-interface element as well as the vertical/horizontal arrangement feature may have an important impact on the effective, efficient and satisfactory use of a user-interface based on a new technology. However, it was discovered that the effect of the quality of the user-interface on its technology acceptance is minimal. On the other hand, we must emphasize that each individual component of the user-interface must be able to convey the correct message to the user when the needs for the healthy operation of the system.

Research question 3: What is the role of usability on the technology acceptance of PBUI kitchen systems?

As this study tried to explore the relation between technology acceptance and usability of a user-interface our findings suggest that efficiency and effort may be more important in smart kitchen systems for the acceptance of the technology.

Consumers will buy products with the expectation of satisfaction related to their technology and aesthetic in the kitchen context. A system must perform its main function while providing sufficient information support to its users. The findings of this study clearly showed that when using a system with a PBUI, the user may have expectations that the product to be consistent, compact, sequential, and logical. The control of 3 different products, which are part of a system, from the same user-interface has led users to find the use of this system efficient.

Based on our findings, the fact that our proposed model is insufficient to explain the acceptance of PBUI systems designed for the kitchen context is an important result. This study's model can be utilized in future research to investigate the technological acceptability of other products as well as the factors that have the greatest influence on acceptability. In addition, new technology acceptance models can be developed by changing the factors of the UTAUT model chosen to be used in this study. Based on the UTAUT model, we did not focus on a particular acceptance variable and instead explored all possible factors that may have an effect.

Most of the participants' comments were about the prototype, which was an uncommercialized version of the product. Therefore, after the product becomes commercially available a similar study can be conducted and the results can be compared. In the near future, PBUIs used in the kitchen can be converted from two-dimensional to three-dimensional user interfaces. Holograms could be new interfaces in the kitchen to help users control their products. Both tangibles and virtual user-interfaces can be used together for interface control, as user preferences may change.

Acknowledgement
This paper is based on the research conducted for the Master's Thesis (MSc) study of one of the authors at Istanbul Technical University Graduate School. The authors would also like to thank to Arçelik AŞ for their support to this study. This paper and the research behind it would not have been possible without their help and permission for the utilization of VUX as the product of this study.

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