The Transformation of Users in Living Lab Construction: The Case of Eco-City Living Lab

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Abstract: To promote the development of user-oriented technology, different approaches are explored, with living labs being one of the most promising. This paper introduces the strategies in making of a community-based living lab with a specific focus on the users. We introduce the practical mechanisms built in a community environment and the methods to facilitate user innovation. We also report a case study of the users' response to a health care technology, finding out that most of the users did not change their opinion after a year's use. The major finding is on the dynamics between living lab construction and the transformation of the users. We reflect on the phenomenon of a living lab itself transforming the users and making it difficult for them to provide specific opinions of the technology.

Keywords: Living Lab; User; method; user transformation; open innovation

1. Introduction: What Is a Living Lab?

As the name implies, a living lab brings the scientific experimentation process into everyday life, or rather transforms everyday life into an experimental context to promote discovery and change. From the perspective of technological development, whether the living lab is seen as a mechanism, a method, or a metaphor, the hope is that it can integrate technological development and its applied services with the actual lives of people. However, as it is still in the stage of formation, the concept of a living lab is constantly changing through the process of interaction among different fields. A review of relevant literature reveals that reports on the subject of living labs are broadly distributed across the fields of building design, urban planning, organization research, technology management, requirements engineering, and man-machine interaction [1-6]. As living labs emphasize the social aspect of human life, research methods from the humanities and social sciences are applied, and anthropological and sociological researchers are involved [7-10].

Among building projects, living labs are commonly applied to *smart living* projects, where information and communications technology (ICT) is the key component. Here, the key questions include how ICT can be effectively applied in smart living projects by facilitating expectation and awareness of the changes brought about by ICT. Furthermore, it needs to be understood what it means for ICT to "have intelligence" and realize smart living. Researchers and investors in the field of ICT have quickly learned that not all ICT products are equally "smart," and do not have the same commercial or social potential. Surveys have shown that among investments in ICT products and services, as much as 70% to 90% (the percentage did not change among different surveys) of the research plans could not be commercialized [11]. It seems that technology that is extremely smart in the lab might not be so smart in everyday life. This situation stems from traditional engineering research approaches not taking real life conditions into account. In other words, when they are "matured" in a closed laboratory system and step into the complicated real life, most ICT technologies encounter difficulties.

This is a major concern in Europe. It is argued that the means (upstream to downstream linear model) and objectives (feedback, complex, or ecology models) of technological development are inconsistent; this leads to the so-called "European paradox" in technological development: how some European countries may have a leading position in the area of technological development, but cannot successfully transform that into commercial success [12]. Consequently, European countries, the European Union, and some major European technological companies (such as Atos Origin, Nokia, and Ericsson) are developing strategies to overcome this paradox in the early 21st century. Most of them are establishing collaborative working environments or platforms for industry, academia, and government in order to accelerate open innovation in real-life contexts – the so-called living lab.

2. Configuration of Users in Living Lab

This paper addresses the issue in the context of Taiwan. We illustrate our experience in building the Eco-city Living Lab with a special focus on user participation and transformation in the development of ICT technologies at the Shuxia community in Hsinchu City. In the following, we discuss the complexity of users in living labs, lab construction, and the transformation of the users.

2.1 Users in Living Lab

Why are the users in living labs so special? Based on the operating styles and goals of living labs, we summarize three major characteristics of the users of living labs.

