To Meet the Needs of Aging Users and the Prerequisites of Innovators in the Design Process

Lessons Learned from Three Pilot Projects

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Abstract. The aim of this paper is to analyze cases where participatory design with different stakeholder groups was a beacon in the development of innovations. An important aspect was a strong foundation both in the needs of the elderly and in the feasibility from the market side. Three cases were analyzed from aspects as: environment and development phase of product; participation of different stakeholders; and proxy involvement of care professionals. The impact of this approach is a benefit for aging end-users as well as increased feasibility for the innovation companies, as a result when collaboration of different stakeholders focuses on balancing the demands of the users and the prerequisites of the industry.

Keywords: Participatory design · Professional-patient relations · Community-based participatory research · Elderly · Social technology · Welfare technology

1 Introduction

User involvement in general is often considered a time consuming process. Therefore it is important to improve the understanding of how this process can be made more effective and efficient in an industrial view. Especially small companies find it difficult to adopt such methods as they value time in respect to both manpower and a fast developing market [1]. The authors believe that existing methods of user involvement in design may be refined to *both* address the needs of the end-users *and* the prerequisites of other stakeholders, such as innovators. When studying participation, different levels of involvement are discussed, often in relation to the end-users' approach and effects on the outcome. The authors were inspired by an article by Östlund [2] remodeling the idea of the "citizen participation ladder" by Arnstein from 1969 [3] to suit older people in the innovation and design process. Östlund [2] states that whether the users are considered as objects or subjects, they get different roles in the design process. Using them as research objects, the designer is seeking generalizations to be applied in design. As a subject they participate themselves in the development process [2]. This is probably valid also for other stakeholder groups participating in an innovation process. Additionally, more active participation is often desired of the stakeholder group of developers

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[4]. New approaches to stakeholder involvement may also contribute to support companies in broadening their market without reducing focus on specific user needs. One recurring example is when technology reaches the hands of real users and is contextualized; its real value turns out [5]. Also, studies point out that technology often starts to be used in new ways, different from what the innovator had in mind [2, 6]. Sometimes this comes as a result of the methods that the researchers bring into the process [7].

We present experiences from three information technology and technology (IT&T) projects where stakeholders from industry, care givers and researchers were actively involved together with aging users. Collaboration of those stakeholders while focusing on balancing the demands of the users and the prerequisites of the industry is analyzed and discussed.

1.1 Research Approach and Methodological Background

Human-computer interaction (HCI) research has come a long way in understanding the importance of involving users in the process of developing new technology. The presented cases are all action research projects that adhere to Participatory Design (PD) [8, 9], as one of the HCI theories that regards system development with user participation and that considers designing a social process. The degree of user participation may vary. Regardless of activation degree, in PD, developers and practitioners/users are seen as actively cooperating partners. Together they aim to reduce uncertainty and risk in the development of innovations, where a detailed conception of exactly which future needs should be supported, often lacks [8, 9]. We also know from HCI research that usability aspects should be brought in early in the development process [10]. Previous research presents several methods to engage users with the aim to create future environments, e.g. so-called Future workshops [11]. Other methods to bring analysis of future needs into system development are iterative prototyping and scenario-based design, preferably applied together with potential users in a collaborative approach [12].

PD is highly context-dependent and each application struggles with the understanding of how to involve different user groups in an optimal way. In this study, the authors have selected cases where the research team has been working as mediators between care professionals and developers from the industry. The approach of the researchers was also the extension of a Triple Helix setting (society working closely with industry and academia) to a Quadruple Helix model (Fig. 1) by involving the main stakeholders, the aging users. Using older adults' extensive experience when trying to meet their needs can result in more adequate solutions and lead faster to the goal [2], rather than relying on interaction patterns based on the computer paradigm [13].

In this Quadruple Helix model, problem-owners in the health and social care sector, aging users, health informatics researchers and developers of novel IT&T work together in a user-centered and participatory design approach, aiming to support aging users by their co-created solutions.

