

DESCRIPTION OF A COMPETENCE ORIENTED APPROACH FOR DESIGNING TECHNICAL ASSISTANCE SYSTEMS

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Abstract

Technology can be tremendously helpful in assisting the elderly to lead an independent lifestyle. However, using a deficit-oriented approach to characterizing these user groups can stigmatize them and adversely affect their ability to conserve their competencies. Hence, this article advocates an alternative approach to characterizing elderly user groups, which emphasizes their competencies and takes their general life situation as well as context-specific performance motivation into account. It is embedded in a support hierarchy, which reflects medical and cognitive-psychological research findings and allows for the derivation of specific development guidelines. The approach is illustrated with a modular concept of mobility support.

Keywords: User centred design, Requirements, Design for X (DfX)

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1 INTRODUCTION

Users of technical systems are more and more recognized as a factor that influences the product development process significantly. There are, especially if we are talking about products for senior citizens, several stakeholders who have different expectations regarding the behaviour of products and whose interests have to be considered. Stakeholders are for example the senior citizen as the actual user, caregivers or nurses, the people who buy the systems or health insurance companies who support the purchase financially. Concurrently the products are becoming more and more complex. The range of functionality has increased significantly. This development is obvious for example in mobile phones, digital cameras or machine tools. Besides the functions that are expected from a product, in many cases functions for safety or comfort are added. Nowadays products are often product-service-systems, which combine the technical system with services instead of stand-alone technical systems. As a result of the increased complexity, the use of these products is complicated; hence the capacity of products or the efficiency of their use is increasingly determined by the users' competences and capabilities.

Engineers develop products according to the principle of finality. This activity is a forward-looking process and requires a target system for the development process. The target system has to include a description of the user as holistic as possible. If this description is available, the human-machine-integration is valid to support self-determination in one's life. Even the definition of the system objective is often focused on the performance restrictions of the senior citizens. This deficit oriented approach leads likely to stigmatization. Furthermore, the use of technical systems in the everyday life of seniors is not determined by rational reasons exclusively. Important influencing factors are neglected by focusing on performance restrictions. One aspect to consider is multimorbidity. Hence the focus on one restriction is not sensible. People develop individual strategies to cope with performance restrictions in order to proceed with their lives. These strategies influence both, ability and willingness to use technical products and should, therefore, influence the product development process as well. Besides this, "weak" factors like education, social integration, experience, but even psychological factors like motivation are factors which determine the use of technical products as well and hence efficient product use.

This article provides a holistic description of the user, which includes environmental, social, educational and further factors of the user, as a result from these considerations. If such a description is available, the product and its functionality can be designed according to this description. The aim is to gain a deeper understanding of the user in order to understand his needs, in order to develop suitable and accepted products. Further strategies are needed to transform the understanding of the user into precise requirements for the actual product development or to validate ideas for products or real products by means of the description of the user. It is expected that the consideration of a holistic description of the user on the one hand will increase the acceptance of the product, and hence increase commercial viability of the companies and leads to a sustainable use of resources. On the other hand the holistic approach has the potential for innovative product ideas to come up, in order to support people in their living situation and their situation of activity at its best.

2 CONSIDERATION OF USERS IN PRODUCT DEVELOPMENT – STATE OF THE ART

As shown in Figure 1, the users' product view and the designers' product view are completely different. The system objective is defined by the designer. According to the system objective, the usage of the product that is developed has a specific effect on the user in a defined situation. Therefore, the designer defines necessary functions, searches for concepts and principle solutions and finally designs the product. This process follows the principle of finality, which means the designer has the system objective in mind and designs the product accordingly. The system objective is often defined by the user's capability.

On the other hand the user has to interpret the system objective according to the principle of causality. He gets the product as an isolated object and has to interpret it, based on his experience and competences. He concludes the system objective from the exterior design. In worst case, the concluded objective is different from the system objective that the designer had in mind. The concluded objective may even differ for different users. Based on the interpretation of the system objective the decision,

whether or not a product is useful, useable and necessary for ones own purpose is made. Hence, a misinterpretation might be fatal as a product considered useful might be useless or vice versa.

