

# A Multi-disciplinary Approach in the Development of a Stroke Rehabilitation Tool

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**Abstract.** This work describes a method used in the development of a stroke rehabilitation tool. The method was based on three key elements. The first key element was iterations between the use of broad groups with different professionals/stakeholders and small hands-on working groups with users from the same profession. The second key element was movement between understanding differences between different organizations and professionals and understanding of specific needs within the different organizations. The final key element was including implementation aspects from the very start of the work.

**Keywords:** Design methods, participatory design, multi-disciplinary approach.

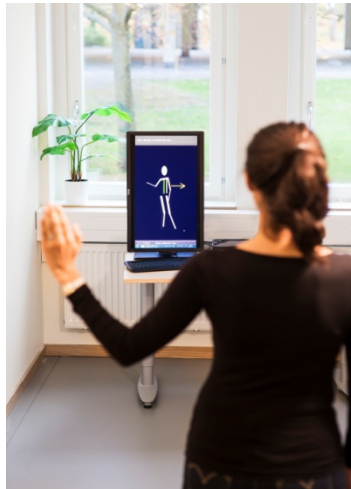
## 1 Introduction

Stroke is one major cause of acquired brain injury and of prolonged, complex disabilities. High quality rehabilitation is important for maintaining the patient's function, independence and quality of life. The need of coordinated rehabilitation efforts for stroke victims is extensive. In Sweden, several caregivers are involved in the process of stroke rehabilitation and there is no national consensus in the process. Generally, there is a need for strengthening the co-operation between different caregivers and increasing the patient's access to adequate rehabilitation, especially in the later phases of the rehabilitation [1].

Today's sensor-based and interactive communication technology opens new possibilities for continuous interaction between therapists and patients as well as between different caregivers in the rehabilitation process. Strengthening the social interaction between patient and therapist is one key aspect for increasing the patient's motivation for motor training. However, there is also a need for increasing the

patient's motivation for training autonomously. One approach for doing this is to provide the patient with a stimulating gaming environment that is built upon evidence-based practice for training.

We have developed a technical tool supporting motor training of stroke patients in their home. The goal was to develop a prototype that can lead to a future product that will be commercially available and used by health care organizations. Our technical approach has been to combine interactive communication technology with a gaming environment. This environment should provide controlled exercises that, through real-time evaluation by sensor technology, give the patient feedback during training with the aim to carry out the exercises correctly. The hardware of the system consisted of a technical setup in the patient's home (including a computer connected the internet, a large screen, Kinect sensor) and a setup at the rehabilitation clinic (including a computer connected to the internet, a normal screen, web-camera and head set). The software in the system consisted of software for planning and follow-up of training, video-communication and home-training program. Each specific exercise contained a basic level with the aim to guide the patient in performing a motion correctly; and more advanced levels, including a gamification environment, to increase the motivation of the patient to continue practicing. The patient's body was tracked by the Kinect sensor and presented on the screen as a stick figure. Hence, feedback was given to the patient upon the motion performed by the stick figure (see figure 1).



**Fig. 1.** The system and the stick figure providing feedback regarding movements

Based on this process we have synthesized a method for user-centered development of motor training technology. The method developed in this work had key elements in terms of: i) Iterations between the use of broad groups with patients, different health professionals and stakeholders; and small hands-on working groups with users from the same profession; ii) Movement between understanding differences between different organizations and professionals, and understanding of

specific needs and ways to apply technology in the different organizations; iii) Include implementation aspects from the very start of the work. The method was applied in three main steps: 1) Broad investigation of user needs – addressing key elements ii and iii; 2) Requirements on technology in different group settings – addressing key elements i, ii and iii; and 3) Addressing the needs in each specific organization – addressing key element ii.

## 2 Method

The work described in this paper was based on the participatory design framework with different participants and stakeholders with different knowledge contributing and sharing knowledge in an equal way [2].

