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LONG PAPER

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# Developing a navigation aid for the frail and visually impaired

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**Abstract** This paper describes the development of a new navigational aid for the frail, elderly, and visually impaired person. The users were involved both in the user requirements study and in the evaluation of different prototypes. The results show that the users were able to provide information on their current aid, the use situation, and their preference regarding different solutions, but they had difficulties to provide the detailed answers on technical solutions required by the technical development team. Further, prototype evaluations with users enabled the technical team to understand the users and their use situation.

**Keywords** User involvement · User oriented product development · User requirement elicitation

## 1 Introduction

The opportunity for independent mobility is a major factor affecting the quality of life for all people. However, this opportunity is restrained for a large number of people due to visual impairment. Actually, four million people in the EU can be described as visually impaired (i.e., with residual vision below 6/18) [8], and this number is expected to increase as a consequence of the aging European population. As age increases, so do physical disorders. Frailty, when combined with a visual impairment, has a devastating effect on the ability of elderly people to move around independently. This category of users is often excluded from conventional mobility aids for the visually impaired, such as long canes and guide dogs. One of the most important drawbacks of these aids is that they do not provide the necessary physical support for the frail individual. In addition, these aids require extensive training in order for the individual to learn and apply the necessary skills. Consequently, elderly, visually impaired people become dependent on carers for personal mobility. However, this level of carer involvement is often beyond the resources of the elderly person or a care centre, and so the person may be forced into a sedentary lifestyle, leading to physical as well as psycho-physical disorders.

The drawbacks of the long cane and guide dog have prompted much research into electronic mobility aids. Several reviews have been carried out (e.g., [2, 11, 19]). These early studies showed that electronic mobility aids are not used by the majority of blind users, primarily due to excessive cost, poor user interfaces, and poor product semantics. Development work have continued, resulting in, e.g., the GuideCane, a cane using ultrasonic sensors to detect obstacles [16] and the ASMONC system, an instrumented handle which provides the user with directional information [8]. However, these projects have focused on navigational rather than on physical support. Consequently, there is a need for a new aid which combines easy to learn navigational support with good support while walking.

## 2 The PAM-AID project

This paper reports on some of the findings from the personal adaptive mobility aid (PAM-AID) project. The aim of the project was to develop a "smart" walking aid capable of both providing the user with support while walking (similar to that of existing walking frames and

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rollators), as well as navigational support by applying technologies from mobile robotics and signal processing. The aid was to improve physical accessibility to different environments for individuals with impaired vision and mobility. However, a pre-requisite for providing this situation is to create "access" to the aid itself, i.e., to design a device with high usability for different categories of users with different experience of IT and new technology.

A fundamental issue in the development of the new technical aid was therefore the involvement of its potential users. Thus, the project was to be run as a user-centred product development project. The main argument for a user-centred approach is that the finished product will be better suited to the needs and requirements of the users. There are also findings that the acceptance of new technology will be higher if the users are involved in the design process. However, involving the user is often perceived as problematic. Users and developers speak different languages, and users have difficulties expressing their requirement in technical terms and often change their requirements as a consequence of learning of new ways to solve problems [35, 13].

The aim of this paper is to describe the development of the new aid and the ways users were involved. In particular, the paper addresses the questions of how users can be involved in a development project and how we can help them articulate their requirements for a new product.

## 2.1 The development project

### *2.1.1 The project plan*

The project plan covered different work packages, of which the following concern the development and evaluation of the aid (Fig. 1):

- User requirements and system specifications. Potential users, carers and mobility professionals were to be interviewed. The aim was to elicit information on a user's specific problems with their present aid, and his requirements and preferences for a new device [8].
- Rapid prototype construction. This part of the work was dedicated to the construction of a rapid prototype using a commercial robot base. Low level control software was to be implemented and a prototype sensor system added. Data from the user requirement study and the user interface study (see below) were to be added towards the end of the task.
- User interface design. The work package was to cover the design of an effective user interface and the choice of modality used for input and output.
- Rapid prototype evaluation. The rapid prototype was to be tested by users in Ireland, the UK and in Sweden. The users were to use the device for a number of hours, after which a focused discussion with users and carers was to take place. The users' feedback was to be used in the development of the prototype, as well as the development of training and service.
- Design of the prototype system. During this work package, the prototype was to be developed into a market ready product.
- Validation and demonstration. The prototype was to be evaluated by users during a longer period of time without the involvement of the development team.

