USER INVOLVEMENT IN PRODUCT DESIGN PRACTICES: A CASE STUDY ON TECHNOLOGIES FOR OLDER ADULTS

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Abstract

Recent efforts to address challenges brought by the aging of the population have looked at technology as a possible solution. In order to effectively deliver value and benefits, it has been suggested that the design of technology for older adults need to be based on proper understanding of the population's needs and expectations with user-centered approaches. This study examines two examples of hardware and software technologies developed to address older adults' needs to stay healthy, independent and socially connected. Based on findings from in-depth interviews, documents and observation of physical artifacts, this paper presents detailed descriptions of the two cases. The case descriptions include design activities, managerial decisions and user involvement practices carried out throughout the process from planning and development to distribution. Implications for design of products targeted at older adults, as well as insights for development of interactive systems in general, are discussed.

Keywords: Inclusive design, New product development, User centred design, User research, Gerontechnology

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1 INTRODUCTION

As a means to address challenges brought about by the aging of the population, technology has gained attention as a solution. Technology is now being regarded to be the center of strategies for effectively enabling older adults to stay healthy, independent, safe and socially connected. However, it has been discussed that older adults' needs and expectations are not properly assessed in practice (Niemelä-Nyrhinen, 2007). The experiential, physical and knowledge gaps that exist between designers and users are larger when products are developed for older adults, but these gaps between older users and typical designers are not being fully addressed and older adults have had limited roles in design, often reduced to test persons later in the process (Eisma et al., 2004; Essén and Östlund, 2011). As a result, existing technologies targeted for the older population have often been designed based on an insufficient understanding or stereotypes, and have thus not been effectively distributed or used with enthusiasm.

In order to realize the benefits promised by technology advancements, older adults' characteristics and the broader social contexts should be comprehensively understood to inform the design, development and delivery of technology. This idea or approach of involving users in the design process of interactive products, as well as understanding their needs and various contexts to inform design, is captured in the concept of user-centered design, which aims to design and develop a product based on the needs and interests of its users so that they will find it useful and usable (Mao et al., 2005; Norman, 2002).

This study aims to find insights for user-centered design of technologies targeted for the older population by examining examples of existing systems. In this study, two industry cases are studied to understand how technologies for older adults are designed, developed, and distributed in practice. The objective of the case study is to describe the key design activities and decisions, and to discuss how they are informed by user involvement and user-centered design approaches using detailed case descriptions.

2 CASE SELECTION

2.1 Selection criteria

A multiple-cases approach was chosen over a single-case approach for its robustness and analytical power, as suggested by Yin (2009). Cases were selected with an information-oriented selection, which enabled one to achieve the greatest possible amount of information on a given problem or phenomenon (Flyvbjerg, 2006). This approach, where selection is based on the contents the cases are expected to contain, was employed instead of random selection to maximize the utility from a small sample.

The selection criteria were specified to include technologies that aim at fulfilling essential needs of the older population. The cases needed to have three characteristics commonly found in systems developed for older adults: 1) having assistive roles in managing health, wellness, and daily activities, 2) focused on delivering service and creating value, 3) designed primarily for use in the home, which is where older adults' activities mostly take place as they age in place. More specifically, among various types of assistive technologies for older adults, those that support compliance in health management or promote personal wellness were selected. Another criteria was to include both hardware and software systems to account for possible differences in design activities and managerial decisions (Hauptman, 1990).

2.2 Selected cases

Based on the selection criteria, two systems were selected as examples of technologies developed for older adults' health and wellness, as shown in Figure 1 and described in Table 1.

Figure 1. Selected cases: MISTY (left) and PARO (right)

Table 1. Characteristics of selected cases

Product	Main component	Key features and applications
MISTY by Parental Health	Software	– Health and medication management – Connection with family and community – Formal and informal caregiving – Management of daily activities
PARO by AIST (National Institute of Advanced Industrial Science and Technology in Japan)	Hardware	– Dementia care and management – Emotional support and therapy – Formal and informal caregiving

MISTY (Medical Information System To You) is an integrated software that includes applications for supporting the needs of older adults and their caregivers. As shown on the left in Figure 1, it includes tools that address challenges facing its target users, including management of chronic conditions and medication intake, monitoring daily activities, and preventing issues related to isolation. This tool was developed to help older adults monitor their medication adherence and vital signs, and communicate that information with healthcare providers and family members.