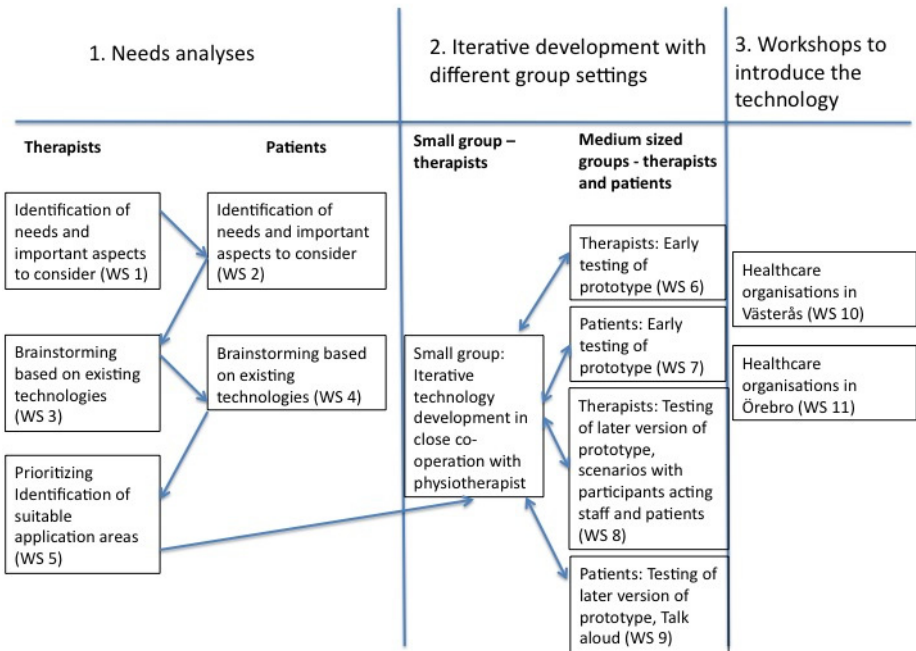


Fig. 2. The workshops and the progress of the work

Within the participatory design framework several methods are suggested to gather needs and to design systems. Here, we held both small group specific workshops, and larger ones with mixed user groups/stakeholders [3]. The needs and requirement phase (see figure 2: 1) consisted of workshops/focus groups to gather information about the different user groups’ situation and needs for support. After that brainstorming sessions based on existing technology were held. The technologies that were used were solutions that we perceived could address needs or parts of needs

described in the first workshops. The aim with showing different technologies was to have a starting point for the discussions [4] and to provide concrete examples of technology that could be used. After the brainstorming sessions we conducted a workshop to prioritize among all the ideas and suggested concepts. All ideas were categorized beforehand in main categories and sub categories. During the workshop the participant ranked the main categories and discussed which aspects in each category that was most important to address.

The workshops in the needs and requirements phase consisted of open discussions with a focus on the topic related to the specific issue to address (requirements, functionality and design). In the prioritizing the discussions were more structured with specific issues to address. The workshop approach was chosen since it is way of gather people with different perspectives and competences in an equal way. All the stakeholders and the user groups were involved in the beginning of the project and continued to participate during the entire process to ensure common goals and how these were met during the project [3].

The development (see figure 2: 2) was conducted iteratively with the different user groups involved. The approach was to gather participants with different knowledge and background and to share their different perspectives. Patients with different needs and different groups of healthcare personnel participated as well as project members including researchers from healthcare and technology development. People with knowledge in introducing technology in health care organizations also participated in the workshops. In the final phase (see figure 2: 3) participants from each participating organization/county was invited to a local workshop. A holistic view involving all relevant stakeholders [5] was applied, and people from different parts of the organizations participated. Aspects related to implementation were addressed in early stages of the work to address the specific context in each organization [6], and in the larger workshops at the end of the process we summarized these discussions and took the conclusions one step further.

## **2.1 User Needs and Requirements**

Initially, five workshops were held. In these workshop needs, requests and demands concerning technical solutions supporting home-based motor training were gathered. The participants in three of the workshops (ws 1, 3 and 5) were physiotherapists and occupational therapists from five different care giving organizations (Västerås Municipality, Västmanland County Council, Örebro Municipality, Örebro County Council and Danderyd Hospital).

