Initiation of the Suan-Lien Living Lab – a Living Lab with an Elderly Welfare Focus

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Abstract: This paper presents the initiation of the Suan-Lien Living Lab. The Suan-Lien Living Lab was established by the Center of Innovation and Synergy for Intelligent Home and Living Technology (INSIGHT Center, National Taiwan University) in the Suan-Lien Elderly Care Center, in north Taiwan in 2009. This paper presents the three key steps to launching the Suan-Lien Living Lab. The first step is to reach a mutual understanding and position of trust while recording and analyzing the data of target users, the second step is to create a protocol facilitating each test process, and the third step is to conduct tests under a sustainable operation model. This paper also summarizes the lessons learnt during the process, suggesting that the five major key success factors are: (1) high involvement of users, (2) versatile forms of communication, (3) effective conversion of tacit knowledge, (4) the building of a multi-disciplinary team, and (5) cohesion of stakeholders. Challenges and future development of the Suan-Lien Living Lab are also fully discussed. This paper also describes two example projects conducted in the Suan-Lien Living Lab. From these projects, we identified the challenges faced by the Suan-Lien Living Lab and its future development.

Keywords: Living Labs; Ageing Society; Healthcare; Assistive Technology; Co-creation; User Participation

Background of the Suan-Lien Living Lab

The need for intelligent products and services for elderly care

As medical technology advances and economic development matures, population structures have significantly changed. Substantial expansions of the elderly population have helped create what may be called an ageing, or even super-ageing, society. According to statistics compiled by the Ministry of the Interior Taiwan, due to a structural change in traditional family systems, the elderly will account for more than 10 percent of the population by 2011, and over 20 percent by 2031, outnumbering the youth.[1]Consequently, Taiwan will change from an ageing society at present to an aged society in 2017, as predicted by the Council for Economic Planning and Development (CEPD). [1]

This phenomenon is also common in other countries, particularly across Asia, where the number of people aged 65 and above is expected to increase dramatically. For the region as a whole, the population in this age group will increase by 314 percent, from 207 million in 2000 to 857 million in 2050. [2] India, for example, is already struggling to support a current ageing population of 81 million people, and that figure is expected to have more than doubled to an estimated 177 million by the year 2025. Constant decline in fertility rates also aggravates the situation; in the developing world as a whole, fertility rates fell by half (to 3) in the 50 years leading to 2000. In 2009, the total fertility rate (TFR (total; a measure of the number of children a woman can expect to bear in her lifetime) was 1.22 in Singapore, 1.15 in South Korea, and 1.04 in Hong Kong. [3] In the face of growing demographic imbalance, the issue of elderly healthcare provisions attracts attention. In Taiwan, many academic studies currently focus on the healthcare

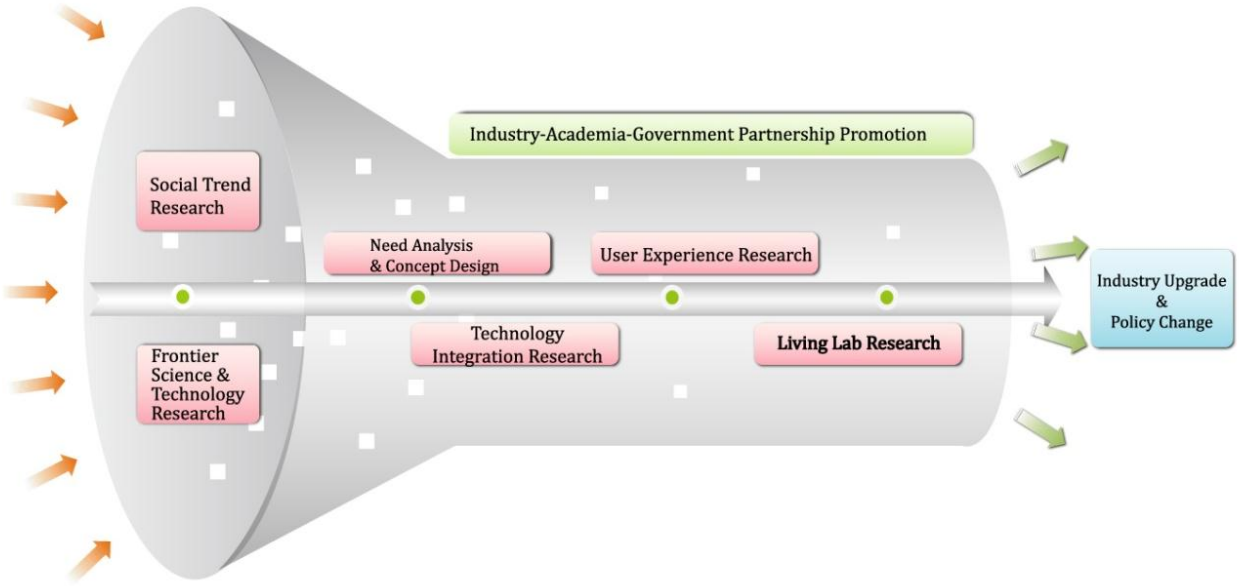


Figure 1. Development strategy of the INSIGHT Center.

workforce and medical service delivery. Technology utilization to improve health conditions among elderly, and resource integration to create new forms of well-being products and services are still emerging research fields.