PARO, which is shown on the right in Figure 1, is an interactive assistive robot developed to deliver therapeutic benefits to older adults. PARO is positioned as an alternative to pet therapy that can bring the intended benefits while preventing possible risks and challenges related to interacting with animals, such as allergies, infections, injuries, and tasks related to taking care of a life. PARO is being used in nursing homes and assisted living facilities to deliver emotional benefits and to help with older adults with dementia. It is also being used in individual homes as a pet for older adults living alone.

3 DATA COLLECTION

Multiple methods of inquiry and data sources were used to gather case evidence. In-depth interviews were conducted with key informants who were deeply involved in the design and development processes, and thus have knowledge of all activities and decisions. For MISTY, the leadership team, including the CEO and CTO, at Parental Health were interviewed over the phone. For PARO, the creator who was in charge of design throughout the process was interviewed in person.

The interviews were conducted as semi-structured conversations. The main questions were designed to investigate the following topics: development timeline and stages, activities during concept generation and selection, decisions related to overall and detailed system design, methods of system evaluation and testing, distribution strategies and channels for reaching target market, and activities for user involvement. A number of questions were prepared in advance, and follow-up questions were asked to gather detailed in-depth information and to find out more about related events. While some follow-up questions were prepared in advance, many of them were asked as necessary during the interviews.

A variety of documents, including academic publications, news articles, reports from meetings or events, memos, brochures, Web pages, and other written materials, were collected for additional evidence. Since documents are prone to reporting biases (Yin, 2009), multiple documents from various authors were collected. In addition to interviews and documents, a PARO robot was studied to investigate the actual operations and interactions. For MISTY, video demonstrations of the system were reviewed. Although not widely used as an information source in many case studies, physical

artifacts used in this study as the technical systems and components were central to the research questions and related discussions.

4 DATA ANALYSIS

A content analysis, described as a class of quantitative and qualitative approaches that are used for analyzing and interpreting text data based on verbal communications, observations, or printed narratives (Hsieh and Shannon, 2005), were conducted to summarize, categorize and interpret the results. In this study, the interviews were transcribed into a readable text format to enable further analysis. Then all pieces of text data, including the interview transcripts and other documents, were examined and categorized. The categorization process included coding individual quotes and sentences according to two dimensions – development stage and activity type. The contents of the interview transcripts and documents were categorized according to the specific design stages they concern. Findings from observation of physical artifacts were also tabulated along the same dimensions.

After categorizing and tabulating collected data, a full description was developed for each case by mapping the design activities and decisions on to a process framework. The generic framework suggested by Ulrich and Eppinger (2004) was used as the theoretical basis. In this study, the framework was extended to include an additional stage to describe any activities and decisions that took place after manufacturing. The development of the single-case descriptions were then followed by a cross-cases analysis, where similarities and differences were compared at each development stage and analyzed with development contexts, team characteristics, or technical features that may be attributed to. The analysis framework is described in Figure 2.