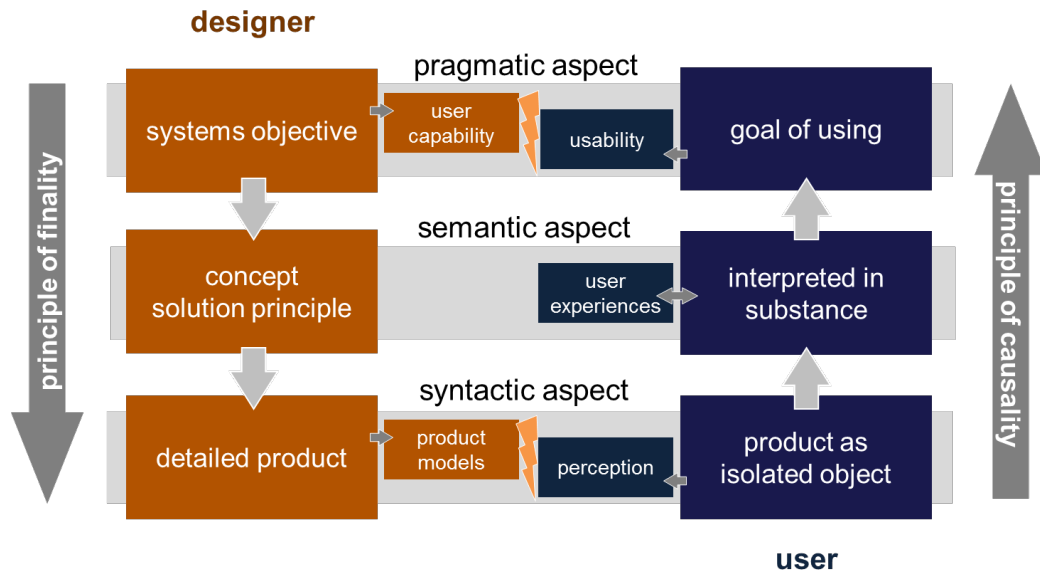


Figure 1: Different views on a product

For both processes, product development and product interpretation, the recognition and the interpretation of wishes and needs is an essential precondition. By defining the requirements during the development process, the wishes and needs become explicit. The user knows, at least implicit, his wishes and needs. He has to combine these needs with the product or its usage and hence the wishes and needs have to become explicit. Especially for the field of product development there are no methods or strategies how the needs of users can be recognised and afterwards transformed into concrete requirements the designer can use.

Essential aspects that are necessary for a holistic description of the user are his living situation, i.e. his social background, his biography, his experience and so on and his situation of activity, i.e. his motivation for acting. This is completely neglected, if the search for technical solutions is reduced to performance restrictions (Biermann and Weißmantel, 2003). In order to gain a better understanding of the users' behaviour, there are mainly two approaches that are used in product development: methods of research of acceptance and methods of user participation.

2.1 Methods of research of acceptance

The approaches of research of acceptance take the user's living situation and his situation of activity into account. These methods are aimed at analysing the individual willingness to actually use a product. Most of these methods are based on technology acceptance models, which are derived from the theory of reasoned action. The "Unified Theory of Acceptance and Use of Technology" (UTAUT, see Figure 2) is emphasized here, as several theories of research of acceptance are summarized in one model. This highlights the UTAUT approach (Venkatesh *et al.*, 2003). Based on a product validation, statements regarding perceived usefulness and perceived ease of used are gathered. Newer approaches, which are based on the UTAUT model, additionally focus on interdependencies between user and technology. Here is emphasised on the work of Leonard-Barton (1988) where an interdependent adaption is assumed.

The results of acceptance research are only partly useable in product development. The disadvantage is that there is no connection to the product. It is evaluated whether a product is accepted or not, nothing more (Birken, 2014). It is not possible to draw conclusions which functionality is or is not accepted and which requirements are resulting. In order to focus on higher acceptance in product development, this would be essential.