Profiles of the INSIGHT Center and the Elderly Welfare Promotion Group

Founded by the National Science Council and sponsored by prominent private enterprises, the Center of Innovation and Synergy for Intelligent Home and Living Technology (INSIGHT Center, National Taiwan University) aims to promote the wellbeing of the elderly's lives while capturing social trends, identifying needs, and securing market entry points. As a domestic synergetic organization in Taiwan, the INSIGHT Center has integrated resources from academia, government, and industries, devoting itself to international and interdisciplinary cooperation. The INSIGHT Center aims to be on the cutting edge of innovative elderly technologies, establish innovative paradigms, and act as the trigger for transformations of industry and wider social practice. For the above purpose, the INSIGHT Center founded the Elderly Welfare Promotion Group to explore hidden needs of the elderly, and to develop elderly welfare products and services, which not only improve their quality of life, but also can be used by the elderly independently.

In order to promote the innovation of products and services needed and desired by the elderly, the Elderly Welfare Promotion Group signed a cooperative agreement with the Suan-Lien Elderly Care Center for the establishment of the Suan-Lien Living Lab. As a platform for multi-disciplinary elderly product and service innovation, the Suan-Lien Living Lab practices user participation in the early stages of product development, facilitates cooperation between industry and academia, and upgrades industries in healthcare, nursing, entertainment, and information technology fields.

Concepts of a Living Lab

'Living Lab' refers to a user-centered, open-innovation ecosystem [4] or a systematic approach, co-created by users, integrating research and innovation processes. According to the definition given by Professor William Mitchell, a Living Lab represents a user-centric research methodology for sensing, prototyping, validating and refining complex solutions in multiple and

Dr. Shih-Chung (Jessy) Kang focuses on researching and developing visualization and robotics tools to solve problems that commonly occur in design and construction processes. In 2005, while working toward his doctorate at Stanford University, Dr. Kang developed the iCrane software system to simulate and render autonomous cranes. In 2007, Dr. Kang and his students developed Erection Director, a system in which physics-based crane models simulate details of erection activities. He later collaborated with industrial partners in studying the application of 4D and BIM management tools in practical construction projects. In 2008, Taiwan's National Science Council awarded Dr. Kang a 3-year project grant to develop an autonomous robot for pavement inspections. In 2009, he was awarded another project grant from the Taiwan Water Resources Agency to develop a decision-making system for disaster prevention and recovery. Recently he began broadening the scope of his research. He currently participates in two multi-disciplinary research projects; a computer-based training platform for surveyors (SimSurvey), and an electronic therapy system for insomnia (Sleep Coach). Beginning in 2010, Dr. Kang began serving as the director of the elderly welfare promotion group of the INSIGHT center.

evolving real life contexts. The idea of a Living Lab has prevailed in Europe and at present several Living Lab descriptions and definitions are available from different sources. [5-7] Living Labs often operate in a territorial context (e.g. city, agglomeration, region), [8] integrating concurrent research and innovation processes within a public-private-people partnership. [9] Living Labs are also recognized as a multi-contextual research approach utilizing existing technology, which is closed to the market in order to develop community-driven innovation.

The Living Lab emphasizes the involvement of users in the early stages of research and development processes. In Living Labs, users contribute to product/service innovation actively and continuously, as based on their social and cultural experiences. It can be said that Living Labs facilitate regional innovation in a global framework. The differences distinguishing the Living Lab from traditional experimental tools lie in the multiple aspects and outstanding ability to interact with users that the Living Lab approach provides. Through the Living Lab, researchers are able to observe and understand user behavior patterns, even those that are not immediately obvious. A Living Lab helps bridge the gap between the conception of a company and that of a current market, resulting in products more in line with the demands of end customers. Their use can also help industries reduce costs associated with making poor decisions in product/service development, and find new technological solutions to social, cultural and economic paradigms.

Living Lab developments across the globe

In Europe, many organizations promoting the concept of the Living Lab have been established. The European Union has also shown its support of large-scale international cooperation projects through the implementation of the Framework Programme. [10, 11] In 2006, the European Network of Living Labs (ENoLL) began to offer a unique and efficient platform in initiating cross-border cooperation, and finding new project partners. [12] To date, over one hundred Living Lab projects have joined ENoLL, including Living Labs from Europe, North America and Asia.

