TOUCH Doctor — A Nutrition Control Service System Developed under Living Lab Methodology

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Abstract: This paper presents a nutrition control service system, TOUCH Doctor, developed under living lab methodology. In addition to user-driven open innovation, the work on this project was highly interdisciplinary, including contribution from professionals in technology, communication, and medicine. The development of TOUCH Doctor not only depended on the work of engineering and medical experts, but also on the links between the product and its users and cooperating company. The final co-creative innovation, then, was realized through academic, business and industry contribution that could be applied to increase the feasibility of the human-centric service design innovations. Additionally, with collected open data, we also designed web service apps for usability tests to continually improve upon the service provided. The entire user-driven innovation procedure of the development of TOUCH Doctor services, including idea generation, concept evaluation, product development, and final product launch, is presented here in detail.

Keywords: living lab methodology; user-driven innovation; need-driven innovation; open data innovation

Introduction

User-friendly innovation of smart products and services will be the key factor in strengthening the competitiveness of players in the highly developed world of information communication technologies (ICT). Much research [1-22] from various methodologies shows that user-friendly innovations with suitable supporting service websites will be the trend in the global market. Due to its prominence and potential payback, much research and corporate attention has been focused on the process of successful innovation. The goals of the innovation process include developing a better understanding of how to quickly identify user needs, fine-tuning designs with ease, and successfully promoting the products and services in the market. Although, with the similar technologies, different innovations using different methodologies from separate corporations will reach totally different results in the market. Moreover, a sluggish response from the companies to the newly developed innovations will seriously cripple their business.

Innovation of this kind could involve science, technology, and the design domains. With key core components, science and technology innovations, of course, should be the main breakthrough for companies. However, in the era of tera-communication and the nano-miniature world, science and technology solutions with CPU, GPU, embedded systems, or VLSI implementation with wire or wireless networking capabilities will become similar. As such, the innovation of designing products, systems, processes, and services should be conducted cautiously.

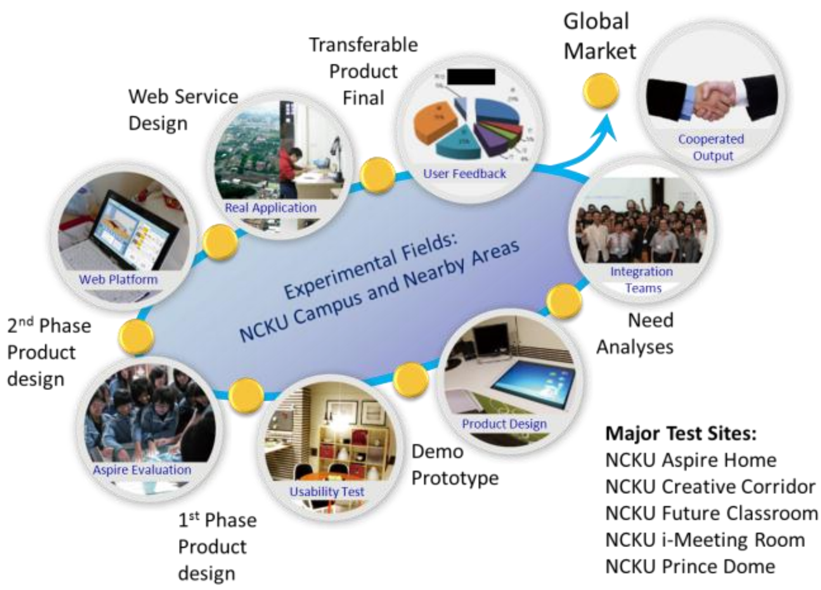

Figure 1. Student-driven innovation process conducted in TOUCH Center.

Today, interdisciplinary innovation should consider the product lifecycle, technology adoption, structural learning and competition. With an open innovation concept, the scope of innovation ranges from studying user needs, adopting technology, realizing products, enhancing process and performance measurements, and exporting real-time services to the market and external corporate environments. The user-driven approach for innovation can be applied to products and services using the so-called living laboratory (or simply called living lab) methodology [1-6, 10-17, 19, 21, 22]. The central concept of a living lab approach is to capture user needs and to design the products and services for a specific group of users, be they in the same community, school, city, nation, or even the world [4, 6, 22]. The concept of a living lab, which began to emerge in 2000, can be interpreted as a human-driven research and development method for designing ICT innovation situated and evaluated in a real-world setting. Moreover, living labs focus not only on the users involved in the development process, but also on the relevant stakeholders facilitating the co-creation, such as academicians, ICT and other professionals, or product managers. Compared to traditional approaches, with living labs the users are heavily involved in all stages of the product development, not just in the end phases.

