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Anticipating needs and designing new items rapidly - a case study for the design of postural aid equipment

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Abstract. In this case study, designers proactively proposed new product ideas to a client by using an ergonomic approach. This approach differs from a more traditional approach where one works within a specific, client-defined project. The methodology used included basic ergonomic techniques such as task analysis and information gathering sessions conducted with users. It was adapted so that these enriched user sessions could be conducted within a short time period. After meeting with five users in seven days, designers identified 20 problems that could be tackled and eight design ideas that could be implemented over the short, medium and long term. The ideas encompassed a wide range of potential projects, including physical product improvements, new product lines, Web-site and software improvements and longer term research. Problems identified and ideas generated involved many disciplines including occupational therapy, mechanical engineering, graphical design, software engineering, sales and manufacturing know-how. This wide range was possible because designers were not constrained to specific project scopes and timelines. The client was involved in the idea evaluation process. As a result of this study two new projects were initiated so far.

Keywords: need elicitation, future needs, design, human factors

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1. Problem description / definition

1.1. The use of a proactive approach

This paper is based on experience acquired by the authors during more than one hundred design projects, most of which were undertaken using an ergonomic approach. These projects were mostly initiated in response to problems identified or needs expressed by a client and bounded by a relatively well-defined scope. Projects were undertaken in sectors including bank, finance, insurance, energy, medicine, transportation and government, and their scope varied widely. They included website redesigns, an improved bus shelter design, software fixes, satisfaction of senior maintenance staff and ensuring that new technology does not impede usability. Clients frequently had a pre-conceived idea of their needs or problems to be resolved as well as an idea of the solutions to be implemented.

Although design clients often define project scopes and have pre-conceived ideas as to how these mandates should be achieved, this does not mean designers should follow guidelines blindly. An ergonomic approach not only provides concrete outputs such as task analysis, prototypes, usability test results and so on, it also provides clients access to knowledge that cannot be provided otherwise. It is not rare to encounter users that are good at recalling details, others that have a unique understanding of the big picture and assessing the future, or others, that have accomplished miracles in their workspace with their ingenuity. This information provides solid foundations that can be used by designers to expand or even challenge their client's assumptions. In fact after a project is completed clients frequently say that they were exposed to ideas they did not expect; including information on their own customers, competitors, industry and strategy.

However, in most current projects, the client drives the show; defines the scope and puts pressure to meet deadlines for specific product deployment dates. Ideas that emerge are often disregarded or never fully exploited because they are beyond the current project's scope. The client generally tries to meet his immediate needs as fast as possible, and is thus not open to new opportunities.

Hence the idea of using a more proactive approach, in which no specific problem or need or design solution is expressed. Instead, this "proactive approach" starts with a proposal to a client that involves identifying new product ideas for his business.

This exercise is a preliminary step (or a "pre-project") that uses an ergonomic approach, and includes the following objectives:

- To provide the client with new design ideas, not only for specific products, but for his overall product lines and general business strategy.

- To quickly anticipate future needs and to design future solutions using basic ergonomic techniques.

One important question relates to how designers should best proceed to find new and smart product ideas that will be used in one, five, or 10 years from now? Does the ergonomic approach used for current projects need to be adapted, and if so, how?

1.2. How to proceed

Unlike current projects, pre-projects are not limited to a specific product or process. They have a wider scope. That said, pre-project designers have an incentive to be particularly efficient and deliver results quickly and efficiently in order to keep costs down. Based on our experience, following is a general approach adopted for pre-projects and its justification:

- **Complete a "pre-project" using an ergonomic approach.** The pre-project consists of sessions with users in their work environment and a task analysis (Figure 1). The aim is to orient future design projects, e.g. Project 1, Project 2 and so on. (Figure 1).
- **Recruit a sample of between two and five experienced users for each profile.** In current projects, designers recruit a sample of between three and seven representative users per profile. This sample usually includes users of all levels of expertise ranging from novices to experts. In this pre-project, designers want to cover a wider scope within a short timeframe. Although observing novice users highlights problems that experienced users do not encounter, designers find, (like Dreyfus and Dreyfus [5]), that novice users have a less coherent sense of the overall task. Experienced users are those whose level of expertise is Stage 3: Competent, Stage 4: Proficient or Stage 5: Expert [5].
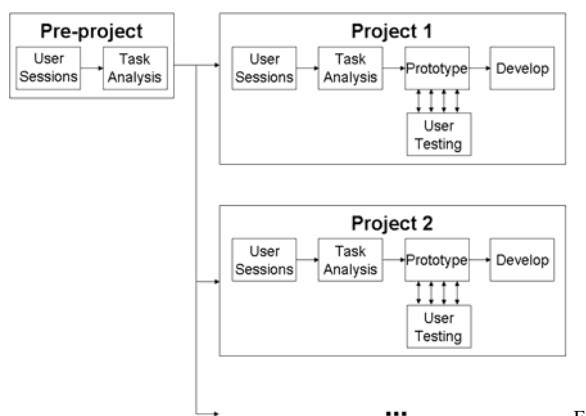
Fig. 1: Pre-project and future design projects

