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Applying the Double Diamond Model to Enhance Service Design in Urban Family Kitchens

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ABSTRACT

This study aimed at the service design defects of the Urban family kitchen, based on the strategy of the double diamond model, to explore the design practice. Problem statement: Diverse intelligent family kitchen products frequently focus on specific pain points, while existing research lacks a systematic approach to family kitchen service design. To enhance the operational efficiency, safe, comfortable, and emotional experiences of kitchen users, and improve the service system of urban family kitchens. This study employs the double diamond model to explore kitchen service design. A stratified sampling method was used to select 2 kitchen novices, 2 home chefs, and 2 kitchen experts each. Data information was collected through observations, interviews, and brainstorming sessions with them. The KJ method and user journey mapping are utilized to analyze user behavior, motivation, and kitchen product usage requirements. This research identifies kitchen user needs mainly encompassing food processing, storage, cleaning, and emotional aspects. Analyzing system functions and background actions provides a valuable reference for the design of intelligent and socially oriented kitchen service systems.

1. INTRODUCTION

As society continues to develop and progress, there is a growing demand for enhanced food safety and improved service experiences within home kitchens [1]. Throughout history, the evolution of kitchen usage needs can be traced from fire cooking in ancient times to the development of ancient stoves, modern public stoves, and ultimately modern private stoves [2]. This process of civilization has shaped the changing requirements surrounding kitchen functionalities. Maslow's hierarchy of needs theory illustrates that humans initially seek to fulfill their basic needs for sustenance and safety, before pursuing spiritual fulfillment as economic conditions improve. Consequently, with the development of modern furniture technology [3], the modern kitchen serves not only as a mere cooking space but also as an interactive area that amalgamates family activities, service experiences, and cultural heritage [4]. To achieve this integrated role, kitchen service design must adapt to lifestyle changes, becoming more rational and accommodating.

Numerous scholars have conducted comprehensive and meticulous research on kitchen design. Notably, Catherine Beecher's concept of the "working triangle" in kitchens [5], has received widespread recognition from both domestic and international scholars. This concept emphasizes the optimal positioning of the sink, stove, and storage area as the main activity zones within the kitchen, facilitating efficient kitchen operations by connecting these three key points. In 1919, Frederick Taylor introduced new ideas for kitchen layout and arrangement through motion studies [6]. Later, in 1926, architect Schutte Lihotzky presented the Frankfurt standardized kitchen [7], which incorporated detailed time and movement research to rationally plan the kitchen's operation process, leading to improved ergonomic design. This model became an exemplar for modern urban kitchens. Subsequently, Pehkonen et al. [8] in Finland conducted an ergonomics study on 59 kitchens, identifying various solutions to reduce workload through interviews and observations. They summarized 402 improvement measures and evaluations. Additionally, Nowakowski and Charytonowicz [9] analyzed the interconnection between kitchen structure, ergonomics, and other functional areas, with a focus on enhancing the quality of life and social integration while meeting fundamental needs.

In conclusion, the current research on kitchen design primarily centers around ergonomics [10]. With the improvement of people's living standards, the approach to kitchen design has shifted from being generally standardized to more personalized ones [11]. The development of new-generation information technologies such as the Internet of Things, big data, and artificial intelligence has also provided new possibilities for the development of kitchen functionalities. The objective of this study is to explore how to coordinate user needs on the basis of technological advancements, aiming to enhance the operational efficiency, safety, comfort, and emotional experience of kitchen users,

thereby improving the service system of urban household kitchens.

2. LITERATURE REVIEW

2.1 Development of service design

In the 1980s, Lynn Shostack's seminal work How to Design Services [12] marked the initial proposal of the concept of Service Design. In her paper, Lynn Shostack introduced the Service Blueprint, a method to visualize service processes, and introduced the concepts of the Line of Visibility and Service Evidence. To illustrate the application of the Service Blueprint, the study used the example of a shoeshine service and demonstrated how this tool could be utilized to enhance the overall service experience. The formal introduction of the term Service Design in the field of design can be traced back to the publication of Gillian Hollins' book Total Design in 1991 [13]. Concurrently, Michael Erlhoff and Birgit Mager from the Cologne International School of Design (KISD) began integrating service design into design education in the same year, dedicating themselves to teaching and research in this area [14]. Moreover, starting in 1992, Carnegie Mellon University's interaction design graduate course system prominently featured the core theme of activities and organized services. It highlights the significance of service design in the context of design education.