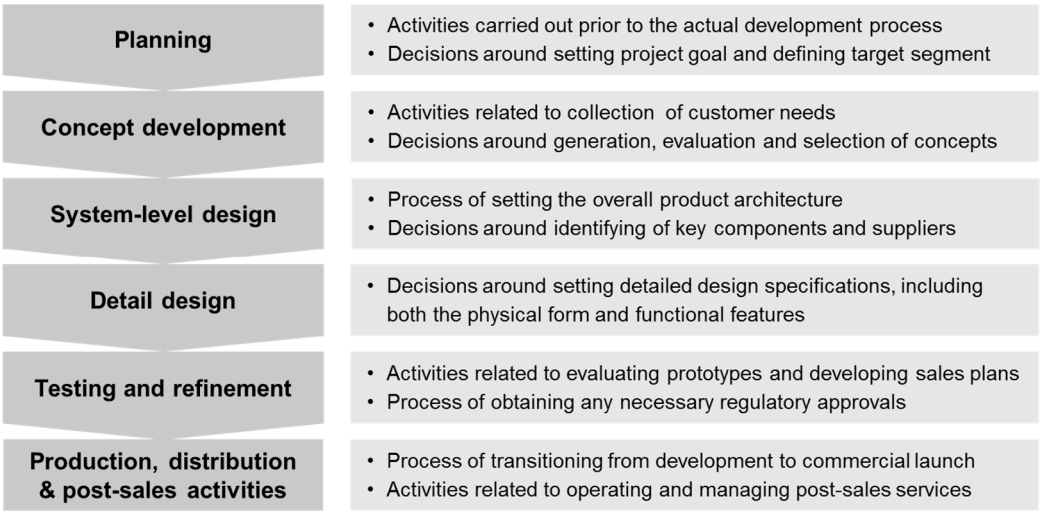

Figure 2. Process framework for case analysis (modified from Ulrich and Eppinger, 2004)

5 CASE DESCRIPTIONS

5.1 Case 1: MISTY by ParentalHealth

5.1.1 Planning

The need for a user-friendly system that integrates health monitoring and family connections for older adults was recognized by the CEO of Parental Health. As a caregiver for his father in mid-80s, he knew that family engagement played a vital role in maintaining emotional well-being and managing stress for older adults living alone. He searched for a solution to enable continued family communications and management of well-being, but couldn't find a system that met the requirements.

Parental Health started sketching an integrated software for older adults and their caregivers. Based on an understanding of older adults' wish to age in place, the project goal addressed the need to stay healthy, independent, and connected, as well as caregivers' need for a more effective and efficient means of caregiving and communication – "digitally moving an older person back into the home" and "connecting generations." The aim was to deliver value and benefits, and the novelty of technology

was considered less important – "They're connected to their family, and there's reminders to help them take their meds, or do whatever they need to do to keep their doctor happy. The rest of it, they don't really care about."
The primary target was defined as older adults who live independently, as well as their healthcare providers and family caregivers. A secondary segment was broadly defined as those who can potentially benefit from MISTY, including people with developmental disabilities and behavioral issues – "It's the same problem of trying to manage their health regardless of whether they are 85 or if they are 18."

5.1.2 Concept development

The team conducted interviews with a large number – about 1000 – of potential users, including older adults, patients, family caregivers and clinicians. Surveys and focus groups were also conducted to explore how people would use the system, what functionalities they would like to see, the information they would want to share, and the price points that would be perceived as reasonable.
Based on the user studies, it became clear that the system would have to be easy to use and affordable. The system also needed to include monitoring components to enable health management. Social connectivity was identified as an important component as it can help with isolation among older adults. Providing a communication channel was thought to offer an added benefit of "generation-skipping connectivity" where the grandchildren, who may not think it "cool" to talk to their grandparents, can be motivated to stay connected. In addition to the emotional benefits, they found that being closely connected with family also help with health management, such as improving medication compliance.
The final concept was defined as "a platform that would help with biometric monitoring, medication adherence, daily activities, information about health records, and social connectivity." In order to ease caregiver burden, nutrition management and medical services components were included. The social connectivity component included texting, videoconferencing, and e-mail to let the caregivers and family use their current methods of communication, while giving the older adult an integrated channel. While the individual features were widely available, the objective "was to have it all in one central place."

5.1.3 System-level design

Before the full-scale development, detailed user stories and scenarios were written and analyzed to inform how the features needed to work. The results from the user interviews at the previous stage informed characterization of personas and detailed description of the scenarios. The stories included possible interactions with the system and the contexts in which the interactions may occur.
The user stories and inputs from user interviews served as bases for outlining the key requirements and channels of information flow. The functional descriptions then informed their decisions on the overall system design. After reviewing multiple technology options, they decided that the software would need to run on Windows PCs and that the information portal would need to be accessible on any browser. While they considered newer devices, the key requirements of ease of use and connectivity with multiple components informed their final decision – "There is a lot of things you have to think about when things are coming through a platform. It can't just be the coolest, neatest, newest, best thing that's there."
Additional design requirements were identified for the clinicians, who already had "rules and roles" with which they communicated information within their organizations. Thus, they decided that the system shouldn't be overly intrusive and that "it needed to be easily integrated into their workflow."