- **Recruit at least one user that has a creative, "conceptualizer" temperament** [7]**.** "Conceptualizer" [7] or "Rational" [2] [3] temperaments are both variants of the Myers-Briggs Type Indicator [6] cognitive style grouping. People with these temperaments naturally analyze systems to understand how they work, so they can figure out how to make them work better. They are hard to find and only represent between five and 10 percent of the population [3]. However, designers gain insightful data from meetings with this type of user, such as higher level goals, problems, and impacts, as they usually have already given a lot of thought and analysis to improve the system under study.
- **During sessions, read users' temperaments and exploit their strengths**. In current projects, single user sessions frequently uncover between 10 and 12 problems or provide detailed task sequences and cognitive goals. However, one or two out of the 10 sessions often provide less information. Some users are less talkative, more reserved, or don't want to criticize, despite the fact that designers put them at ease. During the meetings designers need to constantly adjust. For example some users, when asked to demonstrate their jobs, pay more attention to details rather than about the overall picture. Others prefer answering specific probing questions rather than open or broad questions. Some are good at giving facts and statistics, while others better explain the impact on people. In a pre-project, designers generally meet with fewer users but prefer to cover a broader scope, within a shorter timeframe, than is the case with targeted projects. To do so, training to read users' temperaments [7] is undertaken by designers in order to adapt

faster to the interviewed user. This increases their ability to conduct user sessions that bring richer information faster.

1.3. Pre-project context

With Quebec's aging population, products in the postural aid equipment industry are expected to be in high demand during coming years. Between 1994 and 2003, the number of assigned postural aid equipments increased on average by 12% per year [1]. Of the patients assigned postural aids, 57.5% were over 65 years old in 2003. Projections indicate that the number of people that are more than 65 years old, (which represented 13% of the population in 2001) will reach 21.5% by 2021[1].

The occupational therapy domain and its specialized postural aid branch help people with physical and/or mental limitations. People who require postural aid equipment are affected by:

- Dementia such as Alzheimer's and Parkinson's;
- Progressive diseases such as multiple sclerosis;
- Neurological disorders such as stroke or cerebral paralysis;
- Orthopaedic troubles such as severe osteoarthritis or rheumatoid arthritis;
- Medullar injuries such as paraplegia, tetraplegia.

About half the people using postural aid live in care centers either for a long period or a short rehabilitation period [1]. The others live in their homes, and whenever possible, they live a life as normal as possible (e.g., go to school, go to work). The postural aid equipment attached to a wheelchair or mobile base allows them to move, maintain a normal upright position, stay seated for a long period of time, reduce pain, prevent or treat wounds, etc.

In this case study, the client is a postural aid equipment supplier (e.g., cushions, seatbacks, thoracic support, etc.). The postural system (Figure 2) contains many adjustable components: head rest, back cushion, thoracic supports, seat cushion, covers, each designed for specific needs, e.g., wounds, lateral trunk flexion, slip, etc.

Fig.2: Wheelchair with postural aid equipment

2. Methodology

In this project, two designers proposed a "pre-project" to their client to seek out new product ideas for his business. The initiative encompassed an ergonomic approach that involved sessions with users followed by a task analysis.

2.1. Preparing for the sessions with users

Before the user sessions began, designers trained themselves to observe and detect behaviours that enabled them to classify users into four temperament groups [7]:

- Traditionalists
- Experiencers
- Conceptualizers
- Idealists

In brief, traditionalists are hard workers, serious, they like facts and statistics and pay attention to details. Experiencers are most comfortable when they are in action; they don't like to talk, but are keen observers and pay attention to details. Conceptualizers see the big picture and can think about the future.

Idealists are effective at seeing the impact that systems have on people.