The Living Lab concept can be realized in many fields, including healthcare, environmental protection, energy saving, governance, and urban services. Issues derived from an ageing society are various; physical and mental health, entertainment, and social adjustment of the elderly are well documented globally, making home-care and community-based elderly care a promising business. Indeed, many elderly care innovation Living Labs came into being as a result. TRIAL (Translating Research and Innovation Lab) [13] in the United Kingdom, for example, supports research and innovation activities across several key disciplines, including business, information and communication technologies, occupational therapy, healthcare, social care and clinical medicine. [14] CO-LLABS is another example; as "Community-Based Living Labs to Enhance small and medium enterprises (SMEs) Innovation in Europe", CO-LLABS develops specific pilots for Living Lab-based SME innovation in domains such as e-health, aiming to achieve European-wide adoption of ICT-based Living Lab services and practices in order to allow SMEs to improve their innovation capabilities and processes, and become part of “open innovation” environments. [15]

In Taiwan, leading research institutions such as the Institution for Information Industry (III) and the INSIGHT Center, which recognize emerging trends and anticipate future development directions in time to meet market demand, [16] have started to study the Living Lab methodology and its application to business models, and have even trial-operated the field practices. The Suan-Lien Living Lab, founded by the INSIGHT Center and Suan-Lien Elderly Care Center in 2009, is a pioneer as the first long-term elderly care innovation Living Lab in Taiwan. Residents in the Suan-Lien Elderly Care Center, also regarded as target users of elderly care products and services, have also joined different Living Lab projects, co-creating elderly care product and service innovation.

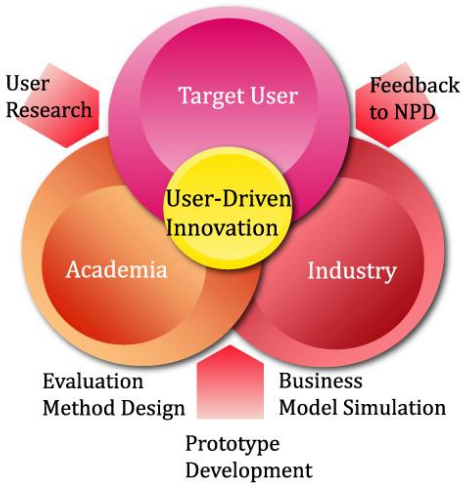


Figure 2. Constitutive elements and stakeholders of a Living Lab.

Figure 2 illustrates the constitutive elements and stakeholders of the Suan-Lien Living Lab. As shown, target users, industrial partners, and academia are the three major stakeholders involved in the Suan-Lien Living Lab. Representing academia, the INSIGHT Center contributes to user research, practices field tests with the Suan-Lien Elderly Care Center, and collaborates with

Figure 3. Suan-Lien Elderly Care Center.

Table 1: Steps to initiating the Suan-Lien Living Lab

Step	Period	Goal	Method
Understanding	Month 1–3	• Identify the possible risks and mutual benefits between the Elderly Welfare Promotion Group and the Suan-Lien Elderly Center. • Increase the interaction between INSIGHT researchers and the residences in the Suan-Lien Elderly Center.	• Use the pilot projects to familiarize elders with the Elderly Welfare Promotion Group. • Set up Sung University to gain the understanding and trust among elders.
Protocol	Month 4–6	• Build a protocol to establish a sustainable cooperation between the Suan-Lien Elderly Center and the Elderly Welfare Promotion Group.	• Construct a standard process composed of proposal, examination and pilot study.
Operation	Month 7–	• Introduce real cases to validate the proposed protocol. • Set up a final examination of the pilot study.	• Conduct user and scenario tests to analyze the habits of users. • A real-life testing environment and long testing time to truly find the preference of users.

industries to develop innovative prototypes, simulate business models and construct evaluation methods. On the other hand, residents in the Suan-Lien Elderly Care Center actively proffer feedback to user researchers and new product development processes. As the target users, residents help realize user-driven innovation.

Profile of the Suan-Lien Elderly Care Center

Founded by The Presbyterian Church in 1990 and located in Sanzhi, New Taipei City, the Suan-Lien Elderly Care Center is one of the biggest and most well organized elderly care centers in Taiwan. The Suan-Lien Elderly Care Center has provided versatile services, including nursing care, dementia care, mental health care, community care, hotel service and learning programs, to the elderly, their families, and the neighborhood community since its inception.

The Suan-Lien Elderly Care Center currently accommodates 432 permanent residents, with a mean age of 82. Of these, 154 live under special nursing care, and 66 are dementia patients living under unit care, a positive individual care service. [17, 18] The Suan-Lien Elderly Care Center is characterized by professional staff, a sound medical service network, open outdoor space, and specialized user-friendly designs. It also integrates resources from the community, builds efficient links with community service systems, and contributes to industry-academia cooperation by co-creating innovative elderly care products and services.

The Three Steps to Initiating the Suan-Lien Living Lab

The Suan-Lien Living Lab follows an original model (See Figure 4), which is comprised of three steps – understanding, protocol, and operation – in initiating Living Lab projects. Differing from other Living Labs, the Suan-Lien Living Lab takes advantage of the bottom-up approach. Beginning by running small projects, researchers enhance the trust and understanding of users, while consolidating their collaborative relationship with the Suan-Lien Elderly Care Center.

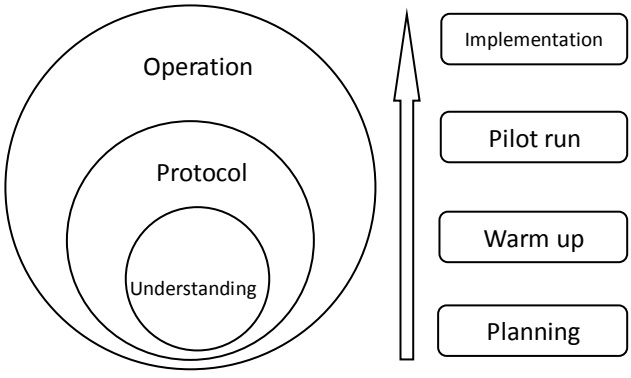


Figure 4. Execution model of Suan-Lien Living Lab.