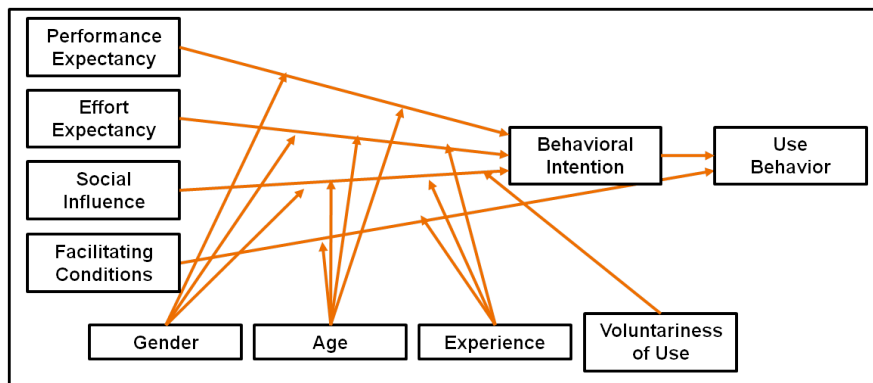


Figure 2: Unified Theory of Acceptance and Use of Technology (Venkatesh et al., 2003)

2.2 Methods of user participation

Furthermore, methods of the field of user participation are used in product development (Figure 3). Methods to involve the user in the phases of idea generation and solution finding are provided as well as methods to evaluate product ideas and products. Concepts for user participation and methods for the application of these concepts are summarised in DIN 9241 (DIN Deutsches Institut für Normung e.V, 2011). There are approaches in literature how to adapt these general methods for special user groups. One example is the work of Reinicke (2004), where the methods are adapted for elderly users. Aspects like “Joy of use” or emotions by the use of products are getting more and more important for product development. The findings of acceptance research, which are mostly focused on cognitive aspects, are used and extended with emotional components in “user experience” (UX) design (Hassenzahl et al, 2008). According to DIN 9241-210 (DIN Deutsches Institut für Normung e.V, 2011) UX-methods gather the user experience, which is experience and reaction of a person, that result from actual and / or expected use of a product. All emotions, imaginations, preferences, experiences, psychological and physiological reactions, behaviour and performance that occur before, during and after use (DIN Deutsches Institut für Normung e.V, 2011). UX describes the impact of a product on the user. The reasons for these feelings are not explained. What causes the subjective impact of a product, which results from the specific living situation and the situation of activity, is often not revealed. Why the application of these methods is difficultly becomes obvious, if the process of interpreting products is observed more detailed.

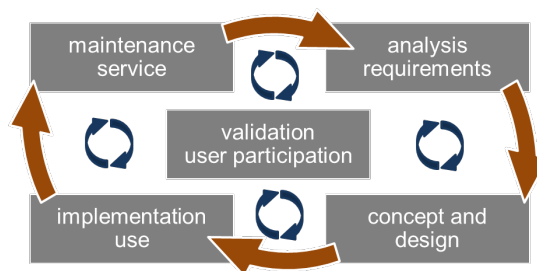


Figure 3: Methods of user participation

During his first contact with a product the user has to use the syntax based on symbols and the exterior design, in order to get hints on the product purpose and its use. Methods of technical design (Steffen, 2000) or human factors (Helander and Khalid, 2006) are based on this syntax as well.

Recognising these symbols includes their interpretation. Then the function of the product is derived based on this interpretation. The interpretation itself depends on the user’s experiences, competences, social integration and so on, i.e. his living situation. Furthermore, the contact between user and product takes place in a specific situation. This situation determines the user’s motivation to action, i.e. it is the situation of activity. The user’s living situation and his situation of activity influences the user’s evaluation of the product implicitly. As it cannot be made explicit, it is impossible to derive requirements or to specify its influence for the product design process.