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Figure 1 shows an example of a student-driven innovation process conducted in the Center for Technologies of Ubiquitous Computing and Humanity (TOUCH Center) when developing the living and learning services at National Cheng Kung University (NCKU). The TOUCH Center possesses four demo sites, including NCKU Aspire Home, Creative Corridor, Future Classroom, and iMeeting Room for small and medium size usability tests. Large-scale tests are conducted in NCKU Prince Dome. In developing TOUCH products and services, the integration team, made of experts in ICT, design, medicine, and psychology, first surveys the student living and learning needs with the latest technologies using the NCKU campus and nearby areas. Then, demo prototypes are introduced into the demo sites for usability tests with visitors to the demo sites. After user and visitor evaluations, the smart living and learning products (after two-phase modifications) will link with a web service platform. Then, the products with Internet service platform are ready for real application. After some user feedback, the transferable products are finally ready for the market. This innovation process, however, will be different when the stakeholders are different, which requires a different type of user.

Traditionally, the innovation process has been based on a "technology-push approach" where a technological breakthrough by the engineers determines what the products will be for the users. In contrast, we have used a "market-pull approach" where market demands and customer requirements [8] determine the end product. Ulwick [21], however, stated that companies should ask users about the desired characteristics of the product rather than to just expect solutions offered by customers. Owning to limited references, users may only know what they have experienced while using products and services and may be unable to think beyond them. In the living lab approach, users should be inspired to play an important role in the innovation process. That said, the development will still need to adjust and integrate in a collaborative and contextual way to demands from other relevant stakeholders or information such as market trends.

In this paper, we introduce the detailed development process under a living lab methodology for a nutrition control service system called TOUCH Doctor. By exploring smart services of nutrition control, TOUCH Doctor also looks for relevant supporting activities and extended services. By adopting Schumacher and Feurstein's suggestions [10], the co-creative product development process of TOUCH Doctor was divided into four phases: product/service idea generation, product/service concept evaluation, product/service development, and market launch. The users participated in each phase in diverse ways. This will be interesting to explore in that services derived from living labs may include functions such as supporting collaborative innovation, validation and demonstration, or cooperating with specific organizations. Moreover, Idea generation, sharing expertise, prototyping, and showcasing all appear in each of the development phases[18].

In the next section of this paper, we will address in detail the development of TOUCH Doctor in regard to the four phases of development. In the section that follows, we will discuss possible revisions and the future development of TOUCH Doctor, which is then followed by a conclusion.

Development of TOUCH Doctor

As illustrated in Figure 2, TOUCH Doctor was developed in four phases: Phase I involved product/service idea generation; Phase II involved product/service concept evaluation; Phase III involved product/service development; while Phase IV involved the market launch. Each phase is presented below in detail.