The project plan thus described a typical user-centred development process, with iterations between development and evaluation [6].

### *2.1.2 The actual process*

The actual PAM AID-project followed the procedure illustrated in Fig. 2. As planned, the process started with a user requirements study providing information about the potential users, and their problems, needs and requirements. Afterwards, and partly in parallel, a first prototype of the aid was built (a rapid prototype). This prototype was evaluated by potential users, as well as carers, further developed and evaluated again. After the second evaluation, a new prototype was built based on the information from the user trials. This new prototype was also evaluated, modified and evaluated once more. Compared to the initial plan for the project, the evaluations were shorter and focused on more specific issues. In addition, the number of iterations between developers and users had increased from one to at least five (Fig. 2).

The project followed two parallel processes: one process involved the technical development (process A) of the aid, while the other involved the elicitation of user requirements and evaluation of solutions from a user perspective (process B). Information from process B to process A was not only transferred at the end of the evaluation tasks, but continuously during the evalua-

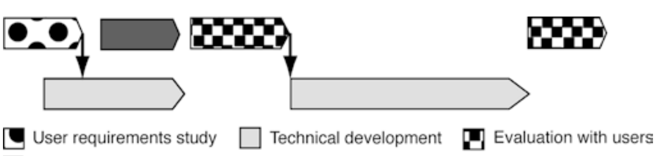


**Fig. 1** The project plan

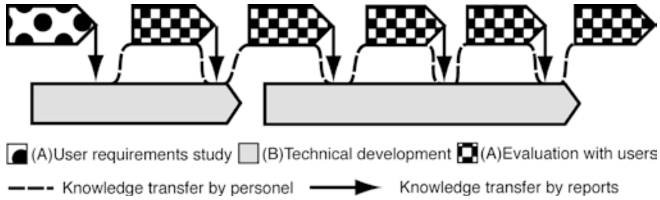


**Fig. 2** The actual process

tions with the users, as a result of the participation of the engineers in the trials.

## 3 Developing PAM-AID

The PAM-AID project was a user-oriented development project. Indeed, the user requirements study and the repeated user trials generated rich information about the users and their requirements. However, there were noticeable differences between the information gathered from the different studies, and the impact of the information on the development project.

### 3.1 The user requirements study

The first step in the development process was the user requirement study [8]. The aim of the study was to elicit information on users' problems with present aids and their requirements for the PAM-AID device. In addition, carers' opinions on PAM-AID and on different design aspects of the new aid were investigated. In order to elicit the user requirements, interviews were conducted with potential users, and with carers as well as with mobility experts in Ireland, in the UK, and in Sweden. In all, the study encompassed 32 users, 12 carers, and two mobility rehabilitation experts. The interviews followed a strict interview schedule, and included open-ended questions to facilitate the discussion between interviewer and participant, as well as questions which required participants to rate their opinions on a 5-point Likert scale. The questions covered the users' habits, feelings, medical status, and disabilities, as well as their preferences regarding a number of details in the design of the proposed aid. In the beginning of each interview, a verbal description of the future aid and two short use scenarios were presented to the participants, in order to provide them with a better picture of what the proposed walking aid might be like. This description was based on the initial concept regarding the design of the aid. For instance, the participants were told that the aid was to be motor-driven, it should navigate with the assistance of a sonar system, it should detect obstacles, down drops, landmarks etc, and it should be able to provide audio feedback on these issues.