3 APPROACH FOR A HOLISTIC DESCRIPTION OF USERS IN PRODUCT DEVELOPMENT

As described in chapter 2 a holistic description of the user is necessary for product development, in order to recognise and interpret the users' wishes and requirements as well as the boundary conditions. It is not suitable to focus on the user's capability or impairment, but the user as a whole person, with his experiences, social background, education etc. has to be considered. Therefore, the findings of other fields, like humanities and social science have to be considered. But these findings have to be prepared in order to become understandable and usable for the product designer. Especially the different usage of terminology and the different meanings, which similar terms have in the different fields, makes the integration of knowledge difficult here. The terminology used here is a result of the collaboration of engineers, sociologists and psychologists. The discussion regarding terminology is not yet completed.

3.1 Holistic model for description of users

Technical products are only able to support people if they are accepted by the user and integrated in his daily life. In this interdisciplinary sense user and technical product have to be recognised as two essential parts of one system. Therefore, the focus is on the human-machine-integration. Behaviour of both, technical system and user, which leads to a self-determined and independent lifestyle, develops from this human-machine-integration.

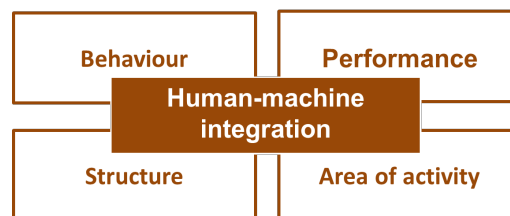


Figure 4: Model for a holistic description of the user

According to the general understanding of a system both, user and technical product, can be described by a combination of function and structure description. Behaviour of user and technical product are represented and most of all the interaction between both. Here, a performance of the product that supports the person's lifestyle is expected. In contrary the user's resources and restrictions influence the range of support that is necessarily given by the product. For both, behaviour and performance in the human-machine-interaction, a specific use case, which is determined by the area of activity, is needed. These four perspectives provide different views on the human-machine system (Figure 4). The essential point is that these views are not independent from each other. Only if all four aspects are considered during the design of the product, the human-machine-integration will be successful.

3.2 Definition of influencing factors on the model for description of users

In order to gain a better understanding and in the sense of a holistic human-machine-integration a more detailed approach is required. Based on the identification of the influencing factors and the basic connections, a more detailed approach is possible.

Description of the structure: Both, user and product have to be considered for a description of the structure. The description of the user's structure includes his physical constitution as well as his living situation and his situation of activity. Describing factors can be derived from sociological (Birken et al., 2014) and from psychological concepts (inter alia Martens, 2012). In order to be able to make a statement regarding functional competences, i.e. the ability to succeed in daily life, the motivation of acting is considered as well. The motivation has a great influence on the choice and kind of performance of activities. Important roles play inter alia: whether the user is convinced to achieve a certain activity and the activity is regarded to achieve a certain goal (Martens, 2012). If these aspects are considered, the means for technical support of the chosen competence can be derived. Combined with methods of the UX design, attributes of the products that are required by the users can be identified and integrated. These attributes are the perceived ability of the product to enable the user to achieve his goals and the ability of the product to fulfil one's needs. These needs are the improvement

of the own ability and the communication of a high self-worth. Hence, positive experiences are connected with the product and lead to the usage of the product (Hassenzahl et al, 2008). The motivation to use technical products can be derived from the life and action situation. This gives valuable hints how the product is interpreted and used as well.

These structure parameters can be transformed into the user's behaviour in the sense of a description of the function. This does not only explain the motivation to use technical products, but also the procedure during the interpretation of products and the actual behaviour in using products. These parameters define furthermore the resources and restrictions of the user, which describe the problem situations that are expected in specific areas of activity.

The focus of this proposal is on the supplement of the holistic human model with product aspects. The product structure is based on the degree of complexity of the product. Therefore, there is distinguished between:

- Simple technical systems on the lowest level are aids that help to make the daily life easier without a significant influence on everyday life. The support that is provided by these aids is passive. They are based on general daily life products that are designed according to the rules of universal design, which makes the handling easier or helps to use the product in a safe way. Examples are inter alia walking sticks or Zimmer frames.
- Regulated technical systems on a higher level provide the opportunity to counteract changes in the users' behaviour due to a change in the personal capability. They are able to compensate specific performance restrictions and thus support the users in their daily life and in going on with their habits. Examples are stair lifts and e-bikes.
- Adaptable technical systems are on the highest level for technical support. Parameters provided by both, environment and user, are collected and interpreted. The technical system comes with actors that provide the ability to succeed in daily life tasks. An example here is an exoskeleton.