- **Collective users:** Compared to regular usability testing during technology development, living labs involve a considerably larger amount of users. This stems from the objectives of ICT products or services. Instead of being limited to one-on-one operation between an individual user and a device, current development of ICT involves community communication, such as remote medicine. Moreover, the structure of the technology itself covers multiple users, such as traffic reporting systems in a city. Therefore, establishing a living lab usually requires an organization, community, or even a city as its basic unit. Particularly when ICT is expected to be applied in public services, citywide scale is the fundamental requirement. For example, the goal for establishing the Copenhagen non-profit organization Living Labs Global was to advance the application of mobility technologies in cities. In this sense, the users involved in living labs are various kinds of collectives.
- **Real-life Users:** Related to their community-based characteristics, living labs recruit users in a real-life context. This is why the results from living labs are different from those of questionnaire analysis and laboratory-based tests. Unlike questionnaires and tests, simulating the living situation of users is unnecessary in living labs, because the experimentation is actually conducted in everyday life. The conventional variable-manipulation experiment method does not fit contingent real-life context. Living lab researchers must be more sensitive to the emerging complexities in the real life process and regard them as crucial findings instead of as errors or interferences in conventional experiment method, especially when they show the misuse and abuse of technology by users unexpected by the researchers.
- **Active users:** In living labs, users no longer passively accept instructions from researchers; they are no longer "respondents" or "tested subjects." In contrast, living lab users can actively

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inform the research team of their own ideas and their participation can contribute alternative implications of the technology, even to the extent of transforming the direction of research. In other words, living lab users participate in the development process and explore the possibilities with the R&D team.

2.2 Eco-City Living Lab

Since 2007, Eco-City, one of the three smart living interactive innovation centers initiated by the National Science Council in Taiwan, has recruited various on-going projects for the construction of a living lab, among them being a community living lab at Shuxia community. Figure 1 shows the formation process of the Eco-City living lab, which mainly involved multiple strategies and three main stages. Since the concept of living lab is innovative and there is no established procedure to follow in building a living lab, our team developed Shuxia living lab step by step by trying many strategies. The development follows a sequence of preparation, contact, and building platforms in order to develop a working mechanism and relationship with the community. Because the development of a living lab and users' lab were intertwined in this case, Figure 1 shows them combined. The discussion which follows, however, will focus on the living lab.

The main task at the first stage entailed searching for a suitable community for the experiment. At this stage, we built a database of the entire community in Hsinchu, surveyed the literature of the current living lab building approaches and methods, contacted various communities, and investigated the possible working mechanism of the communities. The purpose was to find the plausible methods, reliable mechanism, and suitable communities for our lab building.

The main task during the second stage was establishing a relationship with the chosen community. A living lab is a social space where technologies and services interact with community. Every community or social group has its agenda and concerns. Sympathetically understanding the expectation of the communities is not only helpful in developing technology in real life, but also a necessary preparation for establishing a living lab with local characteristics. At this stage, we prepared and developed a standard operation procedure (SOP) for community contact and technology implementation.

The third stage involved establishing mechanisms for the community to provide feedback of user experiences. We devised two categories of platforms according to the development direction. One is specifically oriented toward a specific product or service, whereas the other is for open innovation not aimed at a specific product or service but, instead, freely allows users to use their creativity actively by encouraging open innovation.