The participants in the two other workshops (ws 2 and 4) were stroke patients recruited from the department of Rehabilitation Medicine and the department of Geriatric Medicine at Danderyd Hospital. The inclusion criteria were good cognitive- and communicative skills and experience in post stroke motor training. In one of the two workshops with stroke patients, spouses of stroke patients also participated. The spouses were also recruited via the department of Rehabilitation Medicine and the department of Geriatric Medicine at Danderyd University Hospital.

The first workshop (ws 1) with the therapists covered needs within different groups. The results provided a starting point for understanding the needs in the following workshop (ws 2) with the patients. The results from both these workshops served as a basis for planning and gather example technology to the brainstorming sessions (ws 3 and 4). The brainstorming was first held with the therapists, and here as well we used the understanding we had got from this workshop to prepare the brainstorming for the patients. Finally, in the fifth workshop the therapists prioritized between the different ideas from the brainstorming session (ws 5).

**Workshops with Therapists.** The aims with these workshops were to obtain a general understanding of stroke rehabilitation process and how the stroke rehabilitation process differed between different Swedish County Councils. We also wanted to obtain a general understanding of the co-operative work with patients by physiotherapists and occupational therapists. Further, we were seeking a general understanding of the therapists' opinions regarding needs and requirements on technology. Finally, we also wanted to understand the participants' attitudes towards using distance technology in their work with patients.

The three workshops started with a broad perspective in gathering user needs, moving towards limit the number of suggestions and finally ending up with a list with possible technological solutions that had been prioritized. The workshops mainly comprised structured group discussions lead by the researchers. The themes for the three workshops were:

- Workshop 1: Identification of important aspects concerning technology assisted home based training.
- Workshop 3: Brainstorming based on hands-on trying of different existing technologies.
- Workshop 5: Identification of application areas suitable for technology-assisted home-based motor training. The rehabilitation tasks from the previous workshops were grouped into different prioritized application areas and a list of requirements for each task was established.

**Workshops with Stroke Patients.** Two workshops were held with stroke patients. Both workshops mainly consisted of structured whole group discussions led by the researchers. The first workshop (ws 2) focused on important aspects regarding home based training in general. Discussions were held about the patients' experiences from participating in stroke rehabilitation efforts and their view of important aspects to consider when developing technology for home based training. The second workshop (ws 4) narrowed down the scope to requirements on technology. The theme for the workshop was a brainstorming session based on existing technology. The stroke patients were introduced to the same technologies that were demonstrated to the therapists. Discussions concerning functionality and relevance for stroke rehabilitation were held with patients and their significant others.

The aim with the workshops were to obtain a general understanding of the patients' needs for technology in rehabilitation, and to understand patients' experiences and

attitudes towards using distance technology and technological tools in their rehabilitation. Finally, we wanted to obtain a general understanding of important factors related to future use of the technology in the patient homes. In the second workshop significant other to persons with stroke also participated with the aim to get a general understanding of their situation and attitude towards technology in rehabilitation.

## 2.2 Iterative Development in Different Group Settings

When the concept had been selected, the iterative development was conducted moving between small hands-on groups consisting of physiotherapists and with medium sized groups (4-15 participants) groups consisting if of either patients or therapists from several organizations.

**Small Group: Iterative Development with Physiotherapist.** The small group consisted of two physiotherapists from a rehabilitation clinic specialized in motor training of stroke patients. The technical development in the project was carried out in continuous, close co-operation with physiotherapists from Danderyd University Hospital. All developed exercises were constructed on basis on needs collected in the project and the exercises were designed in collaboration with the participating physiotherapists.

