EXPANDED EVALUATION SYSTEM FOR DESIGN GUIDELINES OF UNIVERSAL SMART KITCHEN

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ABSTRACT:

This study is to develop an evaluation system for kitchen before making design guidelines of universal smart kitchen (USK). For this study, first, basic requirements to be considered to develop USK, such as 'universal design,' 'good design,' and 'kitchen' were investigated and evaluation criteria for USK were deduced. Each criterion is divided into 5 sub criteria. For example, the criterion of 'universal design' consists of 'equitable use', 'flexibility in use', 'intuitive use', 'accessibility' and 'safety'. Then, by using the evaluation criteria, we assessed four kitchens designed in Korea, America and Japan. A newly developed evaluation system (combining universal design, good design, technology and item: UGTI) is expected to be useful in assessing any item other than kitchen by replacing the layer of item.

Keyword: universal smart kitchen, evaluation system, UGTI

1. INTRODUCTTION

1.1. OBJECTIVES

Today's kitchen is being recognized as an important place for family gathering as well as for cooking. Although kitchen design has been improved to meet the increase of importance, existing kitchens still have problems to be addressed. One of them is that many kitchens are still being developed without considering the characteristics of a variety of users including the elderly, the disabled and children etc. Considering the situation, universal kitchens were designed and developed, but some of them have been pointed out to have problems to be commercialized since their appearances are not appealing to users. They were also blamed for only focusing on physical aspects such as accessibility to kitchen counter and adjusting counter height etc. without considering the possibilities of applying advanced technology to enhance the convenience of kitchen use.

In this regard, a kitchen should be designed not only with universal design concept but also with good design aspect. Making technologies applied in a kitchen user-friendly is also important in the age of rapidly developing technology.

This study is to develop an evaluation system for kitchen combining the elements of universal design, good design, technology, and kitchen and to identify the usefulness of the evaluation system by assessing four kitchens developed with new technologies. Results of the assessment can be used to suggest design guidelines for smart kitchen.

1.2. METHODS

For this study, first, evaluation criteria for USK, such as 'universal design', 'good design', 'technology' and 'kitchen' were investigated through literature study. Second, four kitchens where advanced technologies had been applied into them were selected. Then, they were assessed by an evaluation system for USK which were developed by us to examine whether a design is properly created in the above four evaluation criteria. Each criterion is divided into 5 sub criteria. For example, in the criteria of 'universal design', 'equitable use', 'flexibility in use', 'intuitive use', 'accessibility' and 'safety' are included. Lastly, result of the evaluation has been discussed.

2. ELEMENTS OF SMART KITCHEN

2.1. SMART KITCHEN

Significant changes are taking place in today's kitchen. One major change is kitchen is becoming smarter. Smart kitchen is basically kitchen which helps users carry out kitchen work conveniently with the support of advanced technology. Though the basic concept is simple, the applications of the concept are varied to companies.

In some smart kitchens, appliances such as the microwave, refrigerator and dishwasher are networked to easy-to-use computer hardware and software. Although the primary purpose of these smart kitchens are food preparation, they also make the consumer enable to perform various tasks, including monitoring food inventory, shopping grocery online, and obtaining online information about weather and road conditions, sending messages via the internet, and so on.

Another important feature of smart kitchen is its new role as an entertainment tool. For example, an internet refrigerator has an in-built computer, which can be accessed via monitor on the fridge door. Users can watch TV, listen to MP3 music, take and store digital photos, make a video phone-call and use the fridge as a digital message board.

And there is a kitchen of the future which puts a focus on environmentally friendly products to reduce pollution and increase efficiency while lowering operating costs. The kitchen provides clean water purified via ultraviolet, assuring that the water is free of bacteria without chemicals. Consumers will load the dishwater with detergent in bulk and it will be dispensed via algorithms to minimize the cleaning agents in wastewater.

