



Empowering Instead of Hindering – Challenges in Participatory Development of Cognitively Accessible Software

Susanne Dirks^(✉)

TU Dortmund University, Emil-Figge-Str. 55, 44227 Dortmund, Germany
susanne.dirks@tu-dortmund.de

Abstract. Participative design is a method of involving users in the design and development process through a collaborative approach. This method allows to involve the potential users with their needs and peculiarities from the beginning of the development. In agile software development, the potential user of the software plays a central role as a stakeholder, but the rapid development cycles force users to deal with incomplete and faulty software. With the example of two agile projects for the development of cognitively accessible software, the challenges of participative development with people with cognitive impairments are demonstrated and discussed.

Keywords: Software development · Agile methods ·
Cognitively accessible software · Participatory technology development

1 Introduction

The Internet and other digital resources, such as social media channels, digital magazines, online forums, archives, databases, etc., will increasingly become the most important way for individuals to stay informed about news and services, stay in touch with friends and family, and experience independence. Moreover, with the advent of the Web of Things, everyday physical objects are connected to the Internet and have web interfaces.

Problems with understanding and using these many different and sometimes very complex standard interfaces can be caused by various factors, such as advanced age, congenital or acquired sensory or cognitive impairment, or lack of technical knowledge.

People who are unable to use these interfaces due to disability will experience an increased sense of disability and alienation from society. Their opportunities for participation are severely limited in almost all spheres of life and without improved accessibility of digital resources the digital divide will become more pronounced over time [1].

1.1 Digital Accessibility

With the ratification of the United Nations Convention on the Rights of Persons with Disabilities [2] and the resulting national measures and laws to implement the affirmations, the overall accessibility of digital resources has improved significantly. In particular, persons with motor and sensory impairments have benefited from progress in the technical development of assistive technologies and the improvement of the accessibility of information and communication technology services. Modern web development technologies such as HTML5, CSS3, and WAI-ARIA help developers to create websites that can be easily accessed by people using assistive technologies [3].

For people with difficulties in understanding content, structures and contexts, whether due to age, cognitive impairments or lack of technical understanding, the situation is clearly different. As a rule, these people do not use assistive technology to access digital information, but rely on the information being structured and prepared in such a way that they are able to capture it.

The most common measures used to enable these people to participate digitally are either a compilation of specific information in a simplified structure and language, or the creation of a dedicated web site offering selected content in an easily understandable form, e.g. the Times in Plain English [4].

While some countries, such as classic immigration countries like the United States of America [5] or countries with very complex writing systems like Japan, have very precise guidelines on how to write documents in an understandable form, there are many countries where, despite the ratification of the CRPD, there is little effort to improve the cognitive accessibility of digital resources.

Despite the good intentions, the problem with the above-mentioned measures is that people with cognitive impairments cannot use the original sources like everyone else, but merely have access to information that has been specially gathered and arranged on their behalf. This clearly violates the CRPD's demand that all persons with disabilities should have equal access to digital information and communication services.

Since the group of people with difficulties in understanding content, structures and contexts is very large and heterogeneous, it is obviously challenging to prepare all digital information in such a way that every potential user can easily handle it.

To be able to deal with the described difficulties in this context, different approaches are being pursued in current research projects.

One of the most promising actual approaches is the development of tools that provide an individual simplification of Internet sites and other digital resources based on current user needs. Although this approach seems very convincing and offers good long-term opportunities for individual adaptation of the cognitive accessibility of digital resources, there are a number of technical and design-related challenges.

1.2 User Participation in Software Development

The idea that potential users play an important role in the development of products and processes has been widely accepted for many years. User Centered Design (UCD) has also gained acceptance in software development projects in recent years. Based on the work of Norman and Draper [6], UCD is an approach in which the needs and

perspectives of potential users are integrated in an iterative process of product development. Within the framework of classical approaches to software development, users have often been involved only marginally and at only a few points in the development process. For cost and time reasons, it certainly still happens that users are insufficiently involved in planning and development processes, but the proliferation of agile development methods has made it much easier for potential users to be involved in all development phases. Agile development methods like Scrum or eXtreme programming (XP) have many similarities with UCD and offer good possibilities to integrate the potential users with their needs and peculiarities into the development process [7, 8].