Although the requirements study involved three countries and slightly different categories of users, the overall problems and requirement pictures were surprisingly similar. According to the users, the aid should:

- provide physical support
- be easy to manoeuvre with one hand, as well as two
- have the physical structure of a standard rollator, with two handles, one at each side of the frame. However, there were users (as well as carers) who preferred one handle type solution (as a shopping cart), reflecting the specific situation of, for instance, users with only one able side (due to a stroke)
- be adjustable in height in order to be able to cope with users of different heights and postures
- be as small and lightweight as possible without losing its stability and security; it should be possible to bring the aid in a standard car/taxi
- be equipped with a seat to rest on
- be equipped with an alarm for attracting attention
- be equipped with a basket to store small items

A number of questions in the questionnaire concerned the way the users preferred to operate the aid. The users were therefore asked to choose between different options described to them. According to the response, a majority of the users preferred to push rather than to be guided by the walking aid, since they thought that this would give them more control of the aid. However, some users thought that a guided mode would be more suitable as they may not have the strength to manoeuvre the aid (for instance, up and down slopes). These comments demonstrated that the feeling of control and the weight of the aid were important issues.

Another set of questions concerned feedback about the environment. The users wanted the aid to provide them with warnings for obstacles and dangers and notification on doorways and other key characteristics of the physical environment. Most users felt that this information should be given as speech output in a clear voice. The option to alter the volume of the speech, as well as to completely turn it off, should be provided. There were, however, some users, particularly in the Irish study, who had hearing problems and therefore preferred a non-speech solution.

The primary use of the PAM-AID was thought by the technical development team to be in a domestic environment. However, several users regarded mobility outdoors as an important issue. This was most common in Sweden, where most elderly visually-impaired people live in their own homes.

Overall, the interviews showed that the users were able to answer questions concerning those areas of the aid where they had previous experience, e.g., from their current walking aid. Therefore, the users were able to provide detailed information about baskets, brakes, and stick holders, all common items on a standard rollator. They could also provide valuable information on problems experienced in their daily life, e.g., problems in going up steep slopes, and even more severe problems in going down. However, what they could not provide was detailed information on items on the suggested aid that did not have any analogies in their life, e.g., whether the aid should be controlled by switches or a joystick, etc. It was also clear to the interviewers that despite the given description of the aid and the scenarios presented, the users did not fully understand the concept of the PAM-AID. It was not uncommon among the participants to picture the device as an "electronic guide dog", not only capable of finding the closest pub, but also of being a companion.

## 3.2 The first prototype

After the user requirements study, and partly in parallel with it, a prototype walking aid was developed and built. The first PAM-AID had a six-wheel chassis where the two centre wheels were motor-driven. The other four wheels were placed in each corner and free pivoting. The walking aid scanned the environment by using several sonar sensors. The sonar information was processed by a computer, controlling the motors and the audio output. A large structure containing motors, motor controller, sonar sensors, computer, etc., was placed on the chassis. The frame of the chassis came partly around the user, which meant the body of the user was protected by the walking aid chassis. The upper frame of the aid was shaped like handlebars. The aid could move in an "automatic mode" which meant that the aid followed, e.g., a corridor, and in a "manual mode", in which the user had to steer the device according to the auditory feedback on the environment given by the device. The aid was controlled in the manual mode by pushing down or lifting the handlebars.

### *3.2.1 The first user trials and the first iterations*

The first prototype (PAM-AID 1.0) was tested in user trials in order to find the main areas for improvement [12]. The trials took place in England and in Ireland, respectively. Before the trials, the functionality and the way to operate the device were explained to the participants. After this introduction, the users tried the device in an indoor environment at their respective homes. In order to assess the users' subjective opinions, a set of questions was asked during as well after the trials.