The work was structured into four consecutive phases:

- (1) Development of rehabilitation exercises (the content, design, feedback and gamification)
- (2) Collection of feedback on developed exercises
- (3) Production of a system surrounding the exercises
- (4) Final adjustments for increasing usability of user interfaces and gamification environments

**Medium Sized Group: Feedback on the Prototype.** Two workshops (ws 6 and 7) were held to get feedback on an early version of the prototype, one with therapists and one with patients. In the first workshop that was held with therapists (ws 6), the participants could try the exercises. Whole group discussions were held concerning the usability of the technology in stroke rehabilitation and important aspects related to using the technology in different rehabilitation operations. In the next workshop (ws 7) the early version of the prototype was shown to the patients. On a voluntary basis, patients could try the exercises. A common discussion was held in the group concerning how the patients experienced their use of the system and their reflections on the technology.

After further development a later version of the prototype was the focus in two workshops (ws 8 and 9), as before, one workshop with therapists (ws 8) and one with patients (ws 9). In the workshop with the therapists, the participants took part in a role-playing acting therapist and patient. The task resulted in feedback upon the exercises and on the video communication. In this workshop participants from the

same care giving organization also were grouped to discuss questions related to implementation in their organization. In the workshop where the patients participated around the later version of the prototype they could, on a voluntary basis, try the system one at the time. During the testing session, the participants were instructed to “talk aloud” (to gather thoughts and impressions in the moment) and after that a discussion was held between the patients and the researchers.

### **2.3 Addressing the Specific Situation in Each Organization**

As a final step, large workshops (11-23 participants) were held within the different health care organizations. In these workshops (ws 10 and 11), the aim was to involve all relevant categories of participants such as representatives from patient organizations, health professionals and managers within the healthcare organizations.

The aim in this phase was to take the results one step further based on the needs within the specific organizations and to start hands-on work with the implementation of the technology. The workshops started with a demonstration of the technology and its functionality followed by common discussion concerning aspects related to value and risks. After that, the participants were divided in three groups and worked more focused on specific topics: (i) User needs with respect to the technology based on the perspective among representatives from patient organization; (ii) User needs with respect to the technology (exercises and video-communication) based on the perspective among health professionals; (iii) Aspects related to future use of the technology in rehabilitation with health care personnel. Feedback regarding the technology and its functionalities was collected both through discussions and by written questionnaires.

## **3 Results and Conclusions**

The outcome of this work consists of methodological results from the work with gathering user needs and with the iterative development. We also present results regarding the larger workshops that addressed the needs in each specific organization.

### **3.1 User Needs and Requirements from Patients and Therapists**

This section describes the results from the investigation of user needs, the brainstorming sessions and the prioritizing between the different ideas. Finally the setting of the workshops is analyzed.

**Broad Investigation of User Needs.** The advantage of grouping people from different professions was that we obtained a consensus on the functionality of the tool that had high potential of adding value for various rehabilitation organizations and patients. The challenge though was to manage the different perspectives in terms of what they wanted to use the technology for. On the other hand, one aspect of participatory design is to highlight differences between user groups and to take

different perspectives into consideration [7]. One lesson learned was that we, in the early phase as well, should have introduced small group specific workshops to be able to gather more details [4]. However, the way we did this led to interesting and fruitful discussions, and we ended up with ideas that all of the participants felt meaningful even though it might have been more pragmatic to have discussions with each group at a time, and then gather different perspectives on the selected solutions.

The patients that participated were of good health and with good cognitive- and communicative skills. Hence, the situations, needs and requirements of all stroke patients were not reflected in this group of participants. However, the aim was to include participants with experiences of stroke rehabilitation and an interest in motor training with support from technology. In the beginning of the development the participants had to have enough knowledge and interest to be able to provide ideas and suggestions into the brainstorming context.

Even though we had inclusion criteria for participating, we tried to include participants of different ages and with different rehabilitation needs. The aim was to gather different perspectives and different needs. However, when doing so there is also a risk of getting too deep into individual needs. In this work though, the discussion became a common one with all participants contributing to the ideas that was suggested.