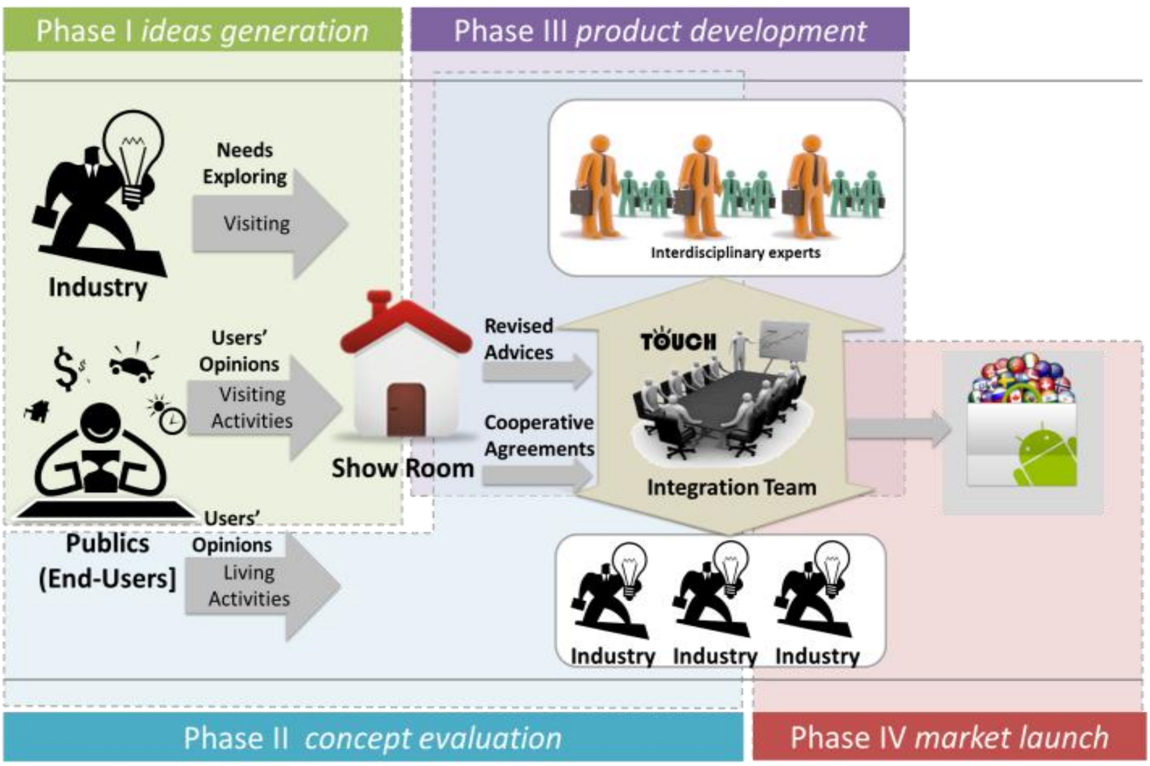

Figure 2. Flow chart and development phases of TOUCH Doctor.

Phase I: Product/Service Idea Generation

Figure 3. Need analyses from food nutrition display on a smart dining table.

TOUCH Doctor was originally just a simple product for everyday life. It was designed in the NCKU Aspire Home showroom, which built scenarios for a future smart home, encompassing the entrance, living room, dining table, kitchen (central island), study, and bedroom. As shown in Figure 3, a scenario probe showing a smart dining table was included in the NCKU Aspire Home. The smart dining table displayed a food nutrition profile, but was also a touch-control interactive table that allowed the user to check the contents in the refrigerator and select a favorite food for the family. The table could then suggest a corresponding recipe, as well as show the nutrition profile of what they consumed. At this stage in the table's development, the design could have been just like one of the other demos in smart house, having an undefined concept and immature ideals. As such, the smart dining table, treated as a living product, became a probe that regularly received suggestions and opinions from the users and visitors. In doing so, it was hoped that the design might inspire some new ideas to help it become progressively mature while also collecting criticisms and continuously improving on the concept. As part of the display, we also stationed tour guides who could introduce the scene and encourage brainstorming on the part of the visitors. With the tour guides observing and taking note, we could gradually adjust some technical imperfections, as well as better steer it in the direction of consumer needs.

In this stage, the tour guides played the role of need analyzers; they integrated suggestions and listed possible product characteristics. Also, with the help of the cooperating company, we could ultimately identify the possible market channel so that the idea could be further conceptualized.

Phase II: Product/Service Concept Evaluation

In the concept evaluation stage, we had to identify the stakeholders, comprehend the status of cooperative items and relative research achievements between institutes, and construct the possible database structures. As shown in Figure 4, we tried to integrate some existing products and establish some possible solutions to conceptualize and validate the ideas for the ultimate product, TOUCH Doctor. In the beginning, we incorporated some major characteristics and potential services that were frequently mentioned by the visitors to the smart dining table. Additionally, we analyzed the recent products/services the cooperating industries already had, as well as service platforms that traits new characteristics could be easily added to. Ultimately we linked to the Inventec website, called Dr. Eye Health, which was used for recording calories burned when on an exercise bicycle. The site also included their e-weight scale and e-blood pressure meter. We were then able to form a health control concept and plan for realizing the entire design begun in the Aspire Home.

Figure 5 illustrates the conceptualized services of TOUCH Doctor, which integrated three major items: the exercise services provided by Dr. Eye Health, the diet control services suggested by TOUCH diet control system, and the data reporting and display systems through TOUCH Chamberlain, which is a smart health guide that can interact with the user and also control the A/V systems and home appliances in the Aspire Home. After a user registers and logs in, TOUCH Doctor can store his or her personal data and health status. On first use, users can set their own health goals. Then, the user's body composition is determined using the e-weight scale and the e-blood pressure meter. Also, total energy burned and the intensity of exercise recorded by the e-bike can be uploaded to the health cloud by the healthy life recorder. TOUCH Chamberlain can keep the users on track, according to their health goals, using a text-to-speech technique. Furthermore, users can order carryout meals directly through the interaction on the smart dining table, or they could prepare the meals by themselves with recipe instruction on the smart central island. TOUCH diet control system can synchronize caloric intake and consumption data. The degree to which each member in a family had a balanced diet can be displayed on the smart central island.