It is crucial to emphasize that service design is not an isolated outcome of design development; rather, it exists as an interdisciplinary field that draws upon various domains to improve service quality, user experiences, and overall system performance. A scholar from Oxford University [15], presents a classification of the concept of service design by integrating various perspectives from different scholars. The classification method initially distinguishes two distinct understandings of design: one to address known problems and the other as a multi-participatory process of exploring meaning [16]. Next, the framework differentiates between various concepts of the relationship between goods and services. One perspective advocate treating goods and services separately, while the other posits that services form the fundamental unit of economic exchange, encompassing goods within its broad scope. Building upon these varying interpretations of design and service, Kimbell positions different concepts of service design as follows: engineering, service engineering, non-engineering design fields, and design for service, as shown in Figure 1.

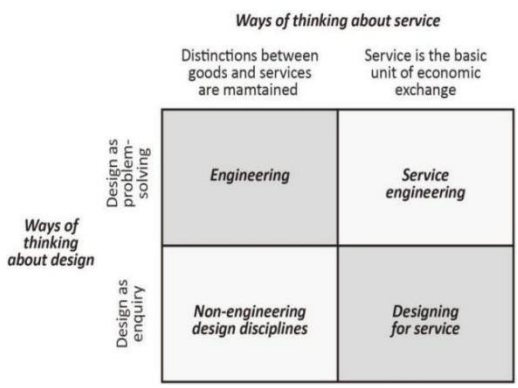

Figure 1. Approaches to Conceptualizing Service Design, Kimbell, 2011 [15]

Overall, different disciplines place varying emphasis on service design, which not only contributes to the development of the service design field but also poses challenges for constructing a unified theoretical framework for service design. Nonetheless, these diversities also present opportunities for advancing service design research [17].

The case study by Kiannu [18] on service and interior design demonstrates that using service design methods and tools in interior design projects can transform spaces into extensions of services, thereby providing more comprehensive process services. The use of design thinking can be combined with various existing tools in services and interior design to create new interdisciplinary tool designs to better meet the needs of current projects. Meanwhile, Holopainen's [19] exploration of service design in architectural design attempts new perspectives and a variety of tools and techniques. He engaged in participatory observation of architects' offices and described in detail how to design services within the architectural context. His research also indicates that service design concepts contribute to enhancing home design experiences. On a larger scale, service design is merging with spatial design, which also provides a theoretical foundation for the kitchen service design in this study [20-22].

2.2 Double diamond model

The Double Diamond model [23] was developed by the UK Design Council (Design Council) between 2002 and 2004, led by Richard Eisermann, Clive Grinyer, and others, with the aim of providing a straightforward means to communicate the design process and address diverse challenges to non-design audiences. The primary focus of this model is to emphasize the accurate identification of problems and appropriate solutions, all with a user-centric approach to better serve the needs of users [24].

The Double Diamond model effectively assists designers in transforming the design process from a state of ambiguity to clarity and coherence. Leveraging its flexibility and agility, the thinking process gradually takes shape within a structured framework. The Double Diamond model concentrates on delineating the design journey until the correct solution is identified. It consists of four stages in the design process, the first diamond stage, called discover and define, is devoted to discovering, analyzing, and precisely defining the problem at hand. Subsequently, the second diamond stage, termed develop and deliver, focuses on devising a solution. It is important to note that each stage in the Double Diamond model is not a linear process but employs cycles of divergent and convergent thinking, fostering iterative exploration of the design process to unveil hidden insights. By employing the Double Diamond model, designers can comprehend and observe human behaviours, deducing outcomes into thoughtful considerations. Design thinking can then be expressed as a fitting solution, meaningfully tailored to address the needs of people [25, 26].