It is important to reach an equivalent balance between these stakeholder groups already from the beginning, especially when designing services for aging users. Many user groups cannot or do not want to participate in design of new IT&T-support, although they are invited as potential end-users of the product. This model relies on aging users

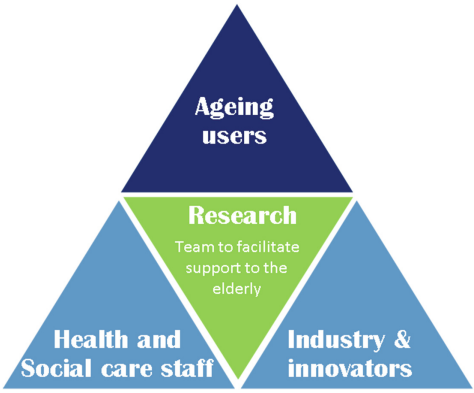

Fig. 1. Quadruple Helix setting

willing and being able to participate, as well as on their health and social care staff that daily works with the potential end-users. Equally important is to align industry into the working model, as they also are seen as supporting actors to the aging users. Experience remarks that the mediating researchers need to "teach user-centered design and participatory methods" before and during the actual project [14, 15]. Once initiated, it is beneficial for the results if the developers also are present in the daily practice that their innovation will be part of. Observation activities as well as sharing knowledge in the form of e.g. demos and being responsive to feedback regarding iteratively presented prototypes create a fruitful environment, where all participants are willing to jointly improve the elderly care situation [12].

To increase the likelihood that a product or service in health and social care of elderly will reach a successful implementation and a usage situation where the users are satisfied with the innovation, it is important to work towards a balance between the demands of the users and the prerequisites of the industry.

The objective of this study was to analyze PD cases with focus on *different* stakeholder groups and their prerequisites to be able to find how this Quadruple Helix PD approach affects the balance between end-user needs and the prerequisites of the innovators. The selected pilot projects were different, but all aimed for a strong foundation in both the needs of the elderly as well as in the co-created result, based on the conditions from the market side, e.g. feasibility.

2 Method

This study used a qualitative case study method containing thorough analyses of the pilot projects in several aspects to investigate effects on the implementation due to the Quadruple Helix PD approach. Apart from aspects of the *innovation*: "environment" and "development phase of the product", the *participation* of Quadruple Helix stakeholders was analyzed in three sub-aspects; "extent of participation of aging users", "Triple Helix joint work", and "proxy involvement of care professionals". A source of inspiration for the analysis was the rework of the "participation ladder" [3] with focus

on older people made by Östlund [2]. For each Quadruple Helix aspect different criteria were used to define an adequate range. Degrees of participation were described using two scales, both of them reworked on the idea of the "Participation ladder" by Arnstein [3]. Care professionals as advocates of the aging end-user needs were used in some of the cases. When so, the level was measured in terms of "proxy involvement".

2.1 Analysis of Level of Participation – Older People

The ladder defined by Östlund [2] illustrates the degree of participation of older people in innovation projects, as part of the Aging and Design program at a Swedish university. Here the ladder starts on the highest level, with

1. Older people are co-actors and are themselves driving the changes they want to accomplish.
2. Older people participate as the experts on their own life situation.
3. Older people contribute with their own views in consultation together with others.
4. Older people receive information and/or are being the subject to different types of operations.
5. Manipulation – people are objects for other's actions [2].

These criteria were used to analyze the aspect of the Participation of aging users on an individual level.

2.2 Analysis of Level of Participation – Triple Helix Joint Work

This analysis model, defined by Scandurra [16] and refined by Scandurra and Sjölinder, is inspired by Lindholm and Moritz [17]. Their "participation staircase" is acknowledged by the Swedish Association of Local Authorities and Regions (SALAR). It has been used since 2011 to represent citizen dialogue techniques ranging from the level where citizens are given information to the level where citizens get a direct role in decision-making [18]. Our remodeled staircase illustrates how different stakeholders in a Triple Helix constellation work together in an innovation process. Starting with the lowest level of joint work, the model increases the cooperation step by step.