Another form of technical support is to design the environment in the sense of a support system for the achievement of everyday tasks, instead of developing products. The hierarchy can be defined in the same way as for the products. The simplest solution is to install handles that help to rise from a chair or the toilet. The next step could be a set of sensors that is integrated in the carpet and switches on the lights automatically as soon as someone steps on it in the dark. Using the smart home technology and the strategies of the internet of things, the home environment can be connected to one big support system. The support in daily life could be that the Zimmer frame automatically drives to the user as soon as he rises from the sofa.

Description of the behaviour: The interpretation of products is influenced by the users living situation and his situation of activity combined with his performance, and it is an important aspect of his behaviour in using products. The behaviour is influenced by the means of technical support as well, which is mainly determined by the degree of complexity of the products. In this context it has to be recognised that products are used by different stakeholders. Users are not only those elderly people that are supported by the product but even nursing staff or family members who may have different requirements concerning the products.

The performance of the human-machine-integration depends on the connection of the chosen or available product and the user's behaviour in using the product. An important role plays the motivation to use the product, which results from the interpretation of the action situation. The complexity of a product influences the perceived degree of reliability. This results in requirements regarding the product safety which influences the willingness to use a product. In the development of products to support elderly people, the designer has some responsibility as the compensation of performance restrictions leads to further decreasing of the compensated abilities and hence to a decrease of quality of life. In order to break this vicious circle of loss of capability a support hierarchy that is medically and gerontologically reasoned has to be considered. In a first step, the system is meant to motivate the user to use it and thus make his daily life easier and increase his capability by training. On the next level the system supports the user with his remaining capability in specific and difficult situations. The aim is to conserve the capability as long as possible and to train alternative capabilities to fulfil the tasks that are required to lead an independent life. Only if the capability is no longer sufficient, the technical product is meant to compensate in order to provide an independent life as long as possible.

Area of activity: The description of both, behaviour and performance of a human-machine-integration requires an application. In this proposal the conservation of mobility in the domestic environment and

the environment near one's home is chosen as an example. The area of activity has to be examined in detail in order to identify the user's behaviour and to describe it generally. The description has to be on two levels, first the abstract level of behaviour and afterwards the level of actual single activities. For mobility in the domestic environment a catalogue of functions was developed. Typical activities and patterns of actions can be derived from the catalogue. Problem situations can be derived if areas of activities and living situations are linked together. Problem situations are those situations in a specific area of activity in which a barrier occurs. The important aspect here is the subjective level of suffering. Three kinds of barriers are distinguished here: (1) the activity can be done, even if it is difficult; (2) the activity is avoided or (3) the complete area of activity in which this activity is necessary is avoided.