The users in the English user trials pointed out few, but severe, problems with the aid. The prototype was too cumbersome, too heavy, detected obstacles too late and had traction problems. The instrumented handles were found to produce a jerky motion. The aid first responded to the users' downward push on the handlebars by abruptly moving forward, and then came to a sudden halt since the user had not started to walk and, consequently, lost the pressure on the handles. Also, the instrumented handles did not provide enough support when walking backwards or when turning. In addition, there were problems with the command confirmation dialogue. The aid produced speech output for three purposes: command confirmation (e.g., "go left"), robot status information (e.g., "going left") and environmental status confirmation (e.g., "opening to the left"). The users interpreted the command confirmation messages as a command from the robot to the user, resulting in confusion.

Based on the results from the English trials, the prototype was evolved into a version 1.1. The new PAM-AID differed from the 1.0 version in the following aspects:

– The device was controlled by pressing switches located on the handles instead of by moving the handles.
– The width was reduced from 70/80 cm to 55 cm to make the aid less cumbersome.
– A hoist was included assisting the user to rise.
– The traction problems (wheel slippage) were eliminated.
– Obstacle detection was improved.

Even though the device was considered already too heavy, the modifications nevertheless resulted in an increased weight.

This modified prototype was evaluated in Ireland. In this study, sixteen participants were involved, all of whom were frail, visually impaired and living in a home for visually impaired persons with 24-hour care.

Many of the problems from the English user trial were still evident in these trials. The aid was still considered too heavy and too bulky. However, it was much easier to control, and information was now obtained on a somewhat more detailed level. Two participants tried the hoist option, but it was clear to the evaluators that the users could not easily get their body weight directly over the rising handles. In addition, the speed of the device had to be adjustable, preferably while walking. The participants were equally divided as to whether they preferred to use the automatic or the manual mode. Most participants thought that the switches on the handles were well positioned, but for two participants with arthritis the main problem was the need to keep the switch pressed all the time to move forwards. Their thumbs became tired and painful. A majority of the participants thought that the handles of the device were supportive and comfortable and would have liked to direct the walking aid with the handles (like a bicycle) commenting that it would be useful to make much sharper turns than was possible with the tried prototype.

## 3.3 The second prototype

The second prototype (PAM-AID 2) differed substantially from the previous model. The users trials had clearly shown that the motor driven solution led to a number of usability problems: the device became too cumbersome, too heavy, and too difficult to control for the intended target group. Therefore, the second prototype was no longer motor-driven; instead, the user had to push it like a conventional rollator. The hoist was eliminated to further reduce bulk and consequent power needs. In addition, obstacle detection was further improved.

The PAM-AID 2 was built largely like a standard rollator, i.e., there were four wheels, the front ones steerable and the aft ones fixed. On the frame were attached computers, motors for the steering, sonar sensors, etc. On top of the frame was a handlebar. Contrary to standard rollators, the handlebars were turnable in order to make the device possible to steer in a manual mode. An on/off switch and a volume control for the speech output were located on the frame. The other controls, i.e., a switch for manual/automatic mode, a switch for the parking brake, and a push button for the "turn on the spot" function, were located on the handlebars (see Fig. 3).

### *3.3.1 User trials of the second prototype*

The PAM-AID 2 was evaluated in new user trials, in Ireland, in Sweden and then in Ireland again. This second series of user trials followed a procedure similar to the previous series. The participants first got a description of the aid and had the opportunity to feel and touch the device. The functions of all switches on the handlebars were explained (automatic mode, manual mode, parking on and off and "turning on the spot"), and the participants were allowed to listen to the different voice messages: "opening right", "opening left", "dead end", "straight ahead", "object right", "object left" and "dead end". During the trials, the participants operated the aid in the manual as well as the automatic mode in an indoor environment. The walk included manoeuvring around corners and avoiding obstacles such as waste bins. After the trial, the participants answered a set of questions. In addition to the questionnaire, researchers recorded the participants' comments while operating the walking aid. The trials were also recorded on video. In all, 24 elderly frail and visually impaired users participated in the second series of user trials.