The designers' goal was not necessarily to precisely classify users into groups, but to assess user characteristics that could help them to more effectively conduct the sessions. Temperament classification is especially useful, because it offers observable cues that enable quick classification [7]. Furthermore the four temperament groups are easy to understand, memorize and use. Other cognitive style groupings require longer questionnaire-based assessments.

2.2. User profiles

Various people are involved with postural aid equipment assignments. These include the patient who has the physical and/or mental limitations, technicians maintaining the equipment, daily care personal in centers, patients' families, etc. Designers worked with the client to narrow users down into two key profiles involved in equipment section: the occupational therapist and the technician in orthotic-prosthetic equipment.

For each user profile, the client found between two and five users having more than five years of experience from two rehabilitation centers in Montreal and Quebec City. These centers are recognized in the industry as specialized in postural aid equipment. A user with a "conceptualizer" temperament and recognized as a leader and creative thinker in the industry was identified and scheduled for a meeting.

2.3. Sessions with users

The designers conducted one-on-one sessions with the selected users in their work environments. The sessions lasted for about an hour. Designers put the users at ease and asked them to "think aloud" as they reproduced tasks that they recently performed with their patients. As the session proceeded designers noted cues that enabled them to differentiate temperaments. Based on the observed cues, they adjusted their probing questions, session instructions and debriefings to get the most information out of the session. All sessions were videotaped.

Since the first user interviewed was the creative user with the "conceptualizer" temperament, the designers hoped and expected to draw from this session the beginnings of a task analysis, a list of problems and possibly design ideas. All this information could then be used to develop probing questions for the

later users who might prefer answering more specific questions or to provide facts and figures, etc.

2.4. Analysis

After the sessions, designers produced written transcripts of the taped sessions, performed a cognitive task analysis [4], listed the problems (errors, hesitations, calls for help, delays, time loss, suboptimal strategies, etc.), identified the impact and frequency of the problems, listed the optimal strategies used and documented user knowledge. The problems were classified according to their importance (criticality, frequency).

A list of potential design ideas was generated from the sorted information. This list included ideas that could be developed within a short term (six months), mid-term (one to two years) or long term (two to five years) as evaluated by the designers.

The client was then involved in the process to help conduct an initial validation of the problems and ideas indentified and of the market potential of leveraging these opportunities.

3. Case Study

3.1. Profiles of the occupational therapists and orthotic-prosthetic technicians

The occupational therapists specialized in postural aid equipment all have university degrees. They work in rehabilitation centers and are part of specialized technical aid departments, where they have clinics and see patients. Some occupational therapists also see patients in other centers such as long-term care centers or other specialized facilities (rehabilitation, amputee, other).

In the two centers visited, occupational therapists were assisted by technicians who helped them choose equipment, handle measure taking, order equipment from suppliers, and occasionally make custom equipment.

3.2. Task analysis

The main goals of the occupational therapists and technicians are to choose, adapt or adjust postural equipment for their patients in order to maximize their autonomy and quality of life, minimize their discomfort or pain, evaluate their life habits (work, move, go to cafeteria, etc.) and their health (disease,

muscular strength, etc.). On a continual basis, they need to ensure that the body maintains an upright position to promote social interaction, that pressure is distributed and that movement is accommodated.

Figure 3 shows a partial view of the process involved in selecting a seat cushion, arranged in a hierarchical fashion. On the right-hand side elementary actions are listed and on the left-hand side the goals derived from the elementary actions and obtained by the user "thinking aloud" and answering probing questions (e.g. why are you doing that?).

3.3. Main problems identified

Twenty problems were identified, ranging from thoracic abutments that cannot be adjusted in a specific angle to low-cost geriatric furniture that is not suited for an aging population and product websites that are not organized according to clinicians' logic or mental models. Following are the most frequent or most critical problems identified:

Fig. 3: Partial view of the hierarchical task analysis

1. **Customers and caregivers do not use positioning equipment appropriately**. Caregivers and patients demonstrate magical thinking. As soon as they get their positioning equipment, they think that things are already better. They no longer do pressure release exercises, do not sit the patient appropriately, etc. The impact is discomfort, as well as occasional wound and condi-

tion decay. Also, occupational therapists and technicians see the patient for adjustments that caregivers could have done themselves.