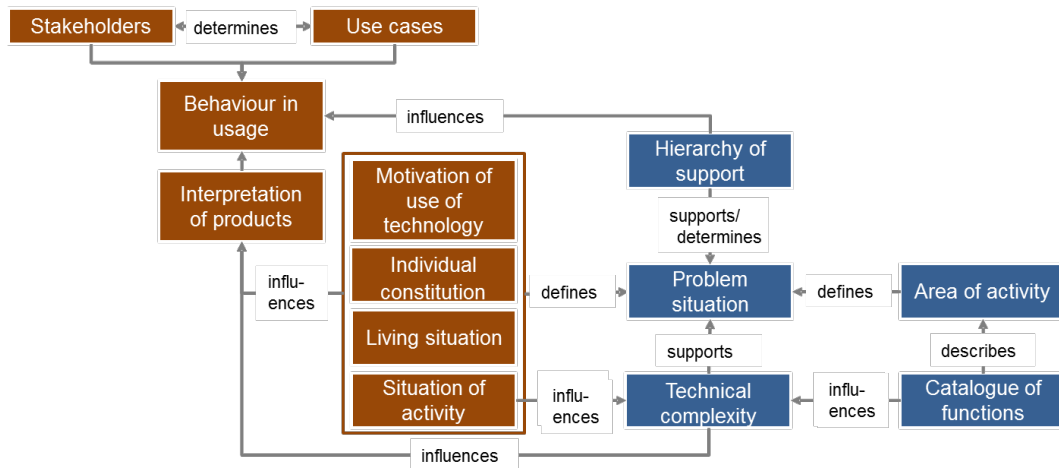


Figure 5: Model for a holistic description of the user

The more precise description of the four views on the human-machine-integration leads to a more precise model for a holistic description of the user that is shown in figure 5. The behaviour in usage is influenced by the user and his background on the left and by external factor, such as the technical complexity on the right. In order to make this model useable the influencing factors, as mentioned and partly detailed in this chapter, have to be described further in detail and the dependencies between these factors have to be made more obvious. Furthermore the model has to be transformed into a form that is useable in the product development process. As human-machine-integration is highly complex – it contains various elements and completely different kinds of relations – the methods of model based systems engineering are used here. The next step is to build the model for a holistic description of the user as described here in SysML.

3.3 Use of the holistic user description

On the one hand, the method for the description of the user that is described here helps to derive innovative product ideas and new solution principle to succeed in daily life. On the other hand requirements for product development can be detailed and solution principles for specific products can be evaluated. The aim of supporting elderly people with technical products is to support their lifestyle by adapting technical products to the user and his living situation and his situation of activity. The users' wishes and requirements serve as starting point for the process of solution finding. As described in chapter 2, today engineers tend to reduce needs on the compensation of performance restrictions. By using the holistic view on people using products there come up new possibilities to include aspects of the users' living situation and their situation of activity in the process of idea generation. This model approach is able to support the transformation of weak and implicit needs, which cannot be named explicitly by the users, into requirements for the designer. Thereby the acceptance of the product is considered in the early phases. Additionally it is expected, that the holistic view provides completely innovative approaches of support. The approach that is described here is validated in the area of activity of mobility in the near surrounding of one's home. The analysis of the area of mobility combined with the analysis of the living situation already revealed that mobility in the domestic environment differs from general mobility. The focus is not on the movement from A to B, but on the performance of daily tasks like preparing meals or cleaning. Here the distances are rather short but

pots or brooms have to be carried. Often the use of walking aids like Zimmer frames is difficult as the rooms are narrow. The main forces are on upper part of the body and the arms. Hence, the search for new solutions is necessary.

In this context product-service-systems have to be considered. The support by a technical product is not suitable, but has to be completed by service. Therefore, the model approach has to be expanded in order to include services. The structure of services has to be specified and relations to include them have to be found. Predictions of the performance of the product-service-system are possible then.

Another challenge for the product development is to make the requirements for the design process concrete and complete. The integration of a description of the user and a description of the product are a precondition for the transformation of needs and boundary conditions in specific technical parameters. This is essential for the designer to proceed in the design process. Starting points here are the functional description of the action fields, the link of general solution principles to specific sub-functions of the action fields and the analysis of the conjunction of the description of the user and the description of the product.

A big challenge for the efficient development of products is to control the great variety not only in requirements but also in the users. Based on the use of concepts from social sciences and psychology it is possible to cluster the users. The aspects for the cluster are the life and action situation and their motivation to use technical products. Hence, strategies for support can be developed and adapted to specific needs and wishes within the user group.

4 CONCLUSION AND OUTLOOK

The approach that is described in this proposal is meant to describe the user in the human-machine-integration in a holistic way. This means that beside the human capability, “weak” factors which influence the use of technical products are considered as well. This is a precondition to support the user in his or her specific action environment by means of suitable technical products. New ideas for technical products can be derived. Furthermore needs can be transformed into requirements and the life and action situation can be included in the requirements. The following steps are a cooperation of engineers, sociologists and psychologists to make the approach more precise. This is meant to assess products for senior users regarding their usability and acceptance. Further research is required in order to derive methods for validation.

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