1. No Communication.
2. Conversation – Mutual telling what you do, as an information or dialogue.
3. Common view – shared goals, common understanding. Requires an agreement between actors.
4. Coordination – the structure of how activities are carried out; procedures, rules and regulations as a basis for Cooperation and Collaboration.
5. Cooperation – Activities carried out by individuals that exceed the organizational boundaries.
6. Collaboration – coordination + cooperation. Activities carried out by organizations, which exceed the boundaries within or between organizations.

These criteria were used to analyze the aspect of Triple Helix Participation on a joint work or group level where all actors from Society, Industry and Academia participate.

2.3 Proxy Involvement

Despite efforts from the developer team, when trying to deploy technology to aging user groups, the technology may be perceived too difficult or cumbersome to use. A challenge for research is therefore to continuously examine when and how to best use the engagement and knowledge of the aging users in the design process, as well as to understand when and how other stakeholders, e.g. social care staff, correctly could define and transfer the needs of the aging users. Inspired by Boyd-Graber et al. [19] and their work regarding using people close to the intended user in the design process, we investigated the extent of "Proxy involvement". The amount of Proxy involvement was weighted in relation to the extent other stakeholders as e.g. the social care staff or next of kin spoke on the aging end-users' behalf. The terms High/Medium/Low referred to a weighted percentage where the activity of the proxies was decreasing: high proxy involvement ~80 %, medium ~50 % and low proxy involvement ~20 %.

3 Materials - The Three Cases in the Study

Many aging users suffer from age-related decline, both with respect to physical and cognitive abilities, which make it difficult to be involved in the design process as well as to use new services and new technology. This was no exception in the cases presented in this paper. Thus, some of the aging users got replaced by others during the projects, resulting in not well defined numbers regarding aging participants.

Each of the cases is described according to the following structure: description of the setting; study design and methods used; results and lessons learned.

3.1 Case 1: Development of a Communication Tool – Usage at a Nursing Home

Short description of the setting: In this project a communication tool and its services were tested [14]. The tool was an innovative mobile communication device connected to the TV, which worked as a remotely controlled large interactive screen. The aim with the study was to find potential users and target groups. During a 1.5 year project in a nursing home outside Stockholm, Sweden five residents (aged 75–88) participated, although suffering from age-related decline, both with respect to physical and cognitive abilities. There were nine persons participating from the care staff were nurse assistants, registered nurses and housing/department managers. The industry participants were four, and their roles were project manager, CTO and developers. The three research participants mediated and supported the project work. Their specialist domains were health informatics, HCI, technology & elderly research.

In the study usage testing was carried out with five devices placed in the residents' apartments and five in public areas. The care staff was deeply involved during the entire project; they recruited residents, gave information to relatives, to users and supported other care personnel in the role of tech ambassadors.

Study design and methods used: The care professionals were invited to co-design services as they are experienced in age-related impairments. Actual test phase lasted

six months and every two weeks the project team was gathered at the nursing home in 2–4 h workshops with different content, led by researchers and industry partners. Three aging user profiles were created by the staff based on characteristics such as social situation, preferred hobbies, previous life in terms of work and family situation as well as medical history, current conditions, medication etc.; brainstorming techniques [20] and semi-structured interviews were used to gather information from the different groups about themselves, but also to gather what they thought about the needs and attitudes of the other groups. The researchers gathered information from the residents in individual semi-structured interviews.