**Fig. 3** The last prototype of the aid during the user trials in Ireland

Some user feedback was consistent throughout the user trials. One of the major problems was still the weight of the device. The users in all user trials agreed that the aid was far too heavy. This made it tiresome to push the aid, and in particular the users had problems turning. Some of the users had difficulties even to move the aid. To many of the users the weight problem overshadowed other minor problems, making them focus entirely on the weight and neglecting other issues. Nevertheless, most of the users liked operating the aid with the handlebars, but they commented that it must be adjustable in height to fit different users. An interesting thing is that the users were positive about the aid and thought that it would be useful; however, none of the users were interested in using one.

*3.3.1.1 The first Irish trial of the second prototype* The device was modified in between each of the trials. In the first Irish trial, only the "manual" mode was functioning, i.e., the user got audio feedback about the environment and could steer the device according to the information given. A technician steering the device by remote control simulated the automatic mode.

In this trial, the participants thought that the PAM-AID walking aid moved smoothly, but a slight vibration was felt in the handle. In the manual mode the participants found the device to be manageable and quite easy to steer. However, most participants preferred the (simulated) automatic mode. In addition, most participants now judged PAM-AID to be quite easy to push. Comments made regarding the handles were that they were "wobbling".

*3.3.1.2 The Swedish trials of the second prototype* In the Swedish trial, both the manual and the automatic modes were in function (PAM-AID 2.1). In addition, a "turning-on-the-spot" function had been implemented, and a stiffer spring had been fitted to take care of the "wobbly" feel of the handlebars.

All participants in the Swedish study found it difficult or very difficult to walk with the aid in the automatic mode. One of the problems that probably contributed to the participants' assessment was that the device had some difficulties staying "on track" when a user walked at a somewhat faster pace. When asked to try the walking aid while a technician steered the aid by remote control, the general comment was that this was "...much better". Obstacle detection had improved but there were still situations when the aid did not detect the obstacle or it detected the obstacle but user feedback was provided too late or erroneously. Furthermore, the first participant in the Swedish study considered the handlebar spring "...too stiff". This was successfully changed for the subsequent sessions. Overall, the switches and buttons were considered easy to use, i.e., they were easy to detect, it was easy to identify their position and they were easy to manipulate. However, the push button for "turning on the spot" was considered somewhat difficult to find, as it was level with the handlebar surface.

The participants found the auditory feedback useful but there were requests for more speech feedback, e.g., some users wanted the aid to distinguish between "obstacles" and "walls", as they felt that a wall is not an obstacle. All participants found the messages easy to hear and understand. They pointed out that it was good that the messages were recorded and not speech synthesis, as they considered voice recordings easier to comprehend.

*3.3.1.3 The second Irish trials of the second prototype* For the last user trial in Ireland, a laser scanner was mounted on the PAM-AID (PAM-AID 2.2). The laser scanner allows much more accurate obstacle detection, which leads to a much smoother operation. In addition, some minor changes were made to the device, e.g., the "turn on the spot button" was redesigned and the handlebars were made adjustable in height.

In this trial, the participants were equally divided in their preference for manual or automatic mode. There seemed to be a correlation between having residual eyesight and the choice of the manual mode. The switches were rated as "quite easy" to learn and to operate. Some participants found the switches difficult to reach, as they had to take their hands from the handlebar. Some of the participants had problems finding the "turn on the spot" button, and suggested that the button be larger and located more closely to the thumb. There was also the risk of confusing the "turn on the spot" button and the "parking mode" switch. The spoken messages were rated as "quite useful" to "very useful". There were, however, problems with the detection of landmarks. Sometimes the aid missed important landmarks that the users knew were present, and in other cases the aid gave information about landmarks that was not relevant. The participants in the Irish study found the quantity of messages about right and seven out of ten rated the messages as "understandable". Three participants wanted the messages to be simpler. All the participants wanted to be able to shut the messages off.