The characteristics of the Double Diamond Model make it widely applicable. Wang et al. [27] based their ideas and solutions for future aging issues on the design guidance process of the Double Diamond Model and tools applicable to various stages of design. They collaboratively addressed this problem, exploring broader directions for the model's development. Ergen et al. [28] analyzed the management process of a Turkish retail chain brand using the first three steps of the Double Diamond Design Model (Discover, Define,

and Develop). By identifying various customer needs to create future services and experiences, they decided to further improve the interior design of retail stores. This also demonstrates the potential of the Double Diamond Model to inspire design thinking. Rian et al. [29] used the Double Diamond approach to create the foundation of the user interface (UI) and user experience (UX) for a health service application (home care), bringing positive user experiences. This provides a good theoretical foundation and method reference for the development of this study.

2.3 Usability analysis of the double diamond model

When analyzing the usability of the Double Diamond model in the context of food production within kitchen settings, it becomes evident that the overall process is characterized by orderliness and systematicity. The process involves the collaboration of various stakeholders, such as home service companies, food supply companies, and kitchen users. In this design practice, the Double Diamond model serves as a valuable guide, enabling the avoidance of linear problem-solving approaches. Instead, it facilitates the systematic extraction and evaluation of requirements and functionalities relevant to the food production process. Through the iterative phases of divergence, synthesis, convergence, and idea testing, designers can refine their concepts [30].

This cyclical process allows for continuous testing and feedback, effectively progressing through the various design steps. Ultimately, the aim is to create a dining and kitchen experience that is both comfortable and highly efficient. The Double Diamond model proves to be a robust framework for achieving this objective, accommodating the complexities of the involved stakeholders and delivering innovative solutions that cater to user needs.

3. METHODOLOGY

3.1 Conceptual framework

Service design for kitchen and home furnishing is essentially a design action aimed at making dining and cooking activities more comfortable and efficient and promoting family harmony. It can be divided into carrier, process, and user role design from material, non-material, and spiritual levels. Service design focuses on collecting and clarifying user needs, pain points, and emotional responses, and finding opportunities [31]. Therefore, this paper takes the kitchen home environment as the research object, based on the concept of service design, and uses the Double Diamond model to investigate, summarize, and analyze the kitchen home.

3.1.1 Double diamond flowchart

The kitchen service design research process based on the double diamond model includes four stages, namely the discovery stages, definition stages, development stages and delivery stages:

(1) In the discovery stage, conduct user research and case studies from the perspectives of people and things to identify opportunities for dining and kitchen activities through research.

(2) In the define stage, pay attention to the relevant attributes of the user base and the value meaning of the design, considering the purpose of use, emotional changes, and other factors, and systematically summarize user pain points.

(3) In the development stage, apply divergent thinking to address pain points from multiple perspectives, such as carrier, process, and user role transformation. Consider the feasibility of design implementation and build user trust while developing a comprehensive solution.

(4) In the delivery stage, summarize and organize the design content, implement the proposed solutions, and visualize the design content in the form of a system diagram, as shown in Figure 2.

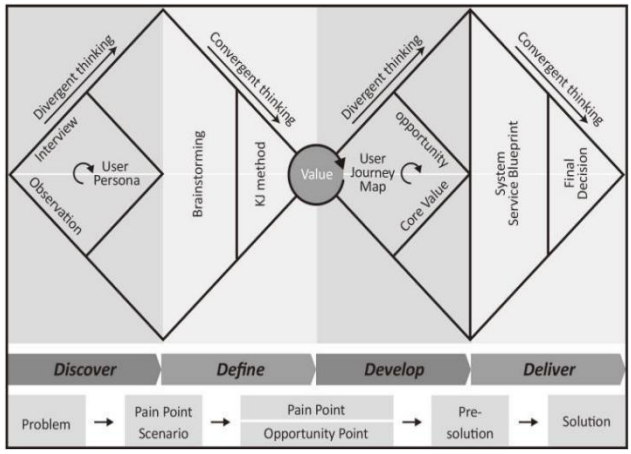

Figure 2. Double diamond flowchart of kitchen service design

3.1.2 Samples and methods

Focusing on the current kitchen home environment, the research employs observation and interview methods to investigate the daily kitchen activities of 6 urban kitchen users. Kitchen needs are then classified and organized based on their conscious and unconscious behaviors. This data-gathering process helps to uncover valuable insights that can inform the subsequent stages of the kitchen service design process.