2.2. DESIGN ELEMENTS OF SMART KITCHEN

There are many design elements to be considered to develop smart kitchens. Of the elements, understanding kitchen itself and technologies needed to make kitchen smart is very important. Also, universal design requiring a kitchen to be usable by as many people as possible regardless of their age or their physical characteristics is also a key element. In addition, good design which is most generally accepted standard to assess a design is also a major element to be considered to design smart kitchen.
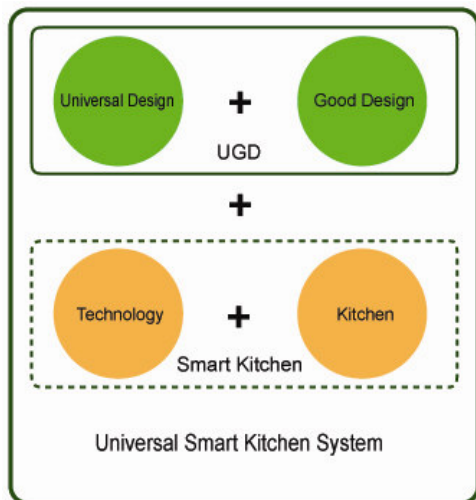
Figure 1: Design elements of smart kitchen

2.2.1. EVALUATION CRITERIA OF UNIVERSAL DESIGN

Universal design, which is related to 'inclusive design' and 'design for all', is an approach to the design of products, services and environments to be usable by as many people as possible regardless of age, ability or circumstances. It links directly to the political concept of an inclusive society and its importance has been recognized by governments, business and industry. Universal design specialists such as Ronald Mace established the 7 Principles of Universal Design to guide a wide range of design disciplines including environments, products, and communications.

Table 1: Universal design principles

The 7 Principles of UD by Ronald Mace etc.	The 4 Principles of UD by Roberta L. Null
- Equitable use	- Supportive
- Flexibility in use	- Adaptable
- Simple and intuitive use	- Accessible
- Perceptible information	- Safety oriented
- Tolerance for error	
- Low physical effort	
- Size and space for approach and use	

Roberta L. Null posited that the above four underlying principles to be considered essential for creating a universal design (Roberta L. Null and Kenneth F. Cherry 1996). She insisted following four interrelated aspects of a design provide useful standards for the measurement and evaluation of new and existing products and environments.(Table 1) After analyzing both principles of universal design made by Ronald Mace and Roberta L. Null respectively, we have made following five evaluation criteria for universal design. (Table 2)

Table 2: Evaluation criteria of universal design

Criteria	Contents
Equitable in use	The design is useful and marketable to people with diverse abilities.
Flexibility in use	The design accommodates a wide range of individual preferences and abilities.
Intuitive use	Use of the design is easy to understand, regardless of the user's experience, knowledge, language skills, or current concentration level.
Accessibility	The design removes barriers in both physical and attitudinal to use it.
Safety	Thoughtful consideration is given to the design so that users do not hurt by an accident. The design minimizes hazards and the adverse consequences of accidental or unintended actions.

2.2.2. EVALUATION CRITERIA OF GOOD DESIGN

The principles of universal design are not intended to constitute all criteria for good design, only for universally usable design. Certainly, other factors are important, such as aesthetics, cost, safety, gender and cultural appropriateness, and these aspects must also be taken into consideration when designing (The Center for Universal Design 2007). Good design is an important issue in current discussions of products and environment designs in general. The explosive development of products and environments has raised the issue of good design. Many of these designs are highly effective, but a significant number fail to meet the expectations of consumers or satisfy the needs of business. As competition intensifies, we wonder if there are criteria to guide the development of new designs.

According to KIDP (Korea Institute for Design Promotion), which manage and control Korea's 'Good Design Award ', good design assessment criteria consist of required criteria and

comprehensive criteria (Korea Institute for Design Promotion 2007). In the required criteria which accounts for 80 points out of 100, aesthetics, dignity, originality, safety, convenience, quality, environmental friendliness and value for money are included.