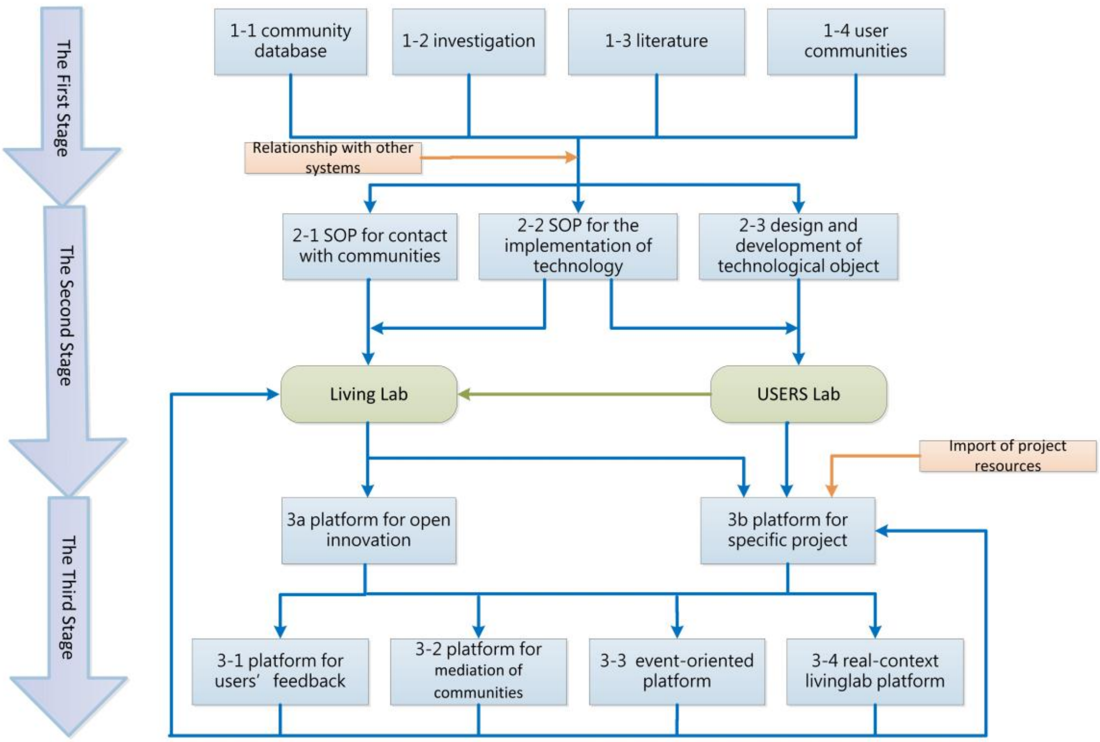

Figure 1. The Strategies of building Eco-City Living Lab.

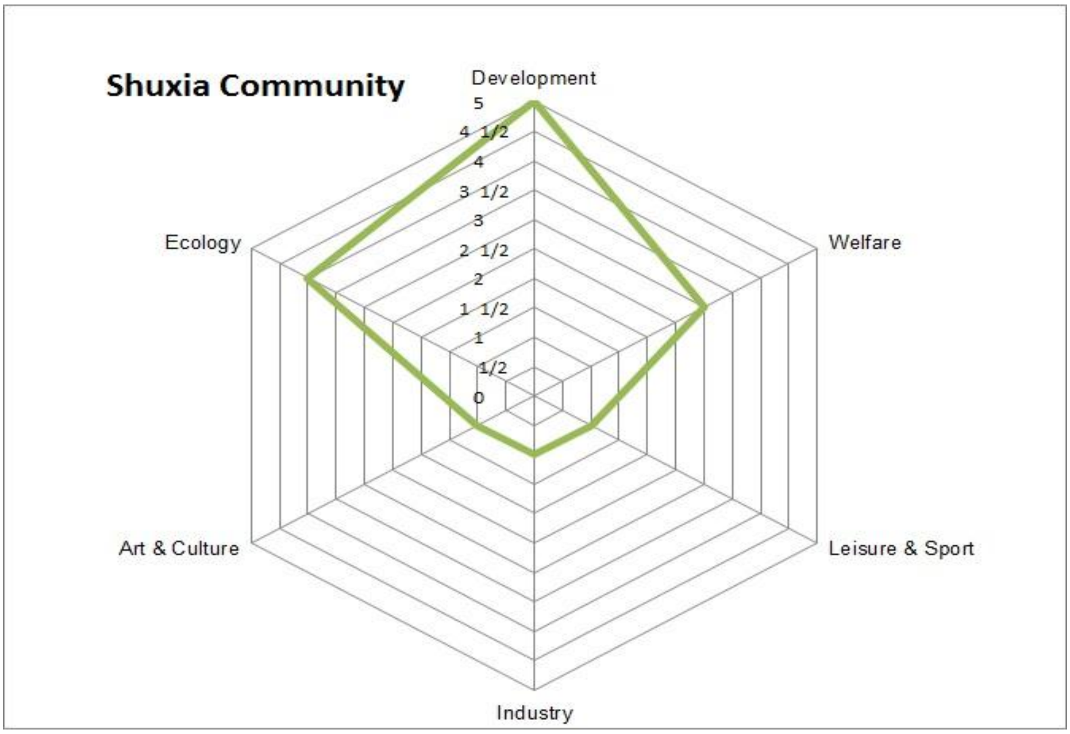

Figure 2. Radar Chart of the Shuxia Community in Hsinchu City.