In the Suan-Lien Living Lab, researchers apply various methods and tools in the different steps, building user-centered environments and allowing users to proffer ideas, share experiences, express preferences,

and show behavioral context in different projects (see Table 1). At the same time, users are involved in all steps of the product development lifecycle, not only at the end phases. The Living Lab concept therefore allows the user to be actively involved as a source of new product/service ideas, test and validate new product concepts, conduct usability tests with real or virtual prototypes, and be part of real or virtual test markets. [7, 19]

Step1: Understanding

The step "Understanding" includes two types of approaches: pilot projects and Sung University courses. The first type of approach can help to identify the possible risks and mutual benefits between two parties. The second type of approach increases the interaction between INSIGHT researchers and those residing in the Suan-Lien Elderly Center.

The pilot projects include Sleep Electroencephalography (EEG), Memory Performance, and Cognitive Behavioral Research. Through the examinations, the elders in the Suan-Lien Elderly Center are able to be familiarized with the Elderly Welfare Promotion Group, because researchers will introduce themselves and explain the purpose of what they are going to do during the examinations. In addition, after the elders experience the examinations by themselves, they feel at ease about the Elderly Welfare Promotion Group. Moreover, data from the examinations will be reported to the elders, making the examinations a part of the self-examination of elders' conditions. For example, researchers use Polysomnography (PSG) to make a comprehensive recording of the bio-physiological changes of elders, such as brain activity (EEG), eye movements (EOG), muscle activity, skeletal muscle activation (EMG), snoring index, apnea index, and heart rhythm (ECG) that occur during sleep. Then, each elder will receive a report about his/her physical condition. From the pilot projects, we found that elders are more familiar with the Elderly Welfare Promotion Group, and have a more complete understanding of the research.

The other approach is that the Elderly Welfare Promotion Group runs a series of courses in Sung University in order to increase the mutual understanding and trust between the elders and researchers. There are weekly speeches or activities to motivate elders' participation, such as providing knowledge on sleep and drug use, or planning fall prevention exercises and body function tests. While elders attend the courses, they not only learn new knowledge but also interact with researchers by sharing their experiences. The company and communication from Sung University deepen the researchers' understanding about the elders in the Suan-Lien Elderly Center. From Sung University, we learned that a platform for elders and researchers being familiar with each other is a key point when initiating a Living Lab.

Step 2: Protocol

This step aims at building a protocol to establish a sustainable cooperation between the Suan-Lien Elderly Center and the Elderly Welfare Promotion Group. After the "Understanding" step, more investigations are conducted in the Suan-Lien Elderly Center. In order to avoid potential harm to the elders and assure the mutual benefits of both sides, the Elderly Welfare Promotion Group designs a standard process following particular protocol for each investigation.

The protocol includes three procedures. First, a proposal describing the purpose and the method of the research is required. Second, the Elderly Welfare Promotion Group and the Suan-Lien Elderly Center will examine the proposal together, ensuring the safety of the research. The third procedure is the pilot study, of which more details will be discussed, such as a first evaluation ('Should we conduct tests for this prototype now?'), method selection ('How should we conduct the tests?'), resource allocation ('What resources do we need and how do we use them?'), user recruitment ('How many users should be involved and how do we motivate them?'), setting ('In what environment or situation should we conduct the tests?'), analysis ('What can we learn from the feedback we have received?'), and final evaluation ('Is this prototype appealing to or required by the elderly?' 'What can we do to improve this prototype?').

There are three benefits to be derived from this fixed protocol. First, it's a select mechanism. The proposal provides sufficient information about the research; if the research isn't qualified this could be found in advance. Second, protocol can standardize the process of the research to establish a sustainable cooperation. Because obvious steps were set up, researchers can follow clear rules to insure the feasibility of the research. The standard processes also make available the opportunity for future cooperation with other possible partners. Third, the protocol can guarantee the involvement of the Suan-Lien Elderly Center to make the collaborative relationship with the Elderly Welfare Promotion Group closer. Since the Suan-Lien Elderly Center examines the proposal together, opinions from them will be emphasized, and it will produce mutual benefits for both sides.

Step 3: Operation

The "Operation" stage is regarded as the official launch of the Suan-Lien Living Lab; meanwhile researchers introduce real cases to validate the proposed protocol. If the cases turn out to have good results, it means the protocol functions well. In addition, the "Operation" step is also for implementing the pilot study. After serious discussion in the "Protocol" step, the "Operation" step plays a role in final examination of the pilot study.

Two main methods applied in the "Operation" step are usability tests and scenario tests, which are principle methods exercised to find the pros and cons of the cases. There are three features of the two methods. First, it's conducted in both private rooms and public living areas; constructing a test environment which is very close to real-life. Second, the longer test time makes the observation more comprehensive. For example, in usability tests, each test user has forty minutes to an hour to express their opinions. In scenario tests, users, the residents, their families as well as the staff in Suan-Lien Elderly Center, experience the cases or services for weeks. Third, through a long period of monitoring and visits, researchers are able to analyze the habits of users when operating products, as well as determine the difficulties and preferences of users when it comes to their functions, interfaces, appearances, or contexts.