(1) Samples

The study adopts a stratified sampling method. Although each kitchen user's situation varies, their kitchen skills gradually improve with increased usage of the kitchen. Based on previous literature research [32], this study categorizes kitchen users into three distinct groups: beginner cooks, family cooks, and cooking pros. Beginner cooks refer to individuals with limited experience in the kitchen. They may have just started cooking or have little familiarity with food preparation. Beginner cooks typically have basic cooking skills and may feel unsure or hesitant about experimenting with new recipes. They may seek simple and easy-to-follow cooking instructions and rely on convenience foods. Family cooks are individuals with a moderate kitchen experience who primarily cook for their family. This group often consists of individuals around 35 years old, responsible for preparing meals for their household members. Family cooks may have acquired some cooking skills and regularly cook daily meals. They focus on creating balanced and wholesome dishes to cater to the diverse tastes and preferences of their family members. Cooking pros are seasoned individuals in the kitchen with extensive experience, surpassing 5 years. They are passionate about food production, have a strong desire for culinary knowledge, and genuinely enjoy cooking. Cooking pros are enthusiastic learners, constantly seeking new recipes and culinary skills. They may experiment with complex cooking techniques and aim to create extraordinary and exquisite dishes. Therefore,

research samples were selected from these three user groups respectively.

In terms of sample size, the determination of sample size in qualitative research is not governed by a general rule, but rather depends on the specific characteristics of the research method employed [33]. In this sense, generalizability is not sought by the researcher, and the focus is less on sample size and more on sample adequacy [34]. The key to sample size is reached when there are fewer surprises and no more emergent patterns in the data [35]. Although each type of kitchen user has their own pain points, there are also common issues. Therefore, in the absence of new information, this study will determine the sample size to be 6 participants, as shown in Table 1.

Table 1. Kitchen user sample

No.	B-1	B-2	F-1	F-2	C-1	C-2
Pic.						
User	beginner cook	beginner cook	family cook	family cook	cooking pro	cooking pro

(2) Methods

This study adopted a cyclic iterative data collection method based on the Dual Diamond Model. Firstly, 6 participants were individually observed for 20-30 minutes while using the kitchen. Observations included cooking activities undertaken by the participants before, during, and after cooking, as well as recording their daily kitchen usage habits.

After the observation period, individual interviews lasting 20-30 minutes were conducted with the 6 participants. The interview content mainly covered three aspects: First, basic information such as the participants' age, occupation, family members, and kitchen habits; Second, problems encountered by the participants during their daily kitchen use; Third, participants' requirements for their ideal kitchen.

In addition, we invited 6 kitchen users and 2 designers to participate in an online brainstorming session. During this session, we discussed common issues, specific problems identified earlier, and the possibilities for design. This collaborative effort aimed to obtain clearer and more accurate pain points and requirements, thereby stimulating further thoughts on service design.

During data analysis, this study utilized user personal to organize the basic information and important characteristics of kitchen users. The KJ method was employed to analyze and address user pain points and requirements, while user journey maps were used to analyze issues in the kitchen service system.

3.2 Discovery stage

During this stage, a comprehensive analysis is conducted from both human and material perspectives through user research and case studies. User data is collected through interviews and observations, enabling the creation of user profiles to understand the pain points and requirements of different users. The goal is to identify innovative opportunities for kitchen services.

Research shows that in a family, the kitchen users are not static. In a household with family cooks or cooking pros, there may also be beginner cooks. The research findings indicate that the kitchen usage process entails users with slightly overlapping needs and pain points. Among these users, beginner cooks exhibit a particular interest in the kitchen's cooking auxiliary functions, such as social sharing and intelligent features. Meanwhile, their pain points in kitchen operations tend to concentrate on the risks of burns, cuts, and disorganized operating procedures. On the other hand, family cooks demonstrate greater proficiency in kitchen operations due to their responsibility for preparing meals for family members of varying ages. However, they are susceptible to pain points related to efficiency and cleanliness in the cooking process. Additionally, there is a family helper role responsible for cleaning and processing side dishes, as well as providing companionship and entertainment. Meanwhile, the family cook assumes the primary responsibility for food processing and cooking. These two roles exhibit certain distinctions in their kitchen needs. Moreover, beyond fulfilling the kitchen's fundamental functional requirements, cooking pros display a heightened emphasis on the entertainment experience within the kitchen environment.