The following section describes an actual community operation of a living lab, established through the cooperation of Eco-City and the Shuxia Community of Hsinchu City.

3. Construction of Living Lab

3.1 Working with the Community

In the community database established for the living lab, we identified the characteristics of the 120 communities in Hsinchu according to six dimensions based on publically available information and preliminary interviews (Figure 2). The six dimensions are: community development, welfare, leisure and sport, industry, art and culture, ecology. A dimension is measured by the number of groups in the community in each dimension. The differences in dimension provide information of the strength and possibility of developing relevant technology. Each community has its distinctive radar map with all of its information.

After review, the Shuxia Community was chosen for our program. It is located in the Xiangshan industrial area, south of Hsinchu. The community is populated by members of the Minnan ethnic group, has 2,432 residents, and has approximately 150 people involved in community volunteer work. The community was originally a mixed agricultural and industrial area, but traditional industries have gradually relocated in recent years, and the nearby farmlands are all contaminated by heavy metals, making it a community without many resources. Shuxia Community's particular characteristics regarding the orientation radar chart emphasize community development, environmental protection, and social welfare. The Shuxia community was chosen because of its active community development and open-minded leaders. In the initial contact with the volunteers and seniors in a care center, we felt that the people had high regard for action and expectations of the orientations of community development, social welfare, and ecological recovery. Also, the simple fact that this community had established a care center and weekly activities for seniors fits well into our purpose of developing healthcare devices for senior citizens.

At the onset, we introduced prototypes of three smart living technology: a smart community healthcare system (Caretogether & i-Heart), the i-Bike bicycle game/fitness platform, and an interactive digital picture frame for seniors. Of these three technology products, the i-Heart smart community healthcare system was widely used and accepted by the community volunteers and seniors. As such, we have the most detailed observation and interview reports from this technology. The feedback included how to use the device to perform health checks, the material of the sensor pads, how to apply it in everyday life, and which groups could benefit from its use.

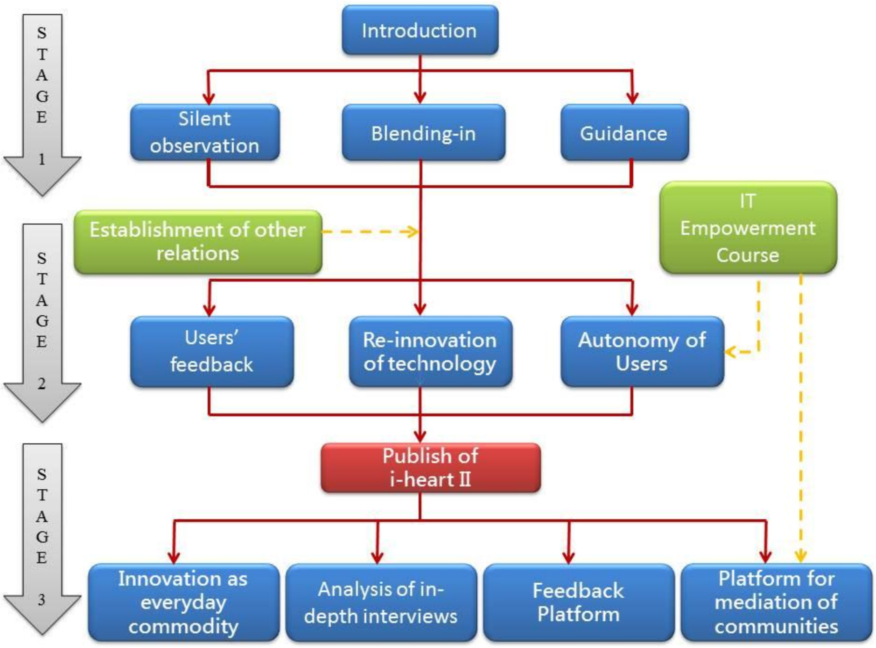

Figure 3. SOP for a technology to enter the Living Lab.