After the "Operation" stage, there are two constructive fiundings. First, protocol is verified through the implementation of cases. The achievement of the cases in the "Operation" step proves the effect of the protocol. Second, the result of the "Operation" step also gives the criterion to judge whether the pilot study is complete or not.

Example Projects in the Operation Step

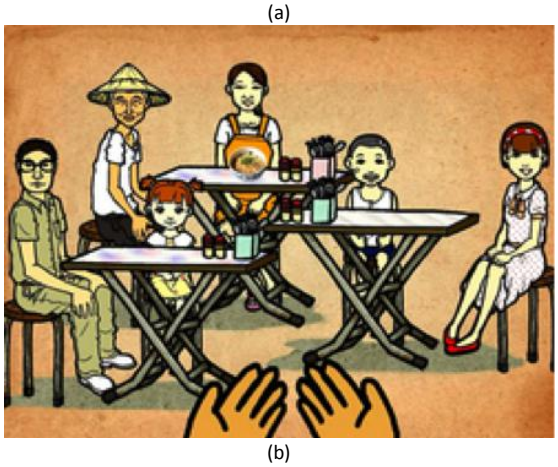
Here we provide two example projects practically operated in the Suan-Lien Living Lab. These projects are TaoGei and Tempo.Tempo which are developed following the protocol. After achieving a mature stage of the pilot study (the last step of the protocol), these two projects are ready to be examined by user tests and scenario tests. The purpose of the project design as well as the details of the user and scenario tests are fully discussed in next paragraph. In addition, how to apply real cases in the Suan-Lien Living Lab and what results comes out after the operation step are presented in the following discussions. These two examples also play a role in confirming the accomplishment of the operation model.

TaoGei

Among the majority of the elderly population, memory loss has become an issue of daily life; a small proportion may also suffer from dementia, such as Alzheimer's disease, typically from the age of 65 onwards. Given the growing elderly population, the need to provide health care services addressing the issue of dementia has become an urgent necessity.

Our design, *TaoGei*, is a unique game for the elderly that integrates reminiscence therapy and memory training. Reminiscence therapy is a common psychological intervention in dementia care, which enables the elderly to integrate living arrangements by recalling people and things familiar to them. In addition, by stabilizing mood, reminiscence therapy also helps the elderly to maintain good mental health. The game tracks the performance of the user in each task and monitors improvements in memory performance. In order to sustain user interest and help with memory training, our game is designed with an interactive interface that provides vivid visual and auditory information. Our goal is to create a game that allows the elderly to feel comfortable and autonomous using modern mobile devices through a game that helps with memory training.

(a)



(b)

Figure 5: Snapshots of Tao-Gei: (a) preparation; (b) serving food.

Usability testing for the game was carried out at the Suan -Lien Living Lab, affiliated with a public aged care center in northern Taiwan, with users aged from 75 to 93 years old. Prior to the actual usability testing, researchers went to the Living Lab to build rapport with the elderly by holding events and interacting with them. At the recruitment stage, researchers accompanied a social worker or physical therapist and asked for participants. On the official testing dates, researchers went through the informed consent form in detail and demonstrated the process. The elderly then began playing the game of *TaoGei*, as real usability testing. An interview followed each session for debriefing and collecting feedback for further improvements. Our intentions were to invite the elderly to become part of our research rather than just be passive participants.

We also interviewed several experts in the fields of psychology, physical therapy, and occupational therapy for their feedback. Their input was used to improve the game and to make it more user-friendly. Due to the usability testing in the Living Lab, we know how to better design a product meeting the actual needs of our target users in an effective manner.

Tempo.Tempo

"Tempo. Tempo" is a rehabilitation exercise specifically designed for Parkinson's disease patients. Parkinson's disease patients exhibit symptoms of tremor and rigidity while resting, as well as postural instability (leaning forward, walking in small steps, and quick walking). In clinical therapy, occupational therapists usually utilize visual and aural hints to give instructions to patients, so that they can follow the instructions to conduct stride training and prevent the symptoms from worsening. "Tempo.Tempo" was designed in reference to these treatment methods. Two-dimensional optical illusions are utilized as visual hints. In facing the two-dimensional image, the user will encounter a three-dimensional illusion and perceives stairs, which would lead the user into walking. Aurally, the user takes steps following the background music. When the user steps on the correct position, the built-in pressure sensor in "Tempo.Tempo" will generate a feedback sound. The user can correct their steps to match the stress sound in the music based on this feedback. In addition, the user may find this process enjoyable by working in harmony with the background music. The "Tempo.Tempo" product itself is composed of dozens of units. Depending on the available space, one can arrange the order of the units as required. The background music can also be adjusted, based on an individual's ability and the occupational therapist's advice, to select the tempo music most suitable for the patient.