According to the evaluation criteria of 'Japan Good Design Award' (Japan Industrial Design Promotion Organization, 2007), basic requirements for good design products or facilities are as follows:

1) Aesthetically superior

2) Designed with safety in mind

3) Sincere

4) Designed to fit the usage environment where it's used

5) Original

6) Meets the need of consumers

7) A good value for the price

8) Offers good functionality and performance

9) User-friendly

10) Attractive

After analyzing the evaluation criteria of good design both in Korea and Japan, we have made following 5 requirements for good design.

Table 3: Evaluation criteria of good design

Criteria	Contents
Originality	The capacity to make a design in a creative and individual manner.
Aesthetics	The appreciation of a beautiful or pleasing appearance of a design
Functionality	The capability to serve the purpose for which it was designed.
Quality	A degree of excellence which makes a design special or noticeable.
Marketability	Character with respect to the appropriateness of a design to be offered for sale in a market.

2.2.2. EVALUATION CRITERIA OF TECHNOLOGY

A variety of technology should be applied to make a kitchen smart. After analyzing new technologies which were incorporated into current kitchens in the world, we have selected 5 of them such as network technology, interaction technology, intelligent technology, cooking technology and ecology which make a kitchen smart.

Network technology is in which computer functions are integrated into everyday life, often in an invisible way. Network technology enables users to download recipes from the Web into an optional cooking data box that is able to transfer the information into a kitchen product such as microwave oven.

Interaction technology defines the behavior of an artifact or system in response to its users over time. Interaction technology aims to increase the accuracy and efficiency of task completion, without diminishing the value of a product's useful functionality. By using interactive technology, for example, users ask the kitchen what it is preparing for dinner and the kitchen will offer a list of foods available and menu possibilities.

Intelligent technology is one which utilizes digital and sensor technology. Smart kitchen with intelligent technology has equipments which have microprocessors and complex circuitry that allow it to remember how to perform certain operations, to track cooking and holding temperatures, and to know when serving is needed to prevent a breakdown.

Cooking technology relates to cooking food deliciously and rapidly to meet the busy daily life of kitchen users. For example, microwave oven using cooking technology allows it to cook a variety of food in accordance with user's taste and an oven using the technology allows it to cook much faster than a conventional oven.

Ecology is also an important requirement in smart kitchen because environmentally friendly products reduce pollution and increase efficiency while lowering operating cost. Recycling of kitchen generated wastes to conserve resources and cut down on the accumulation of solid waste are also important issues to be dealt with to make a kitchen smart. Some company envisions that in the future, gray (waste) water can be diverted for other home and garden applications (GE 2007).

Table 4: Evaluation criteria of technology

Criteria	Contents
Network technology	Network technology is in which computer functions are integrated into everyday life, often in an invisible way.
Interactive technology	By using interactive technology in smart kitchen, users ask the kitchen what it is preparing for dinner and the kitchen will offer a list of foods available and menu possibilities.
Intelligent technology	A household controlled by intelligent technology might have refrigerator that keep track of how much milk is in stock and automatically order more through internet and programmed ovens that know the appropriate cooking time and cycles for restaurant's specialties.
Cooking technology	Cooking technology can be used to cook food faster without losing quality of food.
Ecology	The feature of environment friendliness which reduces pollution and increases efficiency while lowering operating costs.

2.2.4. EVALUATION CRITERIA OF KITCHEN SYSTEM

In order to design a kitchen system, we have to understand kitchen system itself. After analyzing the process of kitchen work and activities in the kitchen, we have drawn 5 requirements to be considered to design smart kitchen such as 'storage', 'preparation/cooking', 'dining', 'information/entertainment' and 'clean up'. In the requirements, the inclusion of 'information' and 'entertainment' reflect changed role of kitchen and lifestyle of users.

Kitchen work starts from storing food materials. Therefore sufficient storage space and good accessibility to cabinetry is one of the most important requirements for kitchen system. Storages such as upper cabinet and lower cabinet are usually the most dominant feature and their usability considerably affects the convenience of kitchen use. Cabinetry can also dominate a kitchen design budget: It generally represents between 25 and 50 percent of a kitchen's total cost (Donald E. Silvers 1994).