(a) (b) (c)

Figure 4. (a) a volunteer helps the seniors use i-heart Image 2; (b) the user interface of i-heart; (c) living lab researcher interviewing a volunteer.

3.2 Entering the Living Lab

The integration of the technology into the Shuxia Community can be divided into three stages (Figure 3).

The first stage of integration involves establishing a suitable relationship with the local community. Initially we blended into community activities in silent observation. We joined the scheduled activities at meeting times and observed how the care station volunteers and seniors learned and shared knowledge. We also took note how everyone approached novel issues and devices, and through this identified suitable users for further study. Regarding guidance, after introducing the technology into we guided the community volunteers in how to use the smart living technology products, and helped the seniors to use them as well (Figure 4 (a) and (b)).

The second stage of integration involved collecting feedback form users. We observed and interviewed volunteers of their personal use experience, eliciting ideas on how the product could be used in daily life (Figure 4 (c)). After collecting users' opinions, we recorded and analyzed the state of the technology application. The living lab team, community users, and the technology team engaged in open communication, discussing and evaluating the feasibility and practicality of improving and applying the technology. In this model, the R&D team collected feedback, and accordingly improved the interface and the integrated application of the technology. After the modification, the R&D team worked with the industrial team to design a prototype product.

At the third stage, we conducted further in-depth interviews and observations with key users. There were a total of five users among the Shuxia Community volunteers who could independently operate the smart living technology products provided by Eco-City. They also took the smart living technology products home and tried combining the smart living technology with the concept of a health checkup, as well as displayed it to their family and friends. For nearly six months, we went to the community and interacted with the users each week. In addition to listening to the opinions of the volunteers and seniors, we conducted individual interviews with the care center volunteers. Furthermore, the living lab team and the volunteers discussed the creation of the opinion feedback platform and community intermediary platform, the Shuxia Community Fan Club, to record and display the study, as well as to understand and internalize the behavior trajectories of the users over the long term. This platform combined the experiences and suggestions of academics, the R&D team, and users to engage in a multi-party discussion. The R&D team can then use the platform's records to reveal new ideas from the different parties. The Shuxia Community volunteers, meanwhile, can use the platform to share their experiences of applying the technology in the activities at the community care center, such a keeping medical records for the seniors and themselves.

3.3 Methods for Involving Users and Collecting Feedback

The Shuxia Community care center has weekly assemblies and scheduled events. We introduced the prototypes of technologies to the volunteers and seniors during the assembly activities. According to the center schedule, volunteers worked with the seniors from 8:30 a.m. to 12:30 p.m., guiding groups of them to interact with that week's instructor. During this time, they were able to help the seniors use the i-Heart and Caretogether products to perform health checks.

In the beginning, we mainly engaged in silent observation. By observing the product use behavior and attitudes of the volunteers, as well as their interactions with the seniors when performing health checks, we learned about the organization and culture of the experiment site. Since researchers may interfere and change the behavior or ideas of the research targets, reducing the level of interference at the beginning of the observation is crucial for understanding precisely what the participants are doing in a real-life context. Therefore, the researchers only played a supportive role at the beginning.

Gradually, the distance between the community and the researchers was narrowed through the service and assistance provided by the researchers. For example, the volunteers were not particularly familiar with computer equipment and they often forgot steps in the operation process. In these cases, we guided and communicated with the volunteers so that they could gradually grasp the computer basics. Step by step, we also found ways to help the volunteers to document every detail of their activities when using the technologies in the community care center through blogging. This not only made them active, but also let them enjoy their involvement in our technological development. Over the course of the process, we interviewed users and kept a chronicle of the trajectory of how users felt about using the technologies, especially when they encountered difficulties or had special findings.

4. The Transformation of Users

4.1 Users' Behavior Trajectories

In order to understand the transformation of users' behaviors and intentions, we recorded their behavior trajectories through observation and in-depth interviews. The corresponding action and events, as well as the users' transformation in general, are shown in Table 1. Their trajectory, from onset to completion, was divided into initial contact, exploration, bonding, internalization, integration, and expansion. One of the major differences of the general trajectory is that we made effort to bond with the community members after the period of silent observation to boost the community's participation in using the technology. The differences in individual users and types of transformation revealed through in-depth interviews are presented in a user orientation chart (Figure 5).