The Suan-Lien Living Laboratory was chosen for testing. The objective of the testing was to confirm the following:

1. Whether the elderly can easily perceive the product's two-dimensional optical illusion as a three-dimensional image.
2. Whether the elderly are able to step following the tempo of the background music.
3. Whether the product's stepping feedback sound is suitable for the hearing of the elderly.
4. The patients' preferences as to the arrangement of the images and colors.
5. The patients' other opinions and feedback on the product.

Figure 6. Snapshot using Tempo.Tempo.

The testing subjects were recruited by staff at the Suan-Lien Living Laboratory. Subjects were 10 elderly patients (5 male, 5 female) over 65 years of age, who had no language or cognitive impairment. Over two days, all ten patients were tested, for a total of 30 minutes each. In the first stage, trust was established by means of filling out basic information. During this stage, researchers explained to the patients the purpose and process of the testing. In the second stage, researchers explained how to use the product and demonstrated the testing procedure. In the third stage, testing began formally. During this stage, researchers first used clapping cues to determine the appropriate tempo for the background music, and led him or her in trying to step on the product following the clapping tempo. Once patients were comfortable with this testing methodology, they were instructed to take steps following the tempo of the background music. If the patient was unable to follow the tempo correctly the first time, he or she would then be led by researchers in the second or the third testing. In the fourth stage, interviews were conducted after the testing was completed, to gather the patient's feedback for product improvement. Finally, compensation was given to patients who participated in the testing, to encourage them to return in the future for further testing and research.

After the testing was completed, the feedback received from these elderly patients was mostly positive. All 10 patients were able to perceive the two-dimensional optical illusion as three-dimensional stairs, and take steps. Several patients even had to rely on their sensory touching to verify if the image was really a flat surface before they dared to take steps. With regards to following the tempo, after practice, most patients were able to understand the game and take steps in time with the background music. One patient had hearing difficulty and could not readily detect the background music and the product's feedback sound, and could not correctly follow the tempo of the music. Six testing subjects indicated that the volume of the product's feedback sound was not high enough, and could be easily overridden by the background music and other sounds in the environment. A feedback sound of low frequency should be improved on in the future. Furthermore, the physical and occupational therapists interviewed indicated that Parkinson's disease patients are less able to maintain balance, thus a quarter circle buffer zone should be created at the turning point, so that the user can make turns in the buffer zone, which may prevent falling.

Lessons learned from the Suan-Lien Living Lab

The Living Lab methodology enables technology prototypes to be developed more in line with the market, while academic research can also be accomplished through the industry. Living Labs connect product suppliers and end-users efficiently, creating synergy and reducing costs of making poor decisions in the product development process.

While the Suan-Lien Living Lab has been successfully embedded into the Suan-Lien Elderly Care Center, the following points are recognized as lessons learned from its operation:

1. High involvement of users is critical

How to make users decidedly and continuously contribute to a Living Lab has been one of the biggest challenges. The European Network of Living Labs (ENoLL) has mentioned that, though user involvement is the key to the success of a Living Lab, methods to encourage users to actively participate in the scheme did not develop as a general formula. [20]

The degree of user involvement should differ according to the industry and target users. For example, by means of Sung University courses and free sleep examinations, the Suan-Lien Living Lab motivates users to participate in and contribute to the research. In Sung University, courses are interspersed with the idea of the Living Lab, motivating the elderly to identify with and involve themselves in the Suan-Lien Living Lab. On the other hand, researchers spend extra time building trust and overcoming different ideologies with the elderly. In addition, the free access to long-term professional evaluation is another incentive for the elderly to take initiatives to involve themselves in the Lab. In the Suan-Lien Living Lab, the majority of the elderly are fully involved and emotionally engaged. [21]

2. Versatile forms of communication play an important role

As the elderly are the target users of medical and nursing products and services, in the selection and use of testing tools, researchers must reduce the use of computers and electronic tools, focusing instead on soft and personal approaches to communication such as storytelling. Sung University, for example, is a transformation of the focus group. Researchers in the Elderly Welfare Promotion Group motivate the elderly to convey their own preferences, knowledge, and cultural experiences in an environment familiar to them. Researchers use professional techniques to conduct prototype testing, and contextual inquiry to observe

behaviors and conduct semi-structured interviews. At the same time, researchers work closely with the staff of Suan-Lien Elderly Care Center to fine-tune these methods to best suit individual users.

3. Effective conversion of tacit knowledge is the key to successful user-driven innovation

In addition to physiological information, the cultural experiences and cognitions of the elderly play critical roles in the elderly welfare product and service development process. Through testing, the elderly are often discovered to have a specific set of logic regarding product use, as well as ideas for how to refine products to meet their needs. Nevertheless, some users have difficulties in expressing ideas and use limited vocabularies, revealing challenges in testing. Researchers in the Suan-Lien Living Lab therefore utilize techniques such as further questioning and analogy, using words the elderly are familiar with and daily situations they can identify with. In addition to verbal expression, researchers pay attention to the behaviors and concerns exhibited by the individual about their background and environment, while establishing experimental methods which achieve the balance between systematization and customization in an aim to explore needs in a faster and easier way.