Figure 3. User personal

Based on the research and analysis, three types of user personals are established at this stage [36], as visually depicted in Figure 3. These character cards serve as valuable tools to guide the subsequent kitchen service design process, ensuring the design solutions are tailored to the specific needs and preferences of novice users, family chef users, and cooking expert users.

3.3 Define stage

During the define stage, building upon the insights gained from the discovery stage, user roles are visualized, and essential attributes are explored. User pain points and demand points are summarized based on their respective tasks, while the core value of the design is elucidated through value propositions. This stage involves inviting 6 kitchen users and 2 designers to participate in brainstorming sessions [37] and guiding participants to discuss the pain points and needs associated with kitchen usage in their daily lives. Furthermore, given the advancements in technology and the elevation of people's living standards, kitchen activities have transcended traditional cooking tasks and now encompass various stakeholders within the catering supply chain. Scenarios such as ingredient purchasing, preprocessing, and storage prior to cooking, ingredient processing, and cooking during culinary activities, ingredient storage and preservation after cooking,

and kitchen waste disposal are all encompassed within the realm of kitchen service design. By analyzing users' cooking behaviors within the kitchen space, the core value of the design is clarified and distilled.

Before cooking, users decide what to eat in random areas. They may discuss with family members or check what ingredients are available. The type of the previous meal influences the decision for the next meal. Users purchase ingredients online or at supermarkets, with a focus on freshness. However, buying too much at once, leading to heaviness, is a major pain point for users. During cooking, users' activities in the preparation area mainly involve selecting, washing, cutting, and seasoning vegetables, which involve various kitchen utensils. This process can make the kitchen space more chaotic. In the cooking area, users engage in activities such as frying, boiling, stewing, and steaming food. They pay attention to cooking times, and the overlapping of operations can make it difficult to work on cluttered countertops. After cooking, users need to transfer food from the cooking area to the dining area, involving multiple trips between the two areas. They pay attention to how dishes are placed and kept warm. Users tidy up leftovers, clean kitchen waste, wash dishes, and store items. Dealing with leftovers, sorting kitchen waste, and cleaning utensils are all pain points for users.

The needs of users in the observed scenario are meticulously refined and summarized. Through the utilization of the KJ method [38], common requirements are identified, leading to the derivation of primary-level needs. These needs encompass food processing requirements, storage necessities, cleaning demands, and emotional considerations. The affinity diagram analysis from the synthesis process is shown in Figure 4. Key keywords, including cooperation, cleanliness and sanitation, and photo sharing, among others, are highlighted and depicted.

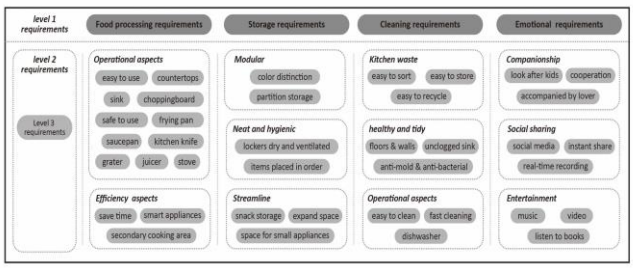

Figure 4. Requirements affinity diagram analysis

3.4 Development stage

The development stage is situated within the second diamond of the Double Diamond model, involving the utilization of divergent thinking to generate and explore potential solutions while conducting rigorous service testing. The iterative nature of this stage allows for the uncovering of underlying issues, necessitating iterative feedback loops that may lead to the refinement of the design solution until an optimal outcome is achieved. Both the Double Diamond process and the kitchen service design embrace a co-creative approach, departing from a linear progression. During this stage, the proposed solution is analyzed based on key influencing factors, and a comprehensive assessment of the entire user experience journey is undertaken. The user journey mapping is utilized to methodically organize the complexities of user behavior [39]. By identifying service touch points within these behavioral patterns, an in-depth analysis of users' emotions and pain points at each touch point is conducted. Subsequent consideration of strategies to address these aspects yields design opportunity points, thus revealing the pain points and potential opportunities within the service process. The user journey map is depicted in Figure 5.