Results and lessons learned: The material was analyzed with regard to differences and similarities; what the residents had described and what the care professionals had thought about them as aging users. One lesson learned was that developing the three aging user profiles together with the care personnel forced them to reflect on their residents in a salutogenic [21] or health promotive manner, beyond all medical conditions and as possible users of new technology. The user profiles were useful also for the developers' understanding of the environment and users that the services should support. The workshops revealed that the care personnel underestimated the technology experience and overlooked that many of the elderly once had worked with technology in different environments. The staff initially placed large focus on the importance of technology experience for using the device and it was clear that they did not quite understand for which resident the technology could be useful. Later, the devices were given to residents with little previous experience of new technology, but curious to get a communication channel with people outside the nursing home, and the technology became useful. On the other hand, thanks to the continuous engagement by the staff, devices were placed in the dining areas. It turned out that the main benefit of the device was social interaction between the residents, and not as expected, interaction with people outside the nursing home. This resulted in positive effects by both residents and staff, when realizing how technology can be used and appropriated when aging users were given the opportunity to start using technology in their own ways, as stated previously by e.g. Wyatt [5] and Östlund [2]. Using the technology together with other residents or with care professionals was not at all considered by the developers. Therefore the device needed to be re-designed in several ways to fit new user groups. The engagement by the staff also contributed to the creation of new content and new services [14].

3.2 Case 2: User Study with a Prototype Aiming at Broadening the Target Group

Short description of the setting: This study was conducted within a project that developed a Kinect™ sensor tool for stroke rehabilitation at home [22], and aimed to investigate whether or not usage could be broadened to other user groups than stroke patients. The number of seniors that participated was nine (aged 68–98). They suffered from physical decline due to diagnoses as Parkinson's disease, stroke and back problems, but their cognitive abilities were less affected. Some of the participants were just old and suffered from normal age-related physical decline. Five care personnel participated: nurses, physiotherapists and occupational therapists. The industry professionals were

five and their roles were developers of technology and marketing. The three researchers mediated and supported the process. Their specialist domains were Technology & Elderly (1) and HCI (2).

Study design and methods used: The system was installed at three activity centers for elderly and there the aging users tested a Kinect sensor for conducting exercises, although the technology was designed for home usage. Each center had responsible care personnel doing observations during tests. The system provided video communication between patient and physiotherapist. Therefore patients could either do the exercises on their own or use the video communication to get direct feedback from the physiotherapist while doing the exercises.

After the session both aging users and staff filled in a questionnaire about usage of the system and the exercises. Aging users answered from their perspective and the staff based on the support given to the users to use the system. Questions regarded whether the exercises were relevant or if they had preferred some other exercise; the level of the exercises; different levels; and if increasing difficulty should have been performed in another way.

Results and lessons learned: Many of the aging users suffered from severe difficulties in being able to move, and some of the exercises were found too difficult. The aging users and the care professionals suggested more simple exercises, but they also expressed a need for a wide range of exercises since some aging users are physically active. The care professionals also requested less demanding exercises that could be performed sitting down and they suggested more exercises based on real life situations and tasks.

It worked well to evaluate the technology in the present environment. Even though it was a prototype containing flaws, the aging users managed to test it and contributed with suggestions for improvements. According to the questionnaires, there were no direct contradictions between the answers given by aging users and care professionals. However, the care professionals provided a deeper insight since they had a more holistic perspective on the situation. They provided valuable information about how and why features and interaction should be changed. The shared experience between care professionals and aging users contributed to a similar view of the situation and of the usage of the technology. The importance of providing exercises and services on different levels and possibilities to personalize the settings became clear i.e. adjusting the technology to fit larger numbers of aging users as well as broader target groups.

3.3 Case 3: An Innovator and Aging Users Develop New Services Together

Short description of the setting: In the project [6], a communication tool and its services were investigated. An innovative mobile communication device connected to the TV worked as a remotely controlled large interactive screen. The study was conducted at a senior center with eight aging users (aged 64–78). They did not suffer from age-related physical or cognitive decline. Three municipality staff participated: physiotherapist, administrator and manager at the center. There were four industry participants, and

their roles were project manager, CTO and developers. Three researchers mediated and supported the project. Their specialist domains were Health informatics, HCI, Technology & Elderly research. The aim of this study was twofold: firstly to investigate novel eHealth services for elderly citizens together with less disabled aging users. Secondly, to examine different methods for combining what seniors perceived as meaningful services in relation to what was feasible by the innovator.