4. A multi-disciplinary team is required

To execute a successful Living Lab, team members should share mutual goals and trust others. The Elderly Welfare Promotion Group is composed of the engineering team, psychological team and medical team, which are led by numerous scholars, doctors, and clinical psychologists. In addition, The Elderly Welfare Promotion Group works closely with the Social Research Group and TechTeam in the INSIGHT Center to understand the specific users' ways of life, and to reach full integration of social science and technology.

5. Cohesion of stakeholders maximizes benefits for each party

Through Sung University, researchers in the Elderly Welfare Promotion Group and residents in Suan-Lien Elderly Care Center are in close interaction, whilst also promoting closer cooperation with the staff of the center. Researchers hold meetings regularly with the staff, and support the activities held in the Suan-Lien Elderly Care Center. In the Suan-Lien Living Lab, all the stakeholders can share their own experience through systematic approaches, and identify the mutual goals of the Lab.

With the above experiences, the Suan-Lien Living Lab aims to upgrade to a national platform for multi-disciplinary cooperation – promoting both academia and industry to commit themselves to elderly product innovation Living Labs.

Challenges of the Suan-Lien Living Lab

Despite being one of the most well organized Living Labs in Taiwan, the Suan-Lien Living Lab has faced numerous challenges, many of which are regarded as significant issues for the vast majority of Living Labs.

Firstly, finding the right people, and keeping them, is one of the most critical factors to sustain Living Labs. After all, talent is what ultimately drives an organization's success and creates value. [22] A Living Lab's performance is driven by superior talent, and talent is the key to pushing a Living Lab's results to commercialization. However, talent management can be extremely challenging. Due to gradual extension and the need to integrate results from different projects, the Suan-Lien Living Lab faces multiple challenges when it comes to recruiting, developing, and retaining people with specific skills and aptitude to meet current and future needs.

Secondly, the Suan-Lien Living Lab currently lacks a powerful and neutral third party or mechanism to monitor progress and settle any disputes that may occur between the INSIGHT Center and Suan-Lien Elderly Care Center, or between the INSIGHT Center and its industrial partners. Lacking in the assistance of this third party/mechanism, the Suan-Lien Living Lab has encountered problems in correctly evaluating the research methods adopted, and the effects of their implementation.

On the other hand, large-scale Living Lab research organizations are not present in Asia; individual Living Labs cannot be associated with a wide range of partners as a consequence, and thus it is difficult to reach a consensus within a short time. Although domestic organizations such as the Industrial Technology Research Institute (ITRI) [23] and the Institute for Information Industry (III) [24] are currently devoted to the development of Living Labs, there are difficulties in forming synergic systems that match the scale and depth of those in European countries (where a Living Lab may extend to the scale of a whole city).

Due to the relative lack of healthcare Living Labs in Taiwan, the Suan-Lien Living Lab has been challenged to integrate findings resulting from other Living Labs, making it difficult for the Suan-Lien Living Lab to upgrade from the "smart lab" or "smart center" conceptual label to that of the ideal "smart city".

In addition, because many domestic industries pay less attention to Living Lab methods and have not been actively involved in Living Lab projects, many

government-funded Living Labs lose their ability to be sustainable and profitable after the initial sponsorship period ends. The Suan-Lien Living Lab, funded by the National Science Council, has also encountered this difficulty.

Future of the Suan-Lien Living Lab

The development of Living Labs in a single city has its own limitations, and connections among cities should be developed and strengthened in order to achieve synergy. The Suan-Lien Living Lab, therefore, is expected to establish a web-based open innovation platform in its next stage, enabling multiple resources and results from different geographical locations to be integrated through a single channel, and to reach the consensus of collaboration. As long as new web services are on the market, multiple Living Lab projects can be planned and developed on this platform. Just how to switch from a virtual community to a physical entity is a greater challenge, and there would justifiably be an increased emphasis placed on the promotion of web services. On the other hand, the Suan-Lien Living Lab should continue to innovate from a human point of view, to create the most needed and preferred elderly care products and services, and to effectively accumulate and apply these results to sustain current Living Lab projects and develop new ones. [6, 20, 25-27]

References

[1] *Population projections for Taiwan: 2010-2060*, Council For Economic Planning Development, Executive Yuan, 2010. [Online]. Available: http://www.cepd.gov.tw/encontent/m1.aspx?sNo=0001457

[2] "Research agenda on ageing for the 21st century: 2007 update," A joint project of the United Nations Programme on Ageing the International Association of Gerontology and Geriatrics, New York, 2007. Available: http://www.un.org/ageing/documents/AgeingResearchAgenda-6.pdf

[3] "Banyan: An exercise in fertility," *The Economist,* 2010. [Online]. Available: http://www.economist.com/node/17039131

[4] H. W. Chesbrough, *Open innovation: The new imperative for creating and profiting from technology*. Boston, Mass.: Harvard Business Review Press, 2003.

[5] A. Schumacher and B. Feurstein, "Living labs — a new multi-stakeholder approach to user integration," in *Enterprise interoperability II*, R. J. Gonçalves, J. P. Müller, K. Mertins, and M. Zelm, Eds. London: Springer London, 2007, pp. 281-285.