**Brainstorming Based on Existing Technology.** In the following two workshops, one with therapists and one with patients, we showed examples of existing technology. We included a wide range of complementary communication technology and we also included additional products in the process upon the participants' requests. We found it highly valuable to use concrete technical products to base the discussion around. It is a challenge though to introduce something new without affecting the way the participants think. On the other hand, the aim with the activity was to provide knowledge about technical possibilities and limitations, and demonstrating different technologies is one way of doing it [8].

**Prioritizing.** In the phase were we had to prioritize and limit the number of possible solutions it became clear that the two groups of professionals prioritized differently and had difficulties in agreeing on which aspects that were most important to address. First, since everything was based on their own ideas they felt that everything was of equal importance. Secondly, the physiotherapist and the occupational therapists argued for the importance of the solutions that supported their aspects of the work with the patients. Our conclusion from this part of the work was that it might be more effective to involve professionals in the work with prioritize. For example, professionals who have knowledge about needs and challenges within the entire health care organisations. This could also reduce the risk of something important being missed.

**Organization around the Workshops.** One important aspect in setting up the workshops was to create an atmosphere were the participants felt comfortable in contributing with their needs and ideas. Mutual learning and sharing of knowledge is



an important aspect of the design process when different categories of people participate [8]. We included different professionals from the project to create a feeling of that everyone in the room were there, based on his/her own experience/knowledge and that the aim was to share this with each other. It could also be an advantage to have professionals within the area to participate in sessions like this. Stroke can affect emotions, and when talking about how the disease had affected every day life it could be beneficial to have someone in the room that has experience in stroke and emotional reactions.

Our general impressions from the workshops were that we met our intention to create an informal atmosphere where every one should feel comfortable in contributing succeeded. The fact that the participants said that they enjoyed the workshops and that they wanted continue being a part of the work also supported that we had achieved in creating a good atmosphere. It is also an important aspect of the design process to have motivated users that enjoy being a part of the development. This will contribute to a better product that is based on important and relevant user needs.

### 3.2 Iterative Development Based on Work in Different Group Settings

In this phase we worked iteratively hands-on with two physiotherapists and with medium sized groups of therapists and patients that discussed the progress of the prototype.

**Small Group: Iterative Development with Physiotherapist.** The technical solution that was developed consisted of four main categories of exercises. When the software for the specific exercises had been developed, the physiotherapists could try the exercises on their own between the scheduled meetings with the technical developers. This enabled the physiotherapists to evaluate the prototype more thoroughly and give feedback based on their own testing of the exercises. Based on feedback from the physiotherapists, modification of existing exercises and development of new exercises was performed between the meetings.

When two exercises were developed, workshops were held with patients and therapists in the medium sized groups. The aim of these two workshops was to ensure that the technical development was on track with regard to the initial analysis of user-needs and demands. Once all four exercises approached finish, discussions were held concerning design and content in a web-based user interface for planning and follow-up of training. When all key elements of the technical functionality were on place, the physiotherapists tested the technologies' usability and the motivational aspects in the games. Final adjustments in the design were done in order to increase the usability and overall user experience.

The physiotherapists were essential in the work concerning concretization of exercises for all four rehabilitation tasks in several ways: Firstly, their knowledge in evidence-based rehabilitation exercises for the different rehabilitation tasks laid the ground for the movements to practice in each exercise. Secondly, their experiences from using other technical tools and computer games in stroke rehabilitation were

highly valuable when designing an environment that should be suitable for patients' needs and cognitive abilities. Since the group consisted of only two persons, the work was highly dependent on their availability and interest. On the other hand, a relationship could be established over a longer time, which enabled an atmosphere that encouraged open discussions including critical feedback.

**Medium Sized Group: Feedback on the Prototype.** To get feedback on an early version of the prototype two workshops were held (ws 6 and 7), one with the therapists and one with the patients. When the feedback had been taken into consideration and the system had been developed further two new workshops (ws 8 and 9) were held, again one with the therapists and one with the patients. As mentioned before, it was important to constantly move between the possibilities that the hands-on work provided and by placing this work in a broader context.