Study design and methods used: The device was tested by eight volunteers who visited a senior center during the 1.5 year project. Formative evaluations consisted of two parts, design workshops and future-oriented workshops where all stakeholders participated with great interest. Seven design workshops elicited demands regarding existing and new services. At the end of the project, the participants' experiences were elaborated in three future-oriented workshops with the purpose to get ideas for improved or new meaningful services, based on what aging users thought would be useful in relation to feasibility of the ideas as viewed by the innovator. Five phases of future-oriented workshops covered a process from user requirements to jointly prioritized services by aging users and innovators.

Results and lessons learned: Case 3 demonstrated how a group of active aging users could contribute in suggesting new services for a company to develop. Besides valuable input, the importance of a social context around such work was clear. The users were very engaged throughout the project and workshops were frequently visited and the participants became friends. The high amount of input from the participants could be explained in terms of social inclusion; they belonged to a group and each member was considered important for the work.

The future workshops contained an iterative process of moving from a large number of new suggested services towards fewer but highly needed services. The requirement list of future services resulted in four categories: cognitive; social; and physical activities as well as information and news,, all high-priority proposals with a strong foundation in both user needs and feasibility for the innovator [6].

4 Comparison Based on Different Aspects of the Cases

Aspects to compare data from the cases were based on the *innovation*: type of innovation; type of environment in which it should work; the project owner and the development phase; as well as the *participation* of the Quadruple Helix stakeholders, divided in three aspects: aging users; triple helix joint work; and proxy involvement. Effects related to user needs and industry prerequisites were described (Table 1).

By working in a Quadruple Helix PD setting where focus was on the joint stakeholder work to balance the outcome between user needs and feasibility, the teams working with the three cases were satisfied with the results: increased common understanding of goals; user needs met by improved technology; new usage situations found; new/other content; Improved social interaction; improved knowledge about other stakeholder interests; and about ways of achieving the goals.

Table 1. Comparison between the cases

Aspects	Case 1	Case 2	Case 3
Type of innovation	Communication tool and services	Rehab tool (extended Kinect)	Communication tool and services
1. Type of environment	Vallentuna Nursing Home	Örebro Activity Center for Elderly	Täby Senior center
2a. Project Owner	Industry	Research	Industry
2b. Development phase	Prototype in late stage	Refinement of prototype	Refinement of prototype
3a. Participation of Aging users[a]	From receiver of information (4) to experts on own life situation (2)	(3) consultant role	(2) experts own life situation
3b. Triple Helix joint work[b]	(6)	(6)	(6)
4. Proxy involvement[c]	High	Medium	No Care professional Proxy
EFFECTS related to user needs/industry prerequisites	User needs met. New usage not yet leading to increased effort from industry part	Improved system, new/other content. Will lead to increased effort by industry (development)	Improved interaction, new/other content. Will lead to great effort by social care staff (creating content)

[a] Participation of older people based on Östlund [2], see criteria in Sect. 2.1.
[b] Assessment of Triple Helix cooperation, see criteria Sect. 2.2.
[c] Proxy Involvement: to which extent staff acted on behalf of aging users, see Sect. 2.3.
[*] Reversed table numbers 5-1: here we use both the number and the textual description.

5 Analysis and Discussion

Each aspect of the Quadruple Helix PD cases is described from the point of view of the "balance between end-user needs and the prerequisites of the innovators".

Type of environment: The analyzed cases consisted of different contexts in terms of way of working with users and investigating user needs. Case 3 had a focus on developing new services and the participants were younger, aiming to design for elderly, under the label "When I get older". The participants in case 1 and 2 had age-related physical and/or psychical impairments but the cases differed with respect to the environment. Case 1 was conducted at a nursing home and case 2 was conducted at three activity centers for elderly. Case 1 and 2 also differed with respect to duration of usage. In case 1 the aging users tested the services for a longer period of time and had the opportunity to use the technology in different ways. In case 2 the participants tested and evaluated the technology at one occasion when they visited the activity center. These different usage situations had an impact both on how the aging users were able to provide

feedback on the technology and on the role of the care professionals as proxies for the aging users.