2. **Cushions are installed in the wrong direction.** Caregivers install seat and back cushions in the wrong direction after washing. Cushions are designed to prevent or treat specific problems. For example, if there is a risk of a pressure wound appearing, a gel material is used in the cushion. In the presence of a wound, air cells are used. Four out of 5 interviewed users reported that the cushions are found installed in the wrong direction, e.g. the patients sit on a rigid surface instead of on the air cells, the gel is underneath the thighs instead of the bottom, etc. In long-term care centers this type of error is found on one patient out of six. The impact is discomfort and condition decay. Also, for particular care centers, when they know that more evolved cushion designs will not be used properly, occupational therapists and technicians select sub-optimal cushions.

3. **Mobile bases cannot be adjusted easily and quickly in care centers.** As soon as care personnel detect a problem (e.g. wound), they seat the patient in a quickly available reused mobile base. This base is frequently not adapted to the patients' needs (too deep, narrow, or wide, etc.). The impact is that the patients need to wait one month for the specialist to come, and two to five more months before they get their own selected equipment. The impact of this delay is especially visible on old patients who suffer from dementia and whose condition decays dramatically rapidly if they don't have the right equipment for their needs. This population of patients represents 60% of all the patients seen by Montreal's technicians and occupational therapists.

4. **Technicians and therapists wish to reuse products but they are not designed for reuse.** There are more and more people in need, but budgets do not increase accordingly. Reuse is seen as a way to save costs and reduce treatment delays in the future. Existing products are not antibacterial nor designed for cleaning. The materials absorb liquids, or when waterproof material is used, the cushions lose the required elasticity. It is difficult to remove the covers, replace the cushions, add gel, remove abutments and interchange them.

5. **Products cannot accommodate dynamic positioning.** Dynamic positioning is seen as a future trend in occupational therapy. While in the past equipment was more or less used to keep people still and straight, occupational therapists now increasingly see the advantages of movement in treatments. The products are not designed to accommodate movement.

6. **Product websites and information not organized according to clinicians' logic or mental models.** When analyzing a patient's case and trying to find the best equipment that suits its needs, clinicians think in terms of clinical logic. For example: "For this patient, afflicted with an anterior pelvic tilt with risk of wound, I might use a shaped cushion with gel." However, the websites and product information are organized and described by products and product features: "Cushion made of rigid foam moulded base with higher percentage of high density viscoelastic foam." The clinicians need to translate this into their clinical logic: "Is this the right product for my patient affected with an anterior pelvic tilt with risk of wound?" The impact is that the clinicians tend to stick to the few products that they know, though these are occasionally sub-optimal. Also, experienced clinicians report that it is hard for novices to choose between hundreds of available products.

7. **Time is lost in manual repetitive entries in software and paper forms, in measure taking and in equipment trials.** Time is lost, and therapists can only see between seven and 12 patients a day and there are waiting lists of about two to three months. Also, there is a shortage of occupational therapists and the need for postural aid equipment is expected to increase. With the support of better tools, it is anticipated that technicians and therapists need to be more efficient and see more patients each day.

3.4. Design ideas

Nine design ideas directly emerged from the user sessions. Six other design ideas were generated by the designers analysing the most critical and frequent problems. Those ideas were validated and augmented by the client. In this paper, a subset of the ideas is presented, and these are classified as short, medium-term and long-term projects.

The short term ideas are quick fixes or more simple projects that can be developed within a six-month period:

1. **Review current cushion and cover design to prevent assembly errors.** Make use of labels, serigraphy, form of cushions and covers, materials that suggest top or bottom. Test with users.

2. **Reorganize the product website, product information and product sales based on therapists' and technicians' mental models.** Once in the product page, users need access to all details, including all dimensions, type of materials, type of covers, location of Velcro, zippers, clinical problem for which the product is appropriate, etc.

3. **Review current product lines to provide waterproof cushions and covers that are easy to disassemble.** Start with products intended for the elderly in order to provide waterproof material as standard equipment. Test materials for elasticity in collaboration with centers that have a pressure measuring device.

4. **Use task analysis to improve sales and marketing messages.** The task analysis provides a goal structure and specific qualities sought in a product, as in Figure 3 for selecting seat cushions. This information is crucial for product design but can be used also for developing sales and marketing messages.

The medium-term design ideas are projects that could be developed within a one to two-year period:

5. **Develop a mobile base that can be adjusted directly in the care centers.** Within the medium-term, the product needs to be adjusted in care centers by technicians. In the longer term, the product must aim to be adjusted by lesser trained personnel in the care centers.