4.2 Trajectory Types

In total, we collected feedback from 15 volunteers and 50 seniors from the care center. The volunteers were around 70 years old and the seniors' ages averaged 83 years. The ratio between female and male was 4:1 among the seniors, 2:1 among the volunteers. Because most of the seniors were not active in using the technology and most of their responses were merely focused on the the care and attention they had from the technology team and living lab team, we decided to focus only on the volunteers.

Based on observation and interviews of the volunteers, we devised four orientations of user participation in terms of attitude (divided into the approving and doubtful types) and practice (divided into the exploring and passive types). The green marks on the chart represent men, and the red marks represent women. The triangles represent people who prefer independent practice, whereas the round shapes indicate those who prefer working with others, i.e. "connectively".

Table 1. The History of Users' Behavior Trajectories.

Time	Action and event	User behavior trajectory
Apr. 2010	Eco-City sent specialists to describe the smart living technology product's functions, significance, and long-term vision.	Initial contact
May 2010	1. Eco-City specialists guided the volunteers to study how to use the product during the community care center gatherings. 2. Care station volunteers studied how to use it and helped the seniors perform health checks. At that time, only two users understood the product's use and could operate it independently.	Exploration
Nov. 2010	Living Lab research assistants visited and participated in community care center activities. By using silent observation and We put more effort in bonding with the users by helping them with the computer and community work.	Bonding
Jan. 2011	1. Volunteers caring for seniors all understood the product operation mode and how to apply it in real life. 2. Most of the volunteers only understood the health check procedure and how to judge the data analysis after the health check data was uploaded, but not how to use the computer to upload the health check data. 3. Because of the division of duties, only the same two users understood the product use and could independently operate it at this time. 4. Based on the observation and initial interview, almost all of the volunteers and the seniors knew how to use the computer for e-mail and news only.	Internalization
Mar. 2011	1. Those that could independently operate the product at this time included a total of five people. 2. Three volunteers took the smart living technology product home to share with their family.	Integration
May 2011	A total of six family members of the volunteers became long-term users.	Expansion