*Workshops with therapists:* In the first workshop where an early version of prototype was shown (ws 6), an important part was to explain the basis for how we have prioritized during the technical development. Since some technical functionality, earlier suggested by the participants, had not been included in the prototype. When this had been explained, the group discussions led to general feedback on the chosen system. In the second workshop (ws 8), the participants worked in small groups with group members from the same health care organization. The work gave feedback on concrete details concerning technical functionality. We experienced that the participants were more comfortable and gave more constructive feedback in this group composition.

*Workshops with stroke patients:* The patients were engaged in the testing of the technology and they gave several suggestions for improvements. They thought trying the prototype was a positive experience, and they asked for possibilities to use the system in their homes. This questioned raised the issue about how to explain to the patients that a product is quite far ahead. Even though much information was given about this, it could be difficult convey the information that it will take some time before the technology will be a product. Especially since some stroke patients are very motivated to work hard to be able to recover as soon as possible.

### 3.3 Addressing the Specific Situation in Each Organization

The aim with these workshops (ws 10 and 11) was to address the needs in each specific organization and to understand their particular way of working with stroke patients. It was also important for the ongoing introduction of the technology to make a larger part of the personnel engaged and interested. Further, these workshops provided us with the possibility to gather data about the system from a larger group than in the previous workshops. Participants filled in questionnaire regarding attitudes towards the usage and the functionality of the system.

Regarding the larger workshops we gained a better understanding of how to adapt the workshop approach after group when several different occupations participated. As with the medium sized workshops, when the group was split into smaller groups with more hands on tasks, the engagement became stronger and more interesting

discussions came up. One topic that was addressed in smaller working groups was about introducing new technology in their organization. This was a good opportunity to do this since the large workshops consisted of many different professions within the same organization.

## 4 Discussion

The method developed in this work had one key element in terms of iterations between the use of broad groups with patients, different health professionals and stakeholders; and small hands-on working groups with users from the same profession. The shifting between these groups was found to be very useful: the small group facilitated close cooperation in the technical development and the broad group confirmed that the prototypes reflected user needs in this group. Another key element was to understand variations between organizations and professionals as well as specific needs within different organizations. With respect to this, the medium sized workshops provided knowledge about how different the rehabilitation process could be between organizations and parts of the country. The large workshops at the end of the process provided input regarding specific aspects related to implementation in the different organizations such as transfer of patients between different caregivers. The final key element was to include implementation aspects from the very start of the work. This was done by including discussions about these aspects in the medium sized workshops that had participants from different professions. Project members in terms of researchers and professionals in introducing technology in health care organizations were also working with these issues throughout the project.

The work presented here takes its inspiration from established methods for design such as participatory design [2], user-centred design [9], and value sensitive design [10]. These methods all underline the importance of putting users centre stage, involving users and other stakeholders in the design process, and base system design and development on user needs, as well as iterating designs and implementations.

As the reader can see, we have to a large extent adopted these methods and underlying philosophies in our work in the phases of user needs investigation, technology requirements, and organizational needs. What we have added is an iteration of perspectives in switching between large, diverse groups of stakeholders and small groups of one profession, between the perspective of the variety of different organizations and the specific needs and opportunities in single organizations. This has helped us to keep the design space quite wide through the process and not narrow in on a single solution too early, as well as ensured that as many needs as possible have been catered for in the system design.

Another contribution is our inclusion of technology in all phases and iterations of the work. It might be argued that bringing technology in at an early stage hinders the design process and narrows the design space since finished technology limits our thinking. However, we argue that the inclusion of technology throughout the whole design and development process has helped in two ways. First it has showed the possibilities of state-of-the-art consumer technology such as the Kinect, which was

quite unknown to many of the stakeholders in terms of possibilities and capabilities. Second, it has helped balancing the workshops not to go off into too futuristic scenarios nor settling for solutions way below the capabilities of the technology.

We believe that the way of working hands-on, both with brainstorming around existing technology and in the development of new solutions is fruitful, especially when doing so in a reciprocal way moving between hands-on work and feedback from other group constellations as well as between organizational and individual perspectives.

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