5.1.4 Detail design

The detail design activities focused on meeting the key requirements that were decided based on user studies. Usability requirements were stated as MISTY serves people who "are not the most technology-savvy." User inputs from the previous stages revealed that the system should have "the least number of clicks and buttons" required. While there may be "a lot of stuff behind the system that's complex", the team made it clear that "it has to be simple for the users." An online help was also built into the software to provide technical support and easily resolve any usability problems.
Another requirement included system reliability and robustness as MISTY serves vital functions with which failures can lead to critical complications. Thus, the key features needed to run even when the

system is not connected to the Internet. The last requirement on data sync and sharing specified that users of different roles at various locations should be able to observe activities in real time.
Software programming was outsourced to developers. Parental Health wrote detailed descriptions with user stories and design requirements, and sent them to the developers. Communication was done through various channels including phone, in-person meetings, e-mails, and videoconferencing. The developers also proposed recommendations and ideas for design, which Parental Health then reviewed to either approve or disapprove. Prototypes were tested at Parental Health with potential users. Feedback from the user were incorporated into design requirements, which were sent to the developers for revision.
The MISTY software was packaged as a small Windows application. The home screen included large buttons that linked users to various features. Button icons and symbols were designed for neutrality and universality, in addition to intuitiveness and clear visibility.

5.1.5 Testing and refinement

A beta version of MISTY was released 18 months after the initial idea generation. The beta version was a complete software that included all of the features that were outlined as the system requirements. It was distributed through organizations that were planned as MISTY's full launch channels.
Feedback was collected from the distributors, end users, market evaluations, and the general public. User evaluations, which mostly came through the distributors, enabled the team to make design refinements and improve functionality. Suggestions for design changes were prioritized based on importance and overall impact. Only those evaluated to sufficiently enhance user experience were implemented. For example, while the original design had an emergency report button on the center of the screen, it was replaced with wellness components based on usage data. Feedback from the general public were collected by observing interaction with MISTY at various events such as health fairs.

5.1.6 Production, distribution and post-sales activities

MISTY is distributed through "large payers, self-insured employers, assisted living facilities, behavioral health entities, and workers' compensation." While the key features are common across organizations, minor details were customized for each organization's needs. The end-user costs vary with the size of the user base associated with each distributor. Since the software cost diminishes when spread across users, MISTY is priced as low as below $1 per month in a larger scale. The only cost issue was related to Internet connectivity. They have thus begun to work on partnering with Internet service providers.
In addition to older adults and their caregivers, MISTY was also distributed to the secondary target including those with behavioral issues or in rehabilitation centers. The ages of its users were mostly between 75 and 85 during the initial distribution, but has gone down as MISTY grew more popular in rehabilitation facilities and behavioral health organizations – "Over time, we have migrated to managing overall chronic conditions, and now have people that vary in age across the spectrum."
Parental Health is now thinking about the future of MISTY, which was built as a platform that can evolve and be reconfigured. The team has identified several features – health risk assessments, health education, smoking cessation, and video coaching – that could provide benefit to the users. They are also exploring different platforms including mobile devices. The team continues to seek feedback from its users. Overall, the feedback has been positive. For example, the team found that MISTY is "definitely not viewed as something granny-specific," but something that appeals universally.

5.2 Case 2: Paro by AIST

5.2.1 Planning

While studying applications of robotics and artificial intelligence, Dr. Takanori Shibata of AIST discovered that caregiving and disease management would be new areas where robots would be able to deliver value. Based on a review of existing means of caregiving, an opportunity was identified as an assistive tool for providing and managing long-term care of chronic conditions such as dementia.
While there is no permanent cure for dementia, it has been suggested that positive emotional stimulations can help better manage disturbances and prevent further development of related conditions (Shibata, 2012). Animal therapy was used for this purpose, but he thought a therapeutic

robot could help since it would not require one to take care of a living thing or be exposed to risks of injuries and infestations.
It was pictured that a therapeutic robot would be the best fit for use in nursing homes and care facilities to help patients with managing stress and emotions. It was also thought to be useful for children and people of other ages with behavioral impairments or developmental disabilities, and also for older adults who live alone and could benefit from increased communication and companionship.