To properly reflect the nutrition consumption of the user, it was paramount for the TOUCH Doctor system to compile exhaustive nutrition information. With open data innovation, we rebuilt the database expanded and expanded that presented in the research report,

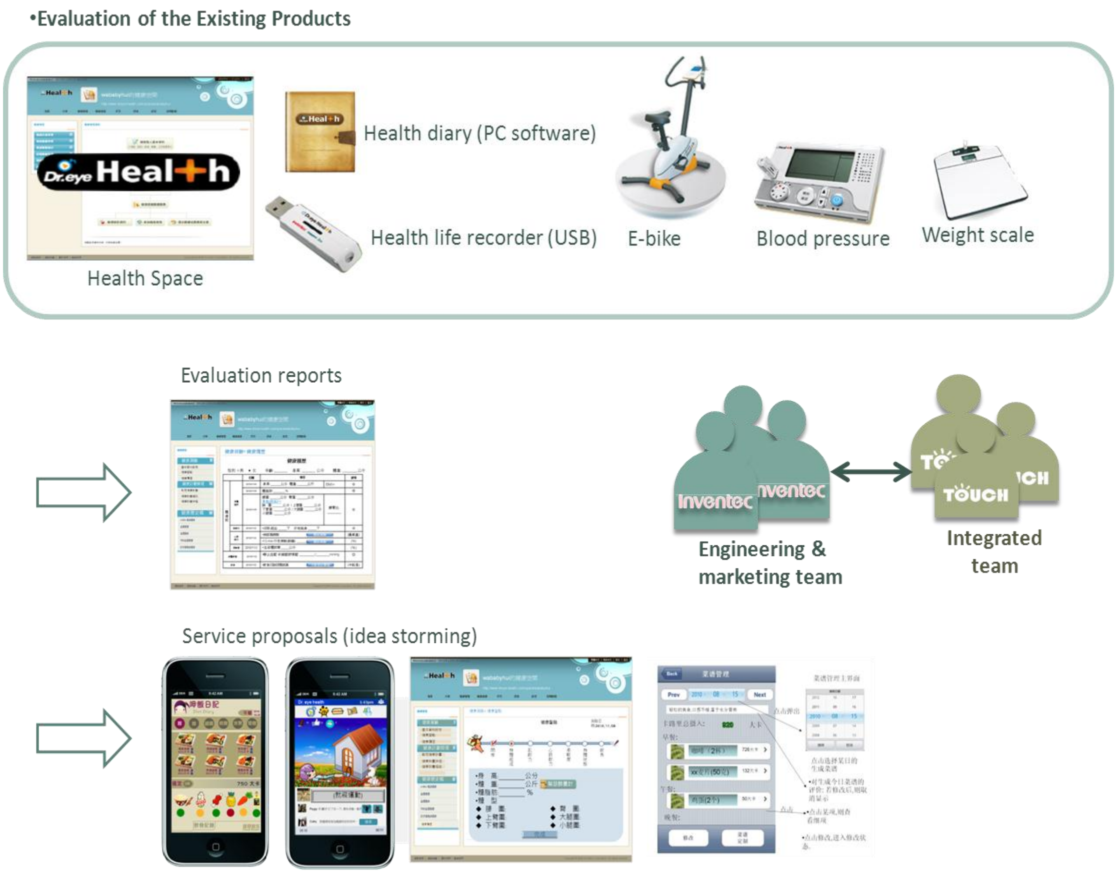

Figure 4. Open innovation process for evaluation of existing products between cooperating institutes and identifying possible services.