6. **Review products to incorporate anything that can facilitate the life of the care personal.** The patient condition in care centers is viewed as more severe than ever and care personnel are under pressure. The tasks of the care personnel with regards to the postural aid equipment need to be analysed and all aspects of the products need to be reviewed to facilitate their tasks.

The long-term design ideas are projects that could be developed within a two to five-year period:

7. **Develop geriatric furniture that costs less than $2,500, can evolve with the patient's condition, is reusable and ergonomic.** Therapists have identified a growing need for such geriatric furniture. This idea requires further analysis. However there are factors arising from this study that favour it: an estimated 60% of

Montreal's patients have similar affliction and needs, e.g. elderly patients with dementia and with the aging population, the number of older patient is expected to grow [1]. Due to the increasing number of patients with similar afflictions, equipment can be manufactured in larger volumes in order to decrease costs.

8. **Develop products to optimize the work of occupational therapists and technicians.** Time is lost in manual repetitive software and paper form entries, measure taking and equipment trials. Three ideas emerged from the user sessions: 1- Facilitate software data entry of 15 frequent and typical diagnoses. 2- Develop "technical gloves" that automatically enter measures in software when the clinician touches the patient. 3- Allow postural aid equipment simulation to determine which equipment would best solve the patient's clinical problem.

4. Discussion

After meeting with five users within seven days, designers identified 20 problems and eight design ideas for implementation in the short, medium and long-term for which the validity is supported by user data. They also produced a preliminary task analysis.

The generated ideas varied widely. These included physical product improvement projects (e.g., reuse, cushion improvements), new product lines (mobile base, geriatric furniture), website improvements and longer term research projects (automated measure taking, simulator). Another idea was to use the cognitive task analysis to help improve sales and marketing material. The problems and generated ideas were not restricted to a single discipline but rather involved occupational therapy, industrial design, mechanical engineering, software engineering, graphical design, biomechanical engineering, electrical engineering, sales, manufacturing know-how and marketing. That wide range of ideas was possible because designers were in pre-project phase and not constrained by the client to a specific project scope and timeline.

At this point, designers only gathered qualitative data about quality of findings. In the review meeting, the client was surprised by the quality of the information provided. He also reported having gained a good understanding of how his products work in the centers and discovered new opportunities, in particular those related to geriatric furniture and product reuse. The client found the task analysis particularly useful

for his marketing and sales messages. He wants to proceed with short-term and medium-term projects. Two of these projects have already begun: mobile base design and website re-organisation.

Since designers only met with five users, one can question the validity of the pre-project's findings. The pre-project does not replace future initiatives that would be conducted using an ergonomic approach. Future projects are planned to include user sessions and task analyses, prototyping and user testing that will confirm or infirm and also refine the findings, including the very preliminary data obtained. To increase validity, another alternative is to increase the number of users that are met with. In this case study, the client was satisfied with the pre-project results.

Another consideration regarding the pre-project was the constraint posed by the short timeframe. To cope with this constraint, designers choose to meet with a smaller user sample than the five-to-seven user per profile normally used in projects. They counterbalanced this smaller sample by selecting only experienced users, by including a session with a creative conceptualizer and by applying user temperament reading techniques to conduct richer sessions.

During the session with the creative "conceptualizer," designers identified eight design ideas and conditions for which the precise needs were unknown or not fully understood. From this set, they prepared probing questions for later user sessions. While the designers also kept the sessions with the other users wide open, they used the probing questions obtained earlier in the study to stimulate discussion. The end result is that designers were able to validate and refine the early findings and also to stimulate discussion with less talkative users.

Use of the temperament reading techniques made it obvious that each user was different and provided complementary information. For example one user spent 35 minutes talking about the same case, offering her detailed thought process, goals and assessment of procedural impacts on the patient. In contrast, another user only discussed a recent patient case in four short and simple sentences. Knowing that she was once a mechanic and noticing her casual appearance as well as other cues, the designer concluded that she might have an "experiencer" temperament. The designer thus brought her to the workshop, where she expanded upon various patient cases, stimulated by the parts and pieces of equipment that surrounded her. Another example is a user who offered this comment: "what I am showing you this morning is the majority." This opened the door to designer's questions on impact, problem frequency and big picture questions. At the end of the sessions, designers believed that although the temperament classifications they made were not necessarily accurate, the training on reading user temperaments enabled them to optimize time spend in the sessions, and to draw richer information.

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