5.2.2 Concept development

To effectively provide benefits similar to those of animal therapy, PARO needed to look and behave like a friendly animal rather than a robot, in addition to delivering its therapeutic effects, so that people would be attracted and drawn to interact with it rather than feeling intimidated or skeptical.
Among multiple alternatives, including a familiar animal, a less familiar animal, and an imaginary or fictional character, an unfamiliar animal was selected because people wouldn't be comparing its behaviors with their mental models of a real live animal. Among different kinds of unfamiliar animals, a baby harp seal was found appropriate from a set of interviews as most people did not know exactly what it does nor had interacted with one (Shibata and Tanie, 2000). Also, it was selected because it had a shape that could be comfortably held by people. In addition, baby harp seals looks cute to most people, and can attract people who would "want to have it as a pet" and wouldn't be shy to show it to others.
The first "hand-made from scratch" prototype was developed to see how the idea could be realized. The second prototype was also built to demonstrate the concept in a physical form with some feature changes. The third prototype was more advanced in its mechanical structure. It had seven actuators to show many of the technical functions, and used parts that were readily available, rather than optimized for the particular system. Later, for the fourth and fifth generations, being durable and practical became the key concern as PARO needed to withstand practical use environments and clinical experiments.
The fifth prototype was tested with users to identify changes necessary for developing PARO into a marketable product. It was shown to the general public at technical exhibitions and tested at nursing homes and hospitals to evaluate its effectiveness, acceptability, and functional performance.

5.2.3 System-level design

Several requirements were outlined prior to full-scale development. Since PARO was aimed to function as a substitute for a pet, it needed to withstand various external forces and "survive" for a long period to have a "life length" comparable to that of a typical dog. The durability requirement was emphasized also to ensure user confidence since many people were afraid that they would break PARO. Physical measures were set to generate positive associations as perceived by users. It was designed to feel similar to a human baby when held – "It should be very comfortable and needs to stimulate people who have experiences having children or grandchildren." PARO was defined to be sensitive and reactive to external stimulation including touch and voice. To behave similar to a live pet, PARO had to show actions and reactions that can be interpreted as those from a pet with "a heart and feelings."
Starting with the sixth generation, PARO was built as a full-scale product using a complete system-level design. The mechanical parts were built into modules which can be easily assembled and repaired – "If PARO has any malfunction in a module, it can be replaced." This prototype was used to confirm the durability requirement. Testing was done with potential users globally. For example, PARO was shown at an exhibit in London for 45 days, during which it withstood interactions with about 110,000 people.

5.2.4 Detail design

Various sensors and actuators enable PARO to interact with users and use environments. It senses light, sound, touch, and motion, and processes the sensory information with two computer chips and several microchips. The computing power allows PARO build a relationship with its user as a companion by recognizing a new name given by its owner and learning which behaviors are more favored.
In order to design PARO as a safe, lovable pet, the materials were chosen to make its body soft and warm. Its body is covered with artificial fur that is antibacterial, anti-dirt, and anti-hair loss. The

internal circuit has an electromagnetic shield to prevent from interfering with other devices, such as a pacemaker, that may operate in its proximity. In order to make its movements and sounds realistic, lively, and cute, an observation was conducted on the appearance of baby harp seals and the cries they make.
Since PARO was targeted at older adults with dementia and children with developmental disabilities, ease of use was defined as a key objective. This requirement was met by putting no other controller except for a power switch and a battery charger that was designed in the shape of a baby pacifier – "I designed PARO to be used very easily. There is one switch and one charger. That's all."
For full-scale development, Dr. Shibata and his colleagues started working with companies that specialize in manufacturing the necessary parts. They searched for candidate collaborators and evaluated their performances. For the eighth generation, the current version that is commercially available, they worked with more than 80 companies who were responsible for different parts of PARO.