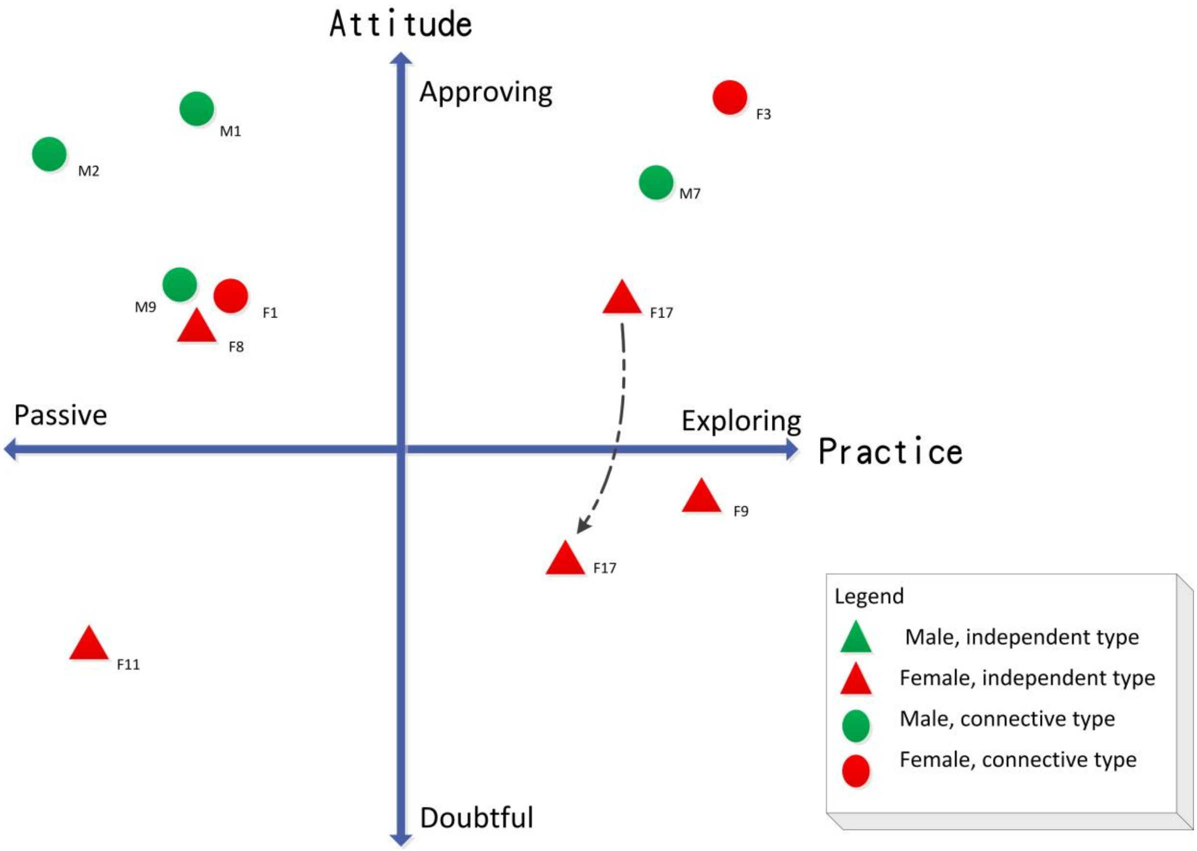

Figure 5. User Orientation Chart.

Analysis of the behavior trajectory of the **approving-passive** types shows that this kind of user knows how to use the technology and they think this technology can help others to monitor their health situation in daily life (approving). However, when they encounter difficulties or receive erroneous information, their attitude is to wait for someone to help them to solve the problem. They do not try to figure out what happened when the sensors reported difficulties. The **approving-exploring** type has a high level of identification with the product and thinks of ways to solve problems when encountering difficulties in operating the product. The **doubtful-passive** type has doubts about the technology and being passive in performing the health checks, not to mention tackling difficulties. The **doubtful-exploring** type has a detailed understanding of the product, and despite having doubts about the effectiveness and future of the product, they are active in finding ways to improve it.

Figure 5 shows 11 cases of significant responses from 10 volunteers (five of them did not show a significant response). Of these 11, five were of the approving-passive type, three were of the approving-exploring type, two were of the doubtful-exploring type, and one was the doubtful-passive type. When analyzing the volunteers' use history, we found that one user (F17) changed from being an approving-exploring type to a doubtful-exploring type. The reason stemmed from her having a history of heart problems. The first time she heard of the i-Heart, she had the highest approval level and expectation. However, when we discussed with her why she changed her mind about the product, she said that the i-Heart was still in the experimental stage and its functional settings and analysis reporting were still not adequately reliable for making instant judgments. She was disappointed that a doctor could not accept the test results. However, she still continued to use the product to perform health checks because she hoped that, in addition to helping her understand her own health situation, she would be able to make suggestions for improving it so that the product could be used to care for the health of the community's seniors.

The following specific cases show interesting results that, after illustration, will allow for a better understanding of the users. Case one – **Not as simple as it seemed** – involved a volunteer at the care center. She was deemed as one of the active users of the i-Heart, collecting and uploading health check data. In life as well, she is an active person who dares to accept new information and discover new applications. At the center, she enjoys taking pictures and using her camera to record the activities and scenes of the care center and posting them in an online album to share what she sees as beautiful experiences.

During the time of the living lab experiment, she was often seen walking back and forth between the data laptop and the seniors. She actively reported problems and experiences to us. For instance, on one day when she saw the researchers, she could not wait report, "Let me tell you. This week, my son-in-law looked at his health check results, and then we checked it against the test results in the database from March to June, and it really was accurate!"