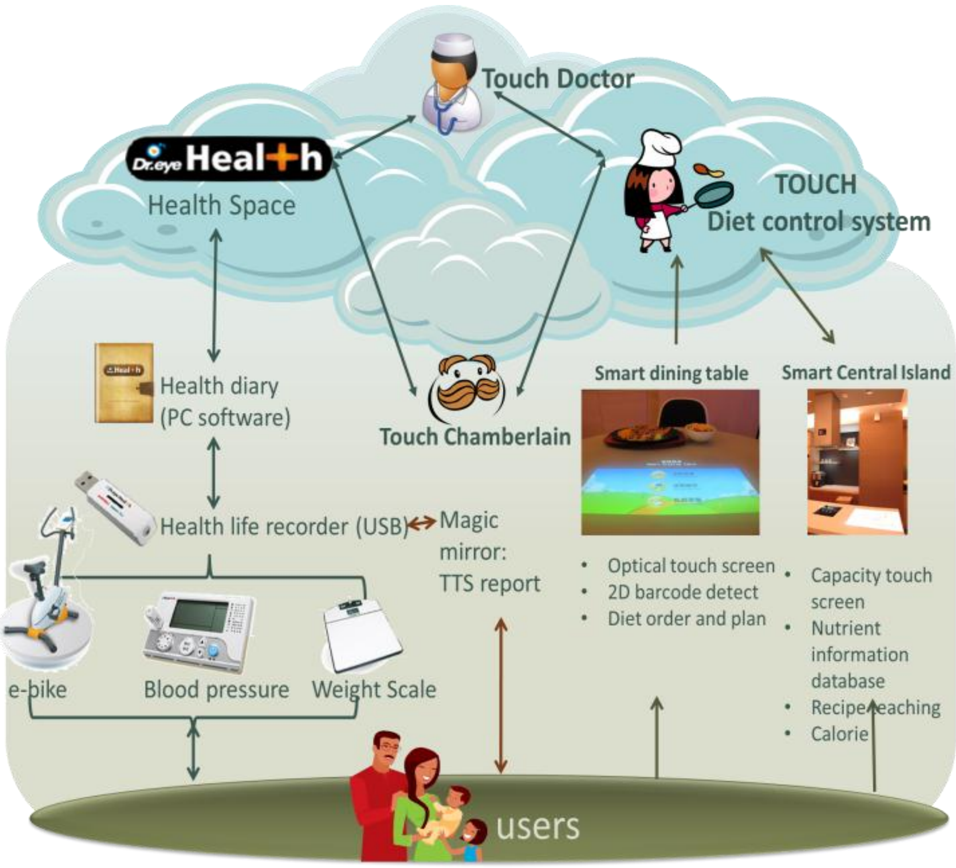

Figure 5. Complete design concept of TOUCH Doctor, combining Dr. Eye Health, TOUCH diet control system, and Touch Chamberlain.

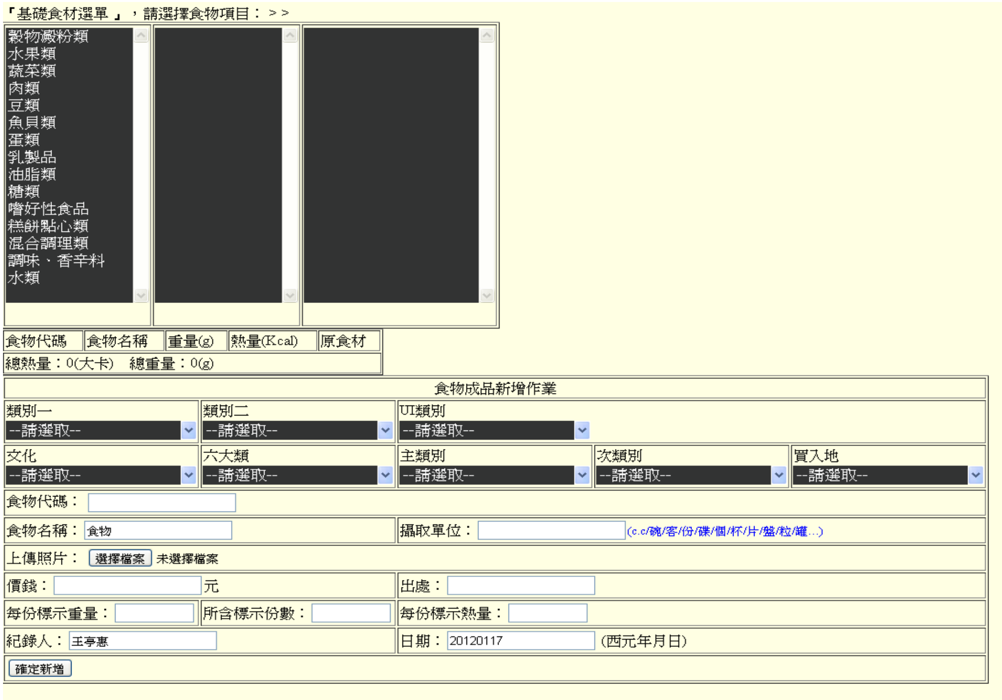

Figure 6. Nutrition open data innovation with the back-end management platform interface.

"Integrating nutrition data bank and developing computer software for dietary nutrient composition analysis" from the Department of Health, Executive Yuan [7]. We obtained authorization from the author. The nutrient data bank contained the basic food ingredients and composite cuisines. The data of the basic food ingredients was obtained from the food databases of different countries, while the experimental analyses of cookbooks and carryout food were the main contributions of our database expansion. This stage of the product development was conducted in a systemic way to rebuild the nutrition data bank. Compared with the original reference [7], the purpose of our use of the data was not exactly the same. Thus, the infrastructure of the nutrition data bank platform had to be changed, as shown in Figure 6.

To compile our additional data, we visited a town nearby NCKU and collected all the possible food from convenient store chains and from all levels of restaurants. Generally, the food packs purchased in convenient chain stores were labeled with sufficient nutrition details; we only needed to check the items and input the data. For the food from different restaurants, the data collection required a bit of effort. How to match the experimental raw data and correctly transform them into a digital format was another important issue in the establishment of the nutrient database. We conducted the procedure as shown in Figures 7 and 8.