5.2.5 Testing and refinement

Each PARO was internally tested for its dependability and examined for defects. A number of tests, including a voltage test, a drop test, and a 100,000-time stroking test, were done to ensure that each PARO can work in various use environments without functional problems.
User acceptance and perceptions were evaluated with questionnaires and user meetings. Questionnaires, which included standardized scales for assessment of emotional states, were collected from about 2000 people in seven countries. People were asked to talk about their expectations and perceptions of PARO, and give feedback based on their interactions. The results showed positive perceptions and high value on its features. Also, the results revealed that people in different cultures perceived PARO in different ways. In the US and Brunei, people expected PARO to perform as both a pet and an assistive tool. In Korea and Japan, people expected PARO to be like a pet, whereas people in the European countries valued its therapeutic features more than its similarity to a pet. Such difference was thought to have come about from differences in the respondents' prior experiences and related mental models.
Clinical trials were conducted to evaluate the therapeutic effects in three dimensions – psychological, physiological, and social. The tests aimed at analyzing PARO's effects on the users' emotional states, medication usage, and behavioral changes. The clinical trials were conducted with regional distributors, academic research laboratories, and hospitals. Some were planned as long-term studies. Based on the clinical trials, PARO was found to be effective for improving conditions related to loneliness and isolation in older adults (Robinson et al., 2013). In trials involving people with dementia, the groups that interacted with PARO experienced less wandering or loitering, showed less aggressive behaviors, and displayed a more calm emotional state compared to those who didn't interact with it.

5.2.6 Production, distribution and post-sales activities

The eighth generation of PARO was first launched in the Japanese market in 2005. Since survey results indicated PARO to be better accepted as a pet in Japan, it was first sold to individuals rather than care facilities and organizations. It was initially introduced to the public through media and department stores. Over time, PARO was increasingly adopted by hospitals, nursing homes and museums.
Currently, PARO is being used in about 30 countries with different purposes. For example, while Japanese users own PARO primarily as a pet, it is used mainly as a therapeutic tool for dementia care in Denmark, where it is only sold to institutions with certified professionals. The decisions on distribution was made based on results from questionnaires that revealed cultural differences.
In order to demonstrate its value as an assistive device, PARO cleared regulations with global agencies including the European Restriction of Hazardous Substances Directive (RoHS), the Conformité Européenne (CE; European Conformity) and the US Food and Drug Administration (FDA).
A key area of concern was affordability. In order to overcome this hurdle, a lease-to-own pricing has been introduced as an alternative to one-time payment. This pricing worked well with organizational users as they saw it easier to execute budgets with small costs distributed over time. Subsidization models and insurance support are being explored as well.

The importance of technical support was emphasized as they developed the customer service – "the reputation depends on the service." In order to keep all PAROs well-functioning for a long time, they set up PARO Clinics, where the owners can send their PAROs for a "health check-up."
Experience was found to be important during initial use. Based on a survey of people who purchased PARO during its early releases, it was found that people who had problems were those who bought one without trying it out first. Based on this finding, the team decided "not to sell PARO to people who have never interacted with one." Now, when people place individual orders, they are first directed to venues where they can have some initial experience and get a better sense of how it looks, feels, and acts.
Lastly, it was considered important to ensure the independence of the older adult users. It was thought that overly emphasizing its therapeutic effects would create a negative association, or a stigma. While it was found to be helpful to emphasize the dementia care function when providing PARO to professionals and organizations, its pet-like features are more emphasized when it is sold to individuals.

5.3 Cross-case synthesis

The main design activities, managerial decisions and user involvement practices shown in the case descriptions of MISTY and PARO are summarized in Tables 2 and 3, respectively.