[6] "Living labs for user-driven open innovation. An overview of the living labs methodology, activities and achievements," European Commission, 2009. Available: http://ec.europa.eu/information_society/activities/livinglabs/docs/brochure_jan09_en.pdf

[7] V. P. Niitamo, S. Kulkki, M. Eriksson, and K. A. Hribernik, "State-of-the-art and good practice in the field of living labs," in *The 12th International Conference on Concurrent Enterprising: Innovative Products and Services through Collaborative Networks (ICE 2006)*, Milan, Italy, 2006, pp. 26-28. Available: http://www.technology-management.de/projects/408/ICE%202006/Innovation%20Management/p36.3-103%20poster.pdf

[8] S. Caird and R. Roy, "User-centric innovations in new product development: Systematic identification of lead users harnessing interactive and collaborative online-tools," *International Journal of Innovation Management (IJIM),* vol. 12, no. 3, pp. 327-355, 2008. doi: 10.1142/S1363919608002072

[9] M. Pallot, *Engaging users into research and innovation: The living lab approach as a user centred open innovation ecosystem*, Webergence Blog, 2009. [Online]. Available: http://www.cwe-projects.eu/pub/bscw.cgi/1760838

[10] *CORDIS: FP7*, European Commission. [Online]. Available: http://cordis.europa.eu/fp7/home_en.html

[11] "FP6 final review: Subscription, implementation, participation," European Commission, Brussels, 2008. Available: http://ec.europa.eu/research/reports/2008/pdf/fp6-final-review.pdf

[12] *The european network of living labs: The first step towards a new innovation system*, The European Network of Living Labs. [Online]. Available: http://www.openlivinglabs.eu/

[13] M. D. Mulvenna, C. D. Nugent, F. Moelaert, D. Craig, R.-M. Dröes, and J. E. Bengtsson, "Supporting people with dementia using pervasive healthcare technologies," in *Supporting people with dementia using pervasive health technologies*, M. D. Mulvenna and C. D. Nugent, Eds. London: Springer London, 2010, pp. 3-14.

[14] *TRAIL living lab (translating research and innovation lab) | open living labs*. [Online]. Available: http://www.openlivinglabs.eu/node/139

[15] *CO-LLABS*, AMI@Work communities. [Online]. Available: http://www.ami-communities.eu/wiki/CO-LLABS

[16] *Institute for Information Industry: Core values*, Institute for Information Industry. [Online]. Available: http://web.iii.org.tw/english/core_values.asp

[17] A. Homma, "Care for the elderly in Japan in 2015," *Psychogeriatrics,* vol. 5, no. 3, pp. 69-72, 2005. doi: 10.1111/j.1479-8301.2005.00095.x

[18] H. Kishida, "A market projection for long-term care in Japan," *NLI Research Institute Bulletin,* no. 116, pp. 241-237, 1998. Available: http://www.nli-research.co.jp/english/socioeconomics/1998/li9807.pdf

[19] S. Jens and F. Karin, "Living labs — the user as co-creator," in *The 13th International Conference on Concurrent Enterprising*, Sophia Antipolis, France, 2007. Available: http://euniversityforum.org/projects/408/ICE%202007/Concurrent%20Innovation%20(concepts,%20cases%20and%20tools)/4-125_Feuerstein_final.pdf

[20] E. Almirall and J. Wareham, "Living labs and open innovation: Roles and applicability," *The Electronic Journal for Virtual Organizations and Networks,* vol. 10, Special Issue on Living Labs, pp. 21-46, 2008. Available: http://www.ejov.org/Projects/264/Issues/eJOV%20Special%20Issue%20on%20Living%20Labs%202008/eJOV10_SPILL3_Almirall_Living%20Labs%20and%20open%20Innovation.pdf

[21] I. Mulder and P. J. Stappers, "Co-creating in practice: Results and challenges," in *The 15th International Conference on Concurrent Enterprising (ICE 2009)*, Leiden, The Netherlands, 2009. Available: http://www.ami-communities.eu/pub/bscw.cgi/S4b7fae0f/d494425/202_Ingrid_Mulder_and_Jan_Stappers.pdf

[22] *What is talent management?*, Oracle Corporation. [Online]. Available: http://www.taleo.com/researcharticle/what-talent-management

[23] *The smart living technology application project (i236 project)*, Industrial Technology Research Institute. [Online]. Available: http://www.i236.org.tw/

[24] *Living lab @ Taiwan*, Institute for Information Industry. [Online]. Available: http://www.livinglabs.com.tw/

[25] T. Kleinberger, M. Becker, E. Ras, A. Holzinger, and P. Müller, "Ambient intelligence in assisted living: Enable elderly people to handle future interfaces," in *Universal access in human-computer interaction. Ambient interaction*, vol. 4555, C. Stephanidis, Ed. Heidelberg: Springer Berlin, 2007, pp. 103-112.

[26] N. Z. Kviselius, P. Andersson, H. Ozan, and M. Edenius, "Living labs as tools for open innovation," *Communications & Strategies,* vol. 1, no. 74, pp. 75-94, 2009. Available: http://ideas.repec.org/a/idt/journl/cs7404.html

[27] H. W. Chesbrough, *Open business models: How to thrive in the new innovation landscape*. Boston, Mass.: Harvard Business School Press, 2006.