The second process of kitchen work is preparation and cooking. Kitchen elements related to this process are kitchen counter, cook top, range and microwave oven etc. Like inadequate counter space forces a cook to work vertically rather than horizontally, a poorly designed cook top will

make you to do kitchen works in the same way. Because this process is so all-encompassing in kitchen work, it deserves as much care and planning as any other aspect of good kitchen design.

Table 5: Evaluation criteria of kitchen system

Criteria	Contents
Storage	The design has enough space to store food materials and kitchen appliances and can be easily reached by users.
Preparation /cooking	The counter space is enough to prepare food and the cook top is convenient for cooking.
Dining	Kitchen products such as kitchen table are appropriate for dining.
Information /entertainment	The design enables users to process information by using kitchen products such as refrigerator and provides them with entertaining features.
Clean-up	The kitchen design is good for clearing garbage etc.

The third stage of kitchen work is dining. In this stage, for example the appropriateness of kitchen table for dining can be taken into consideration.

Among changes related to today's kitchen, another apparent change is that it enables users to process information by using kitchen products such as refrigerator. Also, functions related to entertainment are becoming increasingly important reflecting new role of the kitchen as an entertainment area. Reflecting this tendency, a company has developed a smart refrigerator, through which users can watch TV, listen to MP3 music, take and store digital photos, use the fridge as a digital message board, or surf the web.

Evaluation criteria for clean up assess whether things related to cleaning dishes and disposing food garbage etc. are good or not.

3. EXPANDED EVALUATION SYSTEM

As mentioned before, we have selected 5 requirements for each evaluation criteria such as universal design, good design, technology, and kitchen. We have made all the 20 requirements

are exclusive to the others, so evaluators using the evaluation system do not have to repeat evaluations with the same evaluation item. Figure 2 shows the structure of an evaluation system combining universal design, good design, technology and item (UGTI), which is to be used to assess USK. The evaluation system consisting of 4 layers (universal design, good design, technology and item) can be used for any item other than kitchen. Replacing a layer or layers by another layer or layers, enables a variety of evaluations.
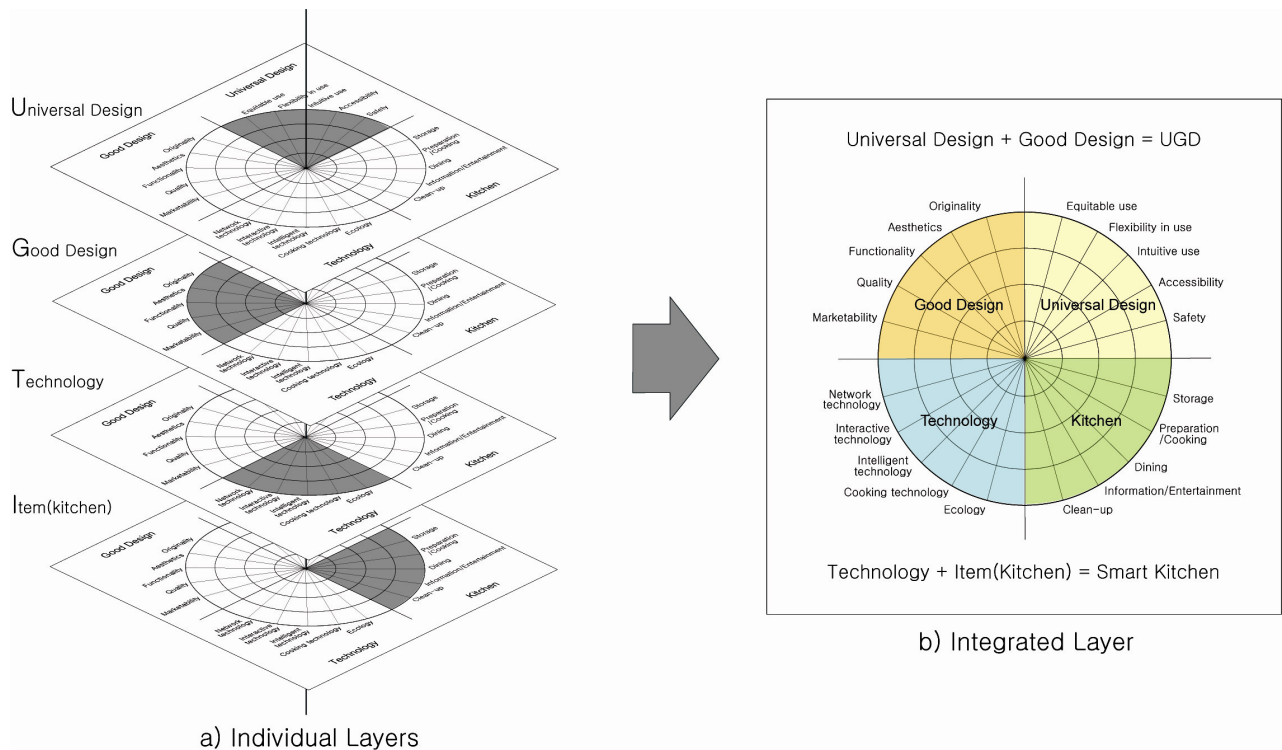