Although it took her two months (four days a month for four hours a day) after first being introduced to the i-Heart to actually start using it on her own, she was enthusiastic. When being asked why she promoted the i-Heart with such enthusiasm, she replied, "Our health is so important. Since this product is available to help us understand our own health, we might as well try it!"

Case two – **Community-based remote health care has a long way to go** – involves a female user who was the first person to use the i-Heart to collect and upload health check data.

She is a retired quality control engineer who worked for an electronics firm in the Hsinchu Science Park. At first, she approved of the vision of the technology. Ultimately, however, she reported that "the community-based remote health care system has a good design, such as the database's data accumulating interpretation reference data so it can give an accurate interpretation based on the individual factors of the subject (such as age and past medical history), but evaluating it in the overall environment, its use as an onsite community-based local community health care system, still has a long way to go." When being asked why she felt this way, she said, "This system needs a large amount of medical resources to support it, but will the hospital be willing? Hospitals of all different levels all have their own operational considerations, and personal medical information is only stored in the database of the hospital where treatment is received. There is no way to connect to a national medical system to get personal medical information. And what about the legal issues? Also, how will the equipment be linked together? These problems need long-term consideration, so that's why I say there's still a long way to go!"

4.3 Discussion

These findings indicate the dynamics between living lab construction and the transformation of the users. Compared to the difficulties and complaints we observed and received from the users, the positive evaluation from the users reveals a discrepancy between our observation and users' opinion. Taking the distribution of the cases in orientation chart, as well as the cases highlighted previously into consideration, we have reached some preliminary conclusions regarding the transformation of users in the living lab. First of all, the importance of specific personal experience is clear. In the above cases, we see that only when a user had very immediate and specific needs, she had specific concerns and requirements for the technology and ended up in disappointment. In this sense, this shows the limitation of integrating the use of technology in a community because there might not be so many users with specific need for the technology, in contrast to recruiting individual target users into a test. This is the dilemma of living lab.

Secondly, we noticed that apart from the user highlighted above, the other users do not change their opinion. This actually indicates a problem. As discussed above, one of the advantages of living labs is that the users in a real life situation will bring the complexities of life into technology development. However, in this case most of the users remained the same throughout their participation, meaning that their experiences with the technology are pretty much determined by their previous experience and assumption of the technology.

Thirdly, there is a problem in the transformation of the users in our case. Ideally, making a community living lab will benefit technology development by bringing in the collective, active, and real life users. Most important of all, we can evaluate the transformation of the users before and after the introduction of technologies and services so as to improve the technologies and services. However, the above discussions indicate that perhaps the transformation happened long before the technology was introduced. Especially in this case where most users are not familiar with ICT technology, the seniors and volunteers had positive responses to the technology partly because that they felt that they were being better looked after and that their opinions were particularly appreciated. Despite being careful in incorporating the technology into their local practices (in order to fit in to the real community life) and using subtle methods to blend into the community rather than to change it, the fact that the community was chosen to be a site of living lab made a difference. Users immediately felt the difference and they mainly thought of the positive implication of our intervention. They even talked to other community groups and leaders that they are working with Eco-city on an important project. In the end, we realize that we observed the users' response to being part of the living lab, rather than their experiences of the technologies of the living lab. In a sense, it is not building a living lab with the users in real life into living lab, but rather that the living lab transformed the users' living context.

5. Conclusion

This paper introduces strategies in the making of a community living lab in Hsinchu city with a specific focus on the users. We introduce the practical mechanisms built in a community environment and the methods for collecting feedback and involving users to facilitate user innovation in health care technology. We also report a case study of the users' response, finding out that most of the users did not change their opinion of the technology during a year's practice. We reflect on a phenomenon where a living lab itself can transform the users and make it difficult for the users to provide specific opinions on the technology. Despite that, users did provide useful ideas for improving the technologies. We noticed the problem that only a limited number of users had substantial expectations and need, the users' opinion was determined by their expectations and previous experiences of the technologies, and that the users were transformed in the making of a living lab and lost their real life context. It is hoped that ours experience will be helpful to the further development of community-based living labs.

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