Having completed these last user trials, some of the project members felt that it was possible to develop the aid prototype into a commercial product. They have continued to improve on the aid, and it is now a commercial product, Guido by Haptica (see http://www.haptica.com).

## 4 General discussion

Evidently, new technology can contribute to creating access to different environments for individuals with visual impairment. For instance, there are several examples of sonar technology being used for providing information on unknown environments. However, offering a technical solution is not enough in order to reach the overall aim. The product and its user interface must be designed to match the requirements of the specific user, the use environment, and the task to be accomplished. Towards this end, the involvement of the intended users in the development process is regarded as a prerequisite.

The aim of this paper was to describe the development of the new aid and the way users were involved. In particular, the paper addressed the questions of how we can create pre-conditions for user participation in a development project and how we can enable users to articulate their requirements for a new product.

### 4.1 Mediating requirement elicitation

A necessary prerequisite for user participation in a development process is a dialogue between the user and the designer. One way of enhancing the dialogue is the use of different tools [17]. A useful tool or mediating object is a representation of the future, or present, product. In this study, two different types of mediating objects were used, a *verbal description* of the future product and its intended use, and a series of *prototypes*.

The first type of mediating object used was the verbal description. The results from the interviews show that this product representation did not really provide the users with enough support to create a mental image of the intended future product. Instead, the users' prior experiences formed their picture of the aid and thus this became the source of their requirements. The users with experience of rollators were able to provide information on problems of their current rollator, and to come up with requirements on features normally associated with rollators. On the other hand, the features of the PAM-AID that make it different from ordinary rollators were only vaguely understood by the users. This is illustrated by the fact that a common association was that of the future PAM-AID in terms of a guide dog. The interview guide used in the study focused mainly on details that were important for the technical development team and contained many questions in which the participants were asked to choose between different and detailed alternatives on how the aid was to be controlled, etc. Even if the participants answered these questions, it was clear to the interviewers that the answers were not grounded in any real understanding of the envisaged product, but rather in the participants' wish to provide an answer to the interviewers' questions. *In summary, the questions that could be answered by the users could be described as problem-oriented, while the interview consisted mainly of solution-oriented questions which the users could not answer since they lacked use experience.*

The other type of mediating object used was a working prototype of the aid. Contrary to the verbal description, the user trials with the different prototypes enabled the users to provide rich information on details and preferred solutions. Trying the prototypes in realistic use situations gave the users an understanding of the product, its shortcomings and its possibilities. The users were able to comment on problems and express preferences to different technical solutions, but they did not provide any radical innovations. When the users came up with an idea of how to solve a certain problem, the solutions were based on solutions known to the users from similar products.

This "leap" in understanding between the verbal descriptions and the working prototype can be explained by the possibility to interact with the prototype (cf. [14]). Actually, Söderman has proposed that "scale" and "interaction" are more important factors in a product representation in order to create understanding, than is, e.g., the "degree of detail". In other words, even if the verbal description had been more detailed, or if we had been able to show the users a very detailed and realistic rendering, the users' understanding of the future product would probably not have been enhanced. Enhanced understanding requires the user to be able to interact with the product representation.

The identified need for physical prototypes in order to give the future users an understanding of the product is in accordance with the findings of Leonard-Barton: "The less resemblance a future product bears to those currently on the market, the more important representational models become for designers to use not only in communicating their vision but also in the process of completing a design by eliciting user reactions." [10]. Also, previous studies by Engelbrektsson [4], Söderman [14], and de Bont [1] have shown the need for physical prototypes to help users understand and give opinions on a future product.