Another critical issue was the user interface. TOUCH diet control system consists of the Smart Central Island and smart dining table. To achieve interactivity,

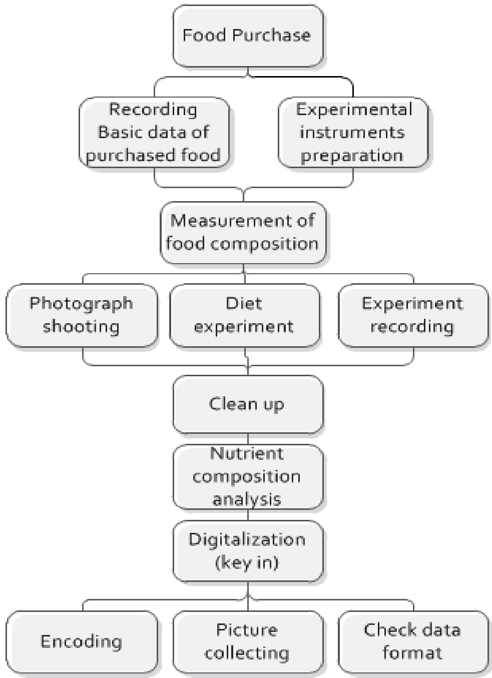

Figure 7. Flow chart of nutrient database expansion.

Figure 8. Diet analysis experiments for nutrient database expansion.

the Smart Central Island uses front projection and e-touch sensors stored under the touch plate, while the smart dining table is uses rear projection and a camera with pattern recognition software. The touch plate with e-sensors is used to avoid any influence from cooking activities. The smart dining table with pattern recognition can offer any possibility of interactive creations. However, the question remained of how best to prepare the user interface. At this stage, a formal user interface proposal was presented which stemmed not only from user feedback, but also aimed to make the interface clear with the system's functions easily understood. We hoped the proposed interface could serve as a blueprint for all professionals involved in the process. Figure 9 displays the preliminary interfaces on the smart central island.

(a)

(b)

(c)

Figure 9. Dynamic displays of calories nutrition: (a) food recipe and instruction; (b) diet plan and recording; (c) smart central island.

As shown in Figure 10, interdisciplinary cooperation was crucial in this phase. Their feedback was a great way to solve problems and answer to requirements from all cooperating professionals. Moreover, one's ideas could receive validation from other professionals.

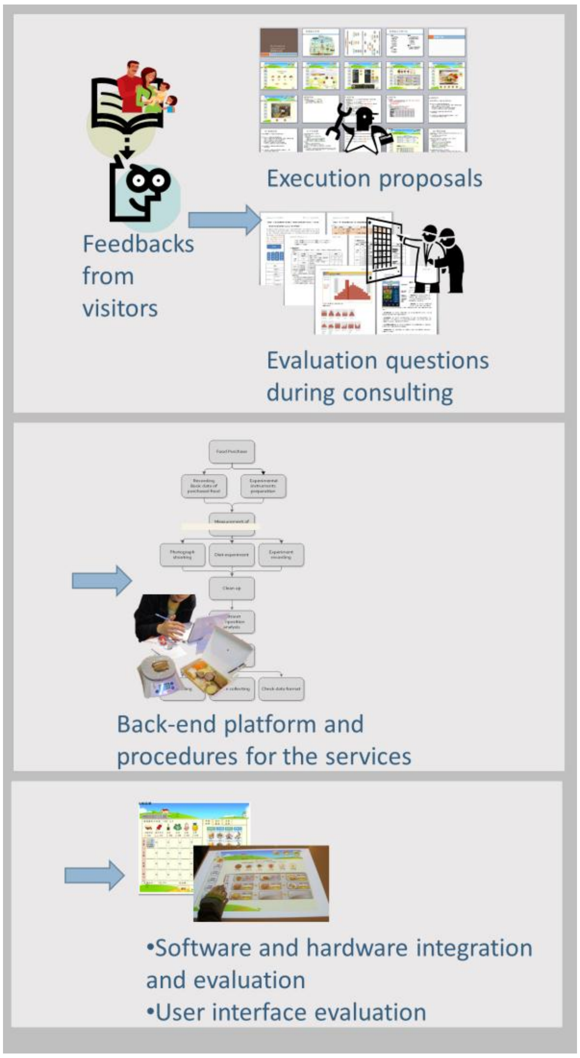

Figure 10. Major work realized in Phase II- product/service concept evaluation.