Project owner: In cases 1 and 3 the participating company led the project, which may explain the large effort in finding the balance between needs of aging users and feasibility of the development. However, this may not always be the case. In many research and development projects several companies participate and it is not clear who is responsible for taking the product to market. Uncertainties may lead to a struggle to find a balance between the different companies' needs rather than between the end-user needs and the feasibility of the development.

Development phase: Depending on the possibility to involve aging users in a theoretical discussion, it may be more feasible to involve aging users at a nursing home in the later stages of the development where there is a well-functioning prototype to test, use and discuss. This was shown in case 2 where aging users of high age tested an almost ready technology and provided good feedback from just one test occasion, in consultation together with others (participation ladder stage 3).

Participation of aging users: The degree of participation of the aging users differed. In case 1 the aging users increased their degree of participation along with the increasing possibilities to test the technology in different ways. On the older people participation ladder [2] the participants went from performers (4) to initiators (2) when they were able to use the technology in their own way. The younger users in case 3 gave feedback related to own life situation (2) and how they perceived the technology could improve their own aging.

Triple Helix joint work: All three cases reached high grades on the Triple Helix participation ladder with close cooperation and activities crossing the boarders of the organizations (6). The Triple Helix participation was especially strong in case 1 and 3 where the company played an active role and worked close to the aging users, the care professionals and the researchers. Using researchers as mediators between other stakeholders was important since double competence (e.g. IT&T development plus aging or health context, and analysis methods) was required to work towards a common understanding. Researchers with knowledge from several of the involved areas facilitated communication and pinpointed important issues to be addressed.

Proxy involvement: The cases revealed interesting effects of proxy involvement. In case 1, initially the care professionals did not quite understand for which resident the device could be useful. This is in line with previous studies [2, 5, 7, 15] and may show that sometimes care professionals act as gatekeepers preventing without any clear reason that the elderly are exposed to new technology. Further, the care professional proxies later elicited different usage areas and needs, thereby creating a basis for a new context of usage and more meaningful services.. Another proxy effect was seen in case 2: Other results regarding use of proxies show difficulties in understanding user needs [14] but in case 2, proxies and users provided similar feedback. From an observing perspective, care professional proxies could see what caused problems and provide suggestions to

solutions, thereby deepening the understanding. This may indicate that, when using proxies, benefits could be gained by assuring that users and proxies will share the situation and experience it together.

Further work will elaborate this Quadruple Helix PD approach to provide a deeper insight regarding in which development stage it is suitable to test the technology, how and with which type of stakeholder, aging users themselves and/or together with care professionals.

6 Conclusion

The impact of this Quadruple Helix PD approach is improved benefit for aging end-users as well as increased feasibility for the innovation companies, as a result when collaboration of different stakeholders focuses on balancing the demands of the users and the prerequisites of the industry. The involvement of aging users in finding the balance between user needs and feasibility in the development, as well as an active involvement of the industrial partner, may contribute to a common understanding in developing realistic and meaningful services. Another important aspect for the companies was finding a market that is large enough to motivate the costs for development. Often there is a tradeoff between addressing user needs of specific groups and developing IT&T solutions that can be offered to a larger market.

The researchers stress the importance of engaging aging user groups based on situation and possibilities to contribute. The situation and possibilities to contribute is also important regarding proxy involvement. Proxies seems to be better suited in the work with testing existing devices in new contexts than working with or describing user needs in an early phase. Another relevant situation to use proxies could be when working with broadening a concept to find additional areas of usage.

Key to the success of the re-designed IT&T was the responsiveness of the developers. This can probably only be reached by a true engagement and by participation in settings where all stakeholders are encouraged and guided to perform at their best. Methods used that worked well were e.g.: observation of real usage performed by the entire Triple Helix team; creation of user profiles together with care personnel and IT&T developers; workshops guided by researchers; as well as enough time to test and to increase the common understanding for all stakeholders. This study found that the Quadruple Helix PD approach with focus on different stakeholder groups and their prerequisites results in improved possibilities to keep the balance between end-user needs and the prerequisites of the innovators, potentially contributing to improved IT&T solutions for aging users.

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