a) Individual Layers

b) Integrated Layer

Figure 2: The structure of an evaluation system combining universal design, good design, technology and item (UGTI)

4. EVALUATION OF KITCHENS

4.1. EVALUATION BY UGTI

For evaluation, first we collected the cases of kitchens which had been developed with new technologies in Korea, USA and Japan, then selected four kitchens from them. They are; 'U-Style designed by Samsung and displayed in a model home in Seoul, Korea. 'Kitchen of the Future' designed by General Electric of USA. 'Cultivation Kitchen' designed by INAX of Japan. And 'Barrier Free Kitchen' designed by ITOKI of Japan.

After analyzing the selected kitchens, we evaluated them by UGTI. Evaluation was conducted according to 5 grade scale; strongly positive (5), positive (4), average (3), negative (2), and strongly negative (1). For evaluation, we first individually examined the kitchens by UGTI, and then unified evaluation scores for each evaluation criterion after discussing with individual examinations. Following is the result of the evaluation.

'U-Style' of Samsung is evaluated very high in consideration for 'storage, 'dining' and 'marketability', although it is assessed low in 'originality' and 'ecology'.

Among the four kitchens evaluated, GE's 'Kitchen of the Future' has been evaluated the highest as a whole. It has been evaluated very high in 'storage', 'information/entertainment', 'interaction technology' and 'intelligent technology'. However, it has received very low score in 'ecology' and 'dining'. It also has been pointed out have problem in 'equitable use'.

'Cultivation Kitchen' of INAX has been evaluated very high in 'ecology' and 'originality', though it has been pointed out not to have problems in 'storage', 'dining' and 'information/entertainment'.

'Barrier Free Kitchen' of ITOKI has been assessed the most universal among the four evaluated kitchens. It has received very high score in 'accessibility', and 'functionality'. In 'equitable use', 'flexibility in use', 'intuitive use' and 'safety', it also has been evaluated high. However, in contrast with these, in most technology related evaluation technology, such as 'network technology', 'interactive technology', and 'intelligent technology', it has been evaluated very low.