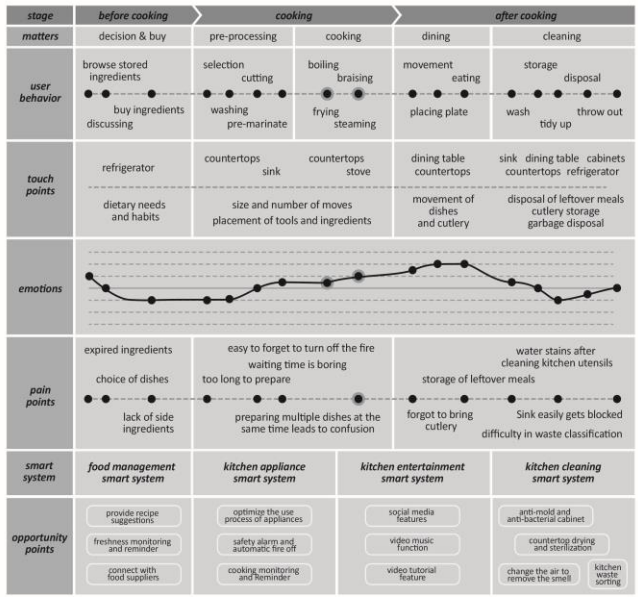

Figure 5. User journey mapping

From the analysis of user journey mapping, it is evident that most kitchen users experience an ascending sense of joy during the cooking stage. However, the subsequent stage of cleaning and tidying after cooking emerges as the most troublesome phase for users, as illustrated in Figure 5. Furthermore, the choice of dishes presents itself as a recurring pain point that often causes distress among users. Other notable pain points, ranked from highest to lowest, include garbage disposal, insufficient side dishes, cleaning kitchen utensils, forgetting to turn off the stove, and a clogged sink. Across the various stages, a total of 12 pain points is identified for kitchen users, from which 4 pivotal keywords can be distilled: multiple ingredients, complex operations, cooking emotions, and cleaning issues. Based on these findings, corresponding intelligent subsystems for the kitchen are derived, yielding 13 opportunity points for potential enhancements.

3.5 Delivery stage

During the delivery stage, the specific design plan of the kitchen service is materialized through touchpoint design, while stakeholders are interlinked through a service system diagram.

Centered around the kitchen user, this system connects various stakeholders through dining and kitchen activities, including food suppliers, kitchen product suppliers, communities, and family members. A kitchen service system is thus established, utilizing a mobile terminal as the primary platform. This system facilitates relevant information integration and interactive incentive services, fostering the circular operation of the kitchen service system. Guided by the value orientation of enhancing user dining and kitchen

experiences [40], optimizing the allocation of social resources, and promoting the concept of green and healthy living, the optimization methods, approaches, and channels converge to give rise to a novel kitchen service system design, as shown in Figure 6.