Phase III: Product/Service Development

Moving beyond the existing feedback collection loop, in this phase we developed the target products and services at the same time to prepare for the market launch. After the determination of the target market, the primary goal of this stage was implementing a main, clearly defined and stable service which could garner attention once on market. At the beginning, our partners at Inventec Corporation drew up online questionnaires to analyze the market trend. The opinions from the sales department were also critical input. After taking the market factors into consideration, we decided that diet control software for mobile devices, smart phones and smart pads was to be the new service we offered to the market.

The diet control software, named Fun Bento, is focused on office populations between the ages of 25 and 45. The typical lifestyle of the targeted population is sedentary with routine and busy workdays. They possibly have irregular dining times and eat a monotonous diet, but are health-conscious. Most of them rely on carryout food or inexpensive restaurants for their meals. Many among the population occasionally overeat and overdrink when being social, and many are concerned about their weight. Fun Bento took this all into account. The core service was rooted in TOUCH Doctor. It offered a nutrition data bank full of various kinds of food. Foods in convenience stores and popular chains were included in the database. Users could quickly record what they consumed, and the data would synchronize with the database in the cloud. Moreover, Fun Bento offered customized meal suited for different genders, health control purposes (weight control or balanced intake) and diet habits (fast-food junkie, lazy cook, and cooking by oneself). This software could also analyze not only the calorie absorption, but also the degree of eating a balanced diet. To provide real and helpful applications, we also added maps to nearby convenience stores.

According to the needs of the customized meals, the back-end platform needed expansion. After meeting with the members of the team compiling the nutrition information, the technical group adjusted the interface and the structure of the nutrition database. In this process, an integrated team was quiet critical; they needed to answer to the demands of technical and medical professionals and interpret the issues into executable steps, for example the coding issue, the column response issue and medical consideration of each item. Another part to coordinate was the user interface design. The layout took into account a combination of leading features in terms of marketing and visual communication design, while the visual content needed to consider the screen resolution of mobile phones in regard to the dynamic visual objects that were controlled by programs. During the coordination process, the collaboration during each development step was recorded. Figure 11 shows the completed project of TOUCH Doctor Apps up to this stage, named Fun Bento v1.0.

In the previous stage, our services could only serve a family. At this stage, however, the services were to be used by a larger number of people. As such, we conducted stress tests on the system to find problems or validate its success.