4.2. LIMITATION OF STUDY

There has been some limitation during our evaluation of the kitchens, because except a kitchen model named U-Style, where we visited the place of installation for evaluation, we conducted evaluation by examining the photos and the descriptions of selected kitchens. In relation to the evaluation, one thing we would like to add is that the aim of the evaluation is not for ranking the selected kitchens but for identifying the usefulness of the evaluation system of UGTI. Despite the result of the evaluation might not be reliable as it was carried out without examining real kitchen models, we have identified UGTI is useful to assess a design from various perspective. UGTI can be useful not only for assessing kitchen but also any item by locating it instead of kitchen.
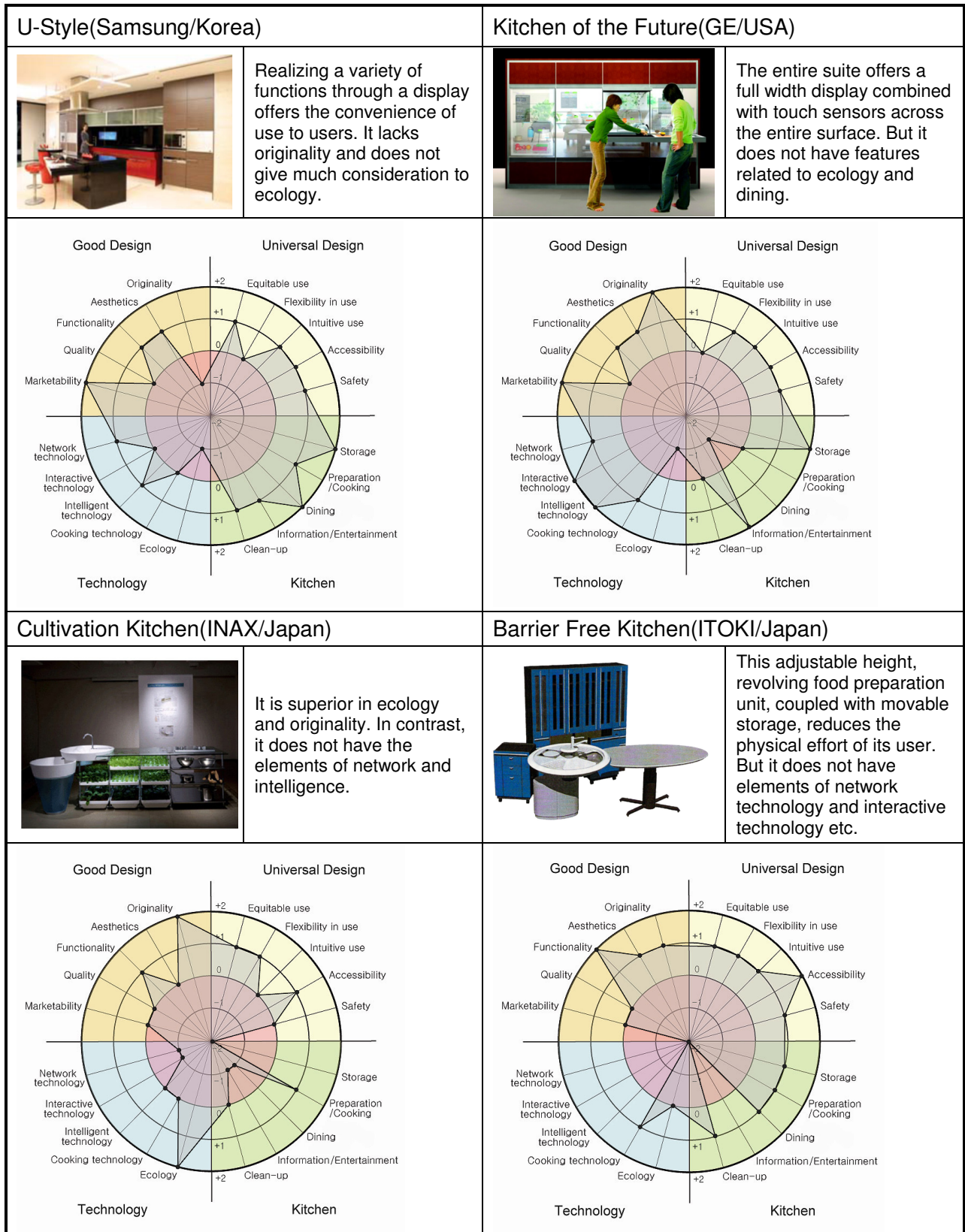
U-Style(Samsung/Korea)	Kitchen of the Future(GE/USA)
Realizing a variety of functions through a display offers the convenience of use to users. It lacks originality and does not give much consideration to ecology.	The entire suite offers a full width display combined with touch sensors across the entire surface. But it does not have features related to ecology and dining.