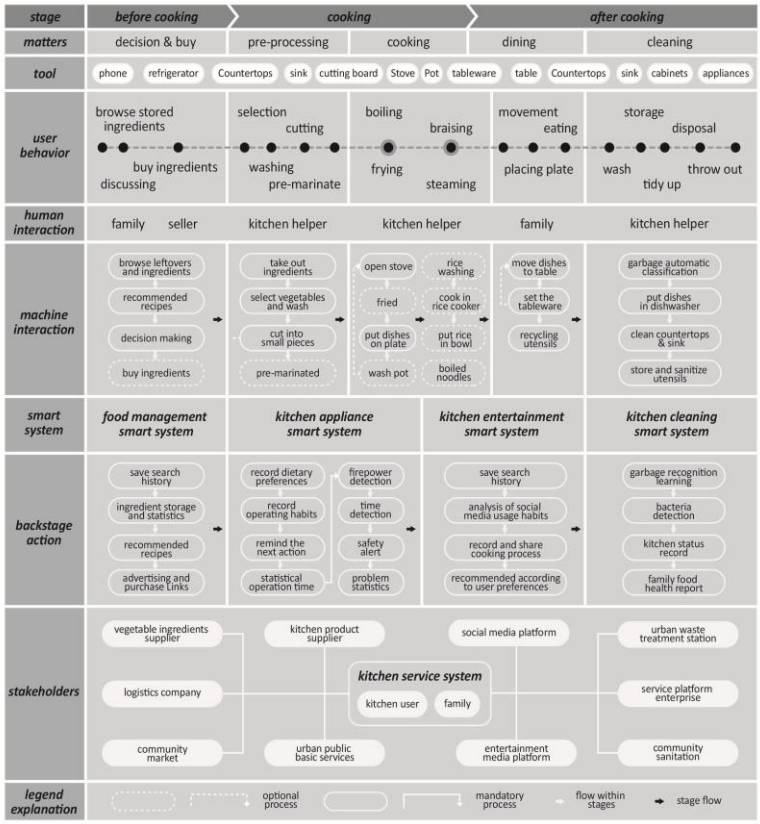

Figure 6. Kitchen service design blueprint

4. RESULTS AND DISCUSSION

Based on the Double Diamond model, a study on kitchen service design was conducted. Following the discovery, define, development, and delivery stages, information data generated from observation, interviews, KJ analysis, and brainstorming sessions were comprehensively analyzed. This culminated in the formation of an urban kitchen service system architecture comprising food management smart system, kitchen appliance smart system, kitchen entertainment smart system, and kitchen cleaning smart system. Each of these four subsystems addresses user pain points and fulfills user needs at every stage of user culinary activity. Simultaneously, they can provide corresponding personalized features, making user culinary activities more comfortable, secure, efficient, and environmentally friendly.

With the rapid development of next-generation information technologies such as the Internet of Things (IoT), big data, and artificial intelligence (AI), the functionalities mentioned in the aforementioned systems have already been preliminarily realized or applied. Vu and Khanna [41] researched the application of artificial intelligence in smart kitchens. They utilized wireless sensor networks, X Bee modules, GUI, microcontrollers, and sensors to introduce a new concept of the fridge, allowing users to receive reminders about food items in the fridge and their expiry dates. By incorporating intelligent home automation systems into kitchen appliances such as stoves and microwaves in daily life, the kitchen food and appliance management systems mentioned in the service design can be realized. Minaam et al. [42] demonstrated the monitoring and reminders for kitchen waste achieved through an Internet of Things (IoT) network system. This technology can be applied to kitchen cleaning systems. As it stands, the majority of traditional kitchens remain fixed in one location. Radha et al. [43] indicated through their research that future kitchens should integrate with living spaces to surpass physical limitations and enable member interaction and emotional exchange, such as recreation, social networking, virtual activities, and family events. This is also the objective that smart kitchen entertainment systems aim to achieve.

Reviewing the current research status of smart kitchens, although various technologies have been preliminarily implemented, the lack of research on genuine advantages for multiple target audiences has resulted in only small-scale applications in real life. In this study, based on the Double Diamond Model, research on kitchen service design was conducted. Through studying the common pain points and needs of users and cyclically refining the data during survey analysis, it avoids the one-sidedness of conclusions caused by linear analysis, thus providing some reference and suggestions for the popularization of smart kitchens in the future.

5. CONCLUSIONS

Kitchen service design surpasses the boundaries of mere interior design schemes; it encompasses lifestyle choices, behavioral habits, and a profound attentiveness to the

intricacies of daily life. Through the application of the double diamond model in design practice, this research has explored the latent needs of kitchen users, advocated for the holistic integrity of kitchen service design, and ventured into new possibilities within the realm of kitchen and home design, by integrating material and immaterial aspects, as well as considering spatial and temporal dimensions.

Problem-solving entails an iterative process that necessitates repeated testing. To effectively apply the double diamond model, a comprehensive understanding of its cyclical verification is imperative, along with the judicious improvement of methodologies.

In the future, with the rapid development of new technologies, new kitchen designs and applications will continue to emerge. Future kitchens will not only be places for cooking but also spaces for people to express emotions, entertain, and share life experiences. As stated by Lau et al., the essence of future kitchen design should be based on "human life" and "human concerns" [44]. Although advanced technologies such as Artificial Intelligence, Robotics, and the Internet of Things will bring various benefits to future kitchens, they should all be centered around people. Based on this, future kitchen service design research will fully integrate into people's daily lives along directions such as sharing, green environmental protection, and sustainable development. This is also something that we need to further investigate in the future.

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NOMENCLATURE

B-1/B-2	beginner cook
F-1/F-2	family cook
C-1/C-2	cooking pro