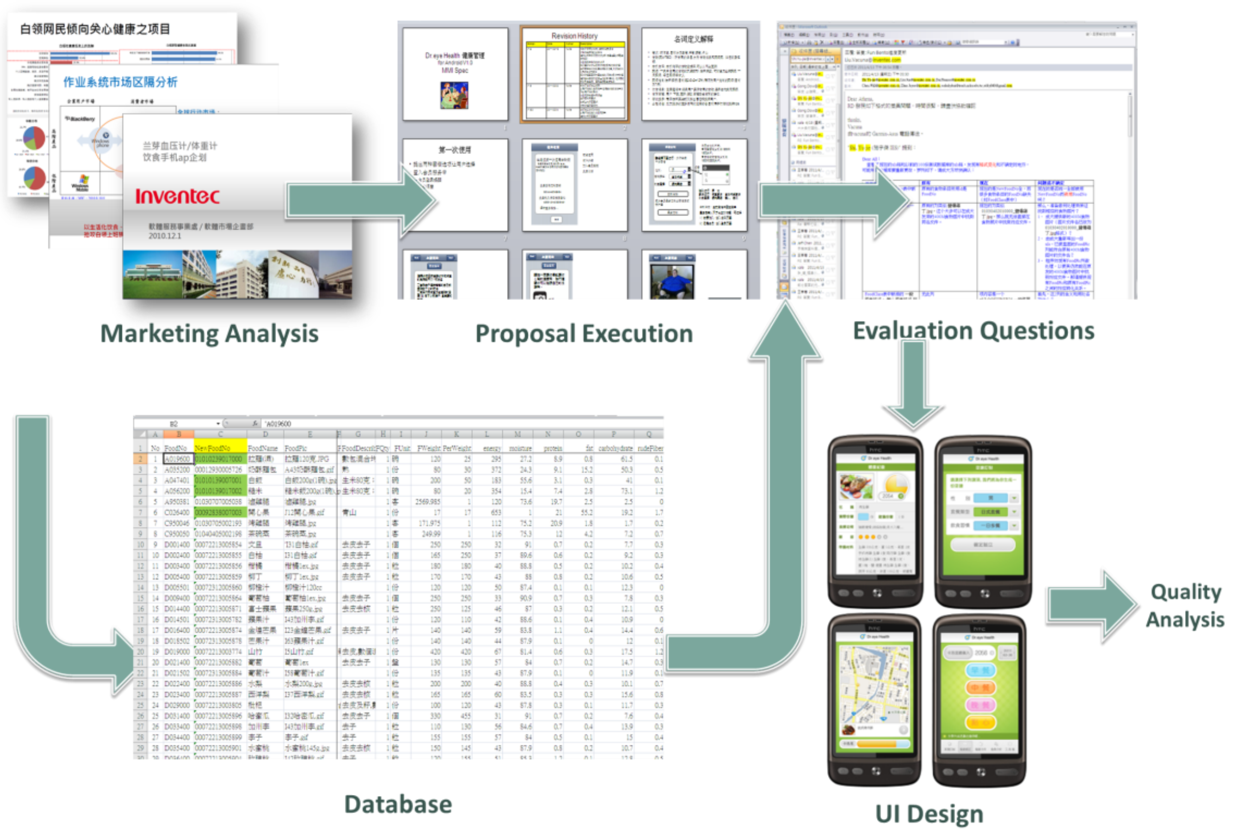

Figure 11. Major work completed during Phase III- process of product/service development.

(a) (b)

Figure 12. Feedback functions: (a) direct feedback (b) from Android market.

(a) (b)

Figure 13. Front pages: (a) the first version and (b) second version.

Figure 14. Process of KJ method for analysis of user feedback.

Phase IV: Market Launch

In the final stage, the developed services are taken to market. Though legal issues were the significant component of this stage; in the spirit of a living labs, user feedback was also quite essential.

After market launch, our service could enter the lives of the initial users. Through the Android Application downloading platform, called Android Market, users could leave their feedback and product rating directly. We also embedded a feedback function in the application which users could use to send opinions directly to the development team. In the second version of Fun Bento, we installed as feedback function in the system as shown in Figure 12(b). In total, 81 opinions were collected. As shown in Figure 14, we used the KJ method to analyze the user feedback. Excluding system mistakes, the major need mentioned was to expand the variety of food in the database since we did not include many popular local snacks. Additionally, many requested a calorie-burning calculator when exercising. In response, we have developed a prototype that is being tested by selected users, with a final service to be offered in the near future.

With ample user feedback, we were able to correct some problems with the user interface and functions of the proposed nutrition control service system step by step. Continuous updating, once again in the spirit of a living lab, is a way to answer to user problems and to make the product more successful. In time, our service will gradually improve and become a true “living” product and service. In response to user feedback, our next version will include a simple calorie-burning calculator and will have an expanded food database. To improve the usability of the service system, we need consider a package including doctor guidance, a healthcare system, as well as health measurement systems. Over time, we hope the cloud recoding system could be used to automatically collect personal food consumption data when users make purchases at cooperating stores or restaurants.

Discussion

In this paper, a living lab approach is highlighted in our development of a nutrition control service system. The user-driven open innovation with interdisciplinary teams as stakeholders played an important role for exploring needs, product/service design, product/service implementation, and market launch. The TOUCH Doctor is an innovative service with contributions from engineering and medical experts, as well as the users and the affiliated company. Within a short timeframe, the co-creative innovation was quickly realized into feasible human-centric services. Additionally, with collected open data, TOUCH Doctor successfully started its first service, called Fun Bento v1.0 in Android Market for a usability test. Extended health services to complete the whole picture of TOUCH Doctor will become possible in the future. To improve the usability of the service system, we need to consider including doctor guidance and more complete health-measurement systems. The establishment of the open platform will be considered in the near future. Additionally, our nutrition information came from our engineers. However, in the future, we could establish an open platform that allows trusted users or food companies to add to the nutrition data bank so that the nutrient control services can provide more complete coverage.

Conclusion

This article presents the development of the nutrition control service, called TOUCH doctor. The process presented can serve as a good example of creating a “living” service under a living lab methodology. At the onset, we put an idea probe in a contextual showroom to inspire the visitor feedback. In this way, we collected divergent, unstructured but innovative ideas. Aspire Home was just like a springboard for imagination where visitors could offer their vision for the product. Good ideas, however, do not necessarily get actualized without evaluation and proper supplementary measures. The ideas were refined by relevant stakeholders, such as the technological team and medical team. From interdisciplinary contribution during the conceptualization phase, possible solutions were assembled and became the core traits of the prototypes that could be used. A highly integrated cooperation process existed in the third development phase. Interdisciplinary communication and project execution were the primary issues at the stage. To make the process more clear for all parties involved, execution proposals were issued for all stakeholders to use as a blueprint. In the first three stages, living labs delivered abundant undefined ideas, corresponding executive strategies, and integrated solutions. In the last phase, we carried out the assembled services in the lives of lead users with the open innovation platform. The living lab approach was crucial in finalizing the products and services.

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