However, during trials with prototypes there is a danger that the prototype may differ in important ways to the actual future product. During some of the user trials, technical functions that were not yet fully implemented in the prototype were mimicked (like in a Wizard-of-Oz methodology). The major technical function that was treated this way was the obstacle detection system, which in some of the trials was replaced by a technician operating the device with a remote control. In the analysis of the trials, it became clear that the participants who used the device with the technician acting the obstacle detection system were more positive to the automatic mode than were the participants who used the real but not as a "skillful" device. A conclusion is therefore that it is important that the simulation is not better than the real product.

### 4.2 An iterative approach to design

The project demonstrates the usefulness of a product development process with rapid prototyping and many but fast iterations. The repeated user trials were not only a way of evaluating the technical performance of the prototype, but also an arena for the elicitation of user requirements as well as for translating them into more detailed specifications. It is clear that the requirements of the users evolved over time and were dependent on the users' experience and what they thought would be possible (cf., the notion of "emergent requirements" in e.g. [7]). In addition, the iterations, resulting in incremental improvements of the aid, were necessary as it seemed that the users were not able to evaluate and comment on features that they regarded as minor problems until the major problems were solved. This is evident, e.g., in that the first evaluation of the prototype only found that the aid was too heavy, bulky and produced a jerky motion, whereas the users in the later trials could comment on design features on a much more detailed level.

### 4.3 Enabling the designer

A somewhat surprising finding from the studies was that the prototypes, or rather the user using the prototypes in the intended use environment, not only enabled the users to understand the future product and its possible use, but also enabled the members of the technical team to understand the user and the interplay between the user, the use context, the task to be accomplished and the offered technical solution. It seems as though this interplay and its consequences in terms of design solutions were difficult to communicate through the traditional information channels used, e.g., the verbal descriptions or the written reports (cf. [10]). During the development process, the technical team focused on solving the problems they thought were the most important, typically improving on the sonar navigation system and the motor controller, and developing the device into a smooth working autonomous robot. Only when the members of the development team were confronted with the users trying to use the prototype, did an understanding emerge of who the possible user is and the reality of that person. For instance, from the start of the project, the technical development team had the idea of a motor-driven rollator. The initial user requirements study revealed, on the other hand, that the users favoured a rollator that had to be pushed like a conventional rollator from a security point of view, and that they considered it important that the rollator was light enough to be easily lifted into the trunk of a car. Nevertheless, the first prototype of the PAM-AID device was motor-driven. A number of provoking experiences from studying users trying to cope with an unsatisfactory product were needed for the technical developers to give up the first concept. One could almost talk about a "paradigm shift" when they finally understood that the first concept did not work and a very different solution was developed, with a design similar to that of a conventional rollator.

The finding that the designers must have direct experience of the user and the use situation to fully understand the problems to be solved is in accordance with, e.g., Veryzer Jr. who in his study of key factors affecting customer evaluations of discontinuous new products concluded that "Several of the development teams that were studied found that the quality and utility of customer research inputs were greatly improved when engineers on the development team participated in conducting customer research'' [18]. Also, Ullrich and Eppinger [15] argue that ''...those who directly control the details of the product, including the engineers and industrial designers, must interact with the customers and experience the *use environment* of the product.'' Karlsson and Rosenblad [9] write that a ''.... pre-requisite for user-oriented product development is the involvement of the user but equally important is the involvement of the designer, and a shared understanding between these two actors. The user must understand the concept and the designer must understand the users' problem to be solved.'' However, the difficulties in reaching this understanding are emphasized when a designer, young, male, strong, and with no physical impairment is to solve the problems of an elderly, visually impaired, and frail woman.

## 5 Conclusions

Creating the possibility for a shared understanding between designers and users is fundamental to the idea of universal access. This study demonstrated that user trials not only enable the users to understand and give opinions on future products, but also enable the engineers to reach the necessary understanding of the users and the use situation. In the specific project, the user trials provided the designers with an opportunity to meet users, and observe hands-on the users and the use situation. This understanding led to major changes in the product concept, and (probably) to a more usable product.

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