Table 2. Summary of the MISTY case description

Design stage	Key activities and decisions
Planning	− Outlining project objectives based an assessment of overall needs − Defining target markets (primary and secondary)
Concept development	− Collection and assessment of user needs through interviews and focus groups − Defining key system components and features − Initial rapid prototyping
System-level design	− Development and analysis of use cases based on interview results − Outlining main operations and defining overall design requirements
Detail design	− Defining specific design requirements − Detailed user interface design and software development (outsourced) − Prototype development and testing including user interactions
Testing and refinement	− Collection of user feedback on beta version through distributors − Prioritization and implementation of suggested design changes
Distribution and post-sales activities	− Full-scale distribution through organizations − System configuration and customization

Table 3. Summary of the PARO case description

Design stage	Key activities and decisions
Planning	− Defining project goals and application areas − Technology assessment − Defining target markets (primary and secondary)
Concept development	− Gathering user inputs through interviews and questionnaires − Defining overall physical appearance and key features − Development and user testing of early functional prototypes
System-level design	− Defining design requirements − Structural and functional definition of main parts − Collection of user inputs through prototype testing and questionnaires
Detail design	− Development and user testing of preproduction prototypes − Material selection and outsourcing of part manufacturing
Testing and refinement	− Internal quality testing − Analysis of user perceptions and acceptance with questionnaires and observations − Clinical trials and controlled experiments
Distribution and post-sales services	− Differentiation of delivery channels between different cultures and types of users − Development of professional certification and technical customer service − Continued efforts in clinical trials

For both cases, involving users early and throughout development was essential as the ideas were new to the target population, and because the benefits they intend to deliver may not be immediately tangible. Due to the gaps in knowledge, experience, and perceptions between users and the designers, selection of the product concepts was highly informed by user inputs, and user testing was done throughout the design activities with working prototypes.

6 DISCUSSION AND CONCLUSION

This paper presented case studies on two existing technologies developed to meet the needs of older adults and their caregivers – MISTY by Parental Health and PARO by AIST. These aging-in-place technologies were selected based on a set of criteria defined around the target market and application domains. During data collection, interviews were conducted with people who were deeply involved in the design, development, and distribution of the systems. Related documents and other materials were also surveyed for additional evidence and for corroborating the findings. Case descriptions were structured with a generic framework, and included detailed description of the activities and decisions, mainly those related to involvement of users that took place during the design processes.

Many of the key activities were common across the two cases, with variations that were brought by differences in project characteristics and product types. Various methods of user studies and user involvement were incorporated throughout the development stages, confirming the need for employing user-centered design approaches and principles. Furthermore, it was found from the cases that user involvement can be made more effective with experience-based methods that include interaction with tangible prototypes that continue from the early phases and repeat through the post-sales stages.

Several design implication were identified from the cases as summarized in Table 4. These include the importance of developing early prototypes, considering multiple needs and their relationships, using various methods to gather inputs from target users and stakeholders, focusing on realizing intended value, and aligning design with existing conceptual models. While some of the implications apply specifically to technologies for older adults, most speak to design of interactive systems in general.

Table 4. Design implications

Application area	Key implications
Technologies for older adults or special populations	− Communicate through appropriate channels with targeted messages − Consider relationships between issues and needs that may be tightly associated − Clearly demonstrate potential benefits, especially when features are unfamiliar − Collectively consider the needs of the stakeholders - caregivers and family − Ensure system connectivity, service alignment, and universal appeal
Interactive systems in general	− Work with prototypes for effective testing and demonstration − Assess user perceptions, experiences and use cases in depth − Iterate quickly and throughout the process − Focus on the main goal to realize value and deliver intended services − Maintain close communications with development collaborators and partners − Consider the look and feel in addition to functionality

The implications outlined in Table 4 emphasizes the need to make decisions related to design, development and delivery of technology based on a comprehensive understanding of user characteristics, social and organizational contexts, and possible associations between various needs. It can be seen that the insights outlined from the two cases are closely aligned with existing principles and guidelines of user-centered design (Norman, 2002; ISO, 2010; Gulliksen et al., 2003), thus illustrating how the ideas of user-centered design can and should also apply to the older user population.

The findings can be further strengthened with additional case studies from broader areas. This study only included aging-in-place technologies. To deliver a more generalizable and detailed understanding, a comparative analysis between technologies of different types and domains can be effective.

Future studies can also include both success cases and failure cases by employing a "two-tail" design (Yin, 2009). By including cases that have failed in any aspects of design, development, and delivery, the specific conditions, actions and pathways that led to such results can be identified to further inform stakeholders with a more prescriptive and actionable framework.

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