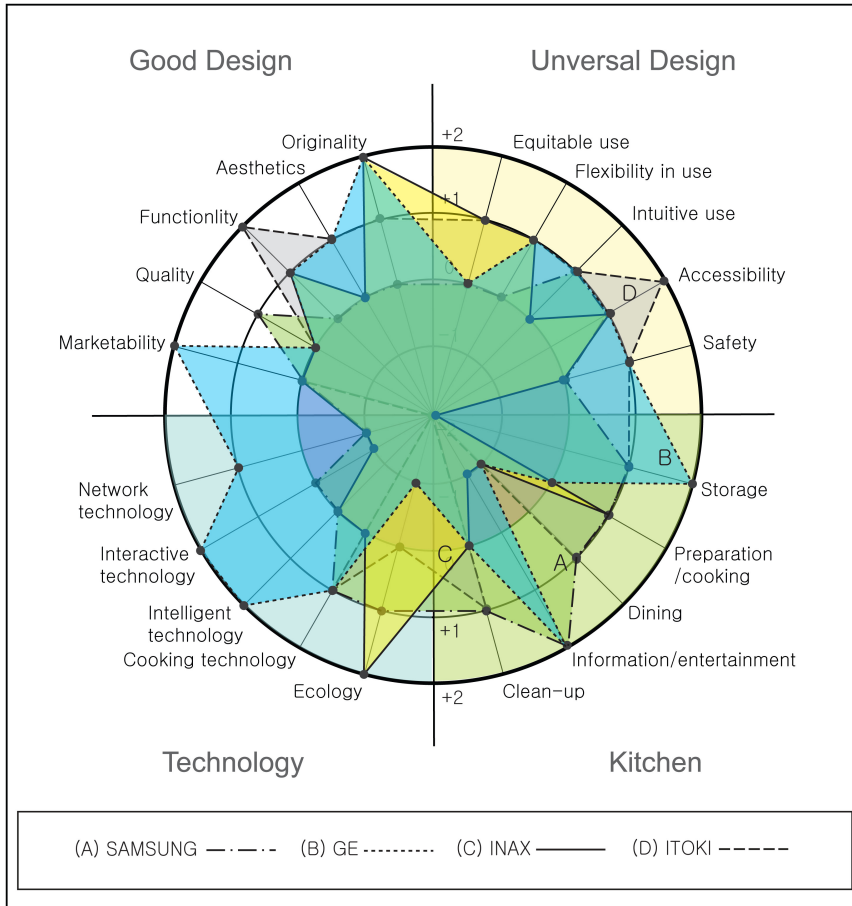| Cultivation Kitchen(INAX/Japan)	Barrier Free Kitchen(ITOKI/Japan)
It is superior in ecology and originality. In contrast, it does not have the elements of network and intelligence.	This adjustable height, revolving food preparation unit, coupled with movable storage, reduces the physical effort of its user. But it does not have elements of network technology and interactive technology etc.

Figure 3: Result of evaluation by UGTI

Figure 4: Synthesis of evaluation

5. CONCLUSION

In this study, we have examined four evaluation criteria such as universal design, good design, technology and kitchen to evaluate USK. Combining the four criteria, we have created an evaluation system named UGTI. To identify the efficiency of UGTI, we have conducted an evaluation on four advanced kitchens.

Using UGTI, we could identify the characteristics of each kitchen system very concretely and which element of a kitchen should be supplemented to improve it.

Despite the fact that the evaluations have limitation in terms of reliability as they were conducted mostly by examining photos and descriptions of kitchen models, we expect UGTI would be efficient to assess an item precisely from various perspectives.

To make design guidelines of USK, which is the ultimate goal of this study, we need to conduct more evaluations by UGTI on a variety of real kitchens.

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