Although the main concern of the UCD is the active involvement of the potential user and his interests in the development process, the user is often not part of the team, but is represented by the designers or researchers involved [9]. Due to this ‘translation’ of user needs, the usability of the developed product may be limited in some areas despite the use of the UCD in the development process.

In order to guarantee users an equal role in the development team, participative approaches for the active involvement of users in software development have been increasingly implemented in recent years. According to the definition of Schuler and Namioka [10], Participative Design can be understood as the active participation of potential users and all other stakeholders in the design and development process. Occasionally, the term Cooperative Design is also used as a synonym.

It is undisputed that the active involvement of potential users in software development usually leads to products that can be better used by the target group and are more readily accepted. Nevertheless, the satisfaction of users, designers and developers with their respective roles in the development process and the product that is created at the end is not always convincing. Both the power relations in the team and the actual consideration of the needs and opinions of the various team members are regarded as sources of dissatisfaction [11, 12]. Other reasons for dissatisfaction include user-related aspects such as user motivation or prior knowledge, communicative aspects such as misunderstandings and conflicts between team members, lack of management support, and project-related aspects such as time constraints and technical problems.

Users with cognitive impairments represent a special target group, both with regard to their requirements for a software system to be developed and with regard to their integration into the development process [13]. People with cognitive impairments have difficulties understanding complex language, reading longer texts, understanding abstractions, generalizing insights and following different perspectives in group discussions [14]. All these skills are relevant for successful work in research teams. Currently, there is no methodologically sound basis for working in research teams with team members with cognitive impairments and many development teams, although generally open-minded, are uncertain of how to deal with these demands.

In the following sections, the challenges associated with participatory software development with people with cognitive impairments are discussed on the basis of two specific research projects.

2 Study

It is indisputable that people with disabilities benefit in many areas of life from the Internet and other digital resources. People with cognitive impairments benefit from these advantages just like other people, but they often have to deal with the fact that their environment does not trust them to be able to handle the Internet independently and safely. The potential risks associated with Internet use in terms of data security, privacy, harassment and unintentional purchase, which all people can encounter, are considered to be more pronounced for people with cognitive impairments [15]. Meanwhile, the potential benefits of the Internet for people with cognitive impairments are also seen as more pronounced. This raises the question of why efforts to enable people with cognitive impairments to access and use the Internet are not being intensified.

The Department of Rehabilitation Technology at TU Dortmund University has been conducting a number of research and development projects to improve the digital participation of people with cognitive impairments over the last few years [16–19]. Two projects focusing on participatory and user centered development of cognitively accessible software will be analyzed in the following.

2.1 Mediata App

The Mediata App is a mobile application that gives people with cognitive disabilities easy access to online platforms and social media [20]. During the development of the app, special attention was paid to communication with friends and family, independent surfing on the Internet and the use of social networks and communication platforms. In addition, a simple and individually configurable single sign-on mechanism was implemented, which enables the user to log in via image selection or pattern input in addition to the text-based login.

To enable people with poor reading and writing skills to access digital resources independently, the app was implemented in a way that an alternative voice input is available in almost all positions (except password input). The search results of the Internet search and the contacts are displayed in a very clear way and the users can initialize a call or send a message directly from the contact overview. For even easier access to certain Internet pages defined in the user profile and for direct contact with the most important contact person, the so-called Easy User Mode was implemented. In the Easy-User Mode, immediately after login, an image-based overview of the specified Internet pages and the most important contact are displayed.

For a better understanding, Fig. 1 shows an example of the image-based login screen and the Easy User Mode of the Mediata app.

The app was developed within an agile approach and the potential users were involved in different phases of the software development. Since the limitations and support needs of the target group are very heterogeneous, a comprehensive user needs analysis was carried out before the start of the actual development. A user needs analysis carried out in advance may be in contrast to a strict interpretation of the principles of agile development in which user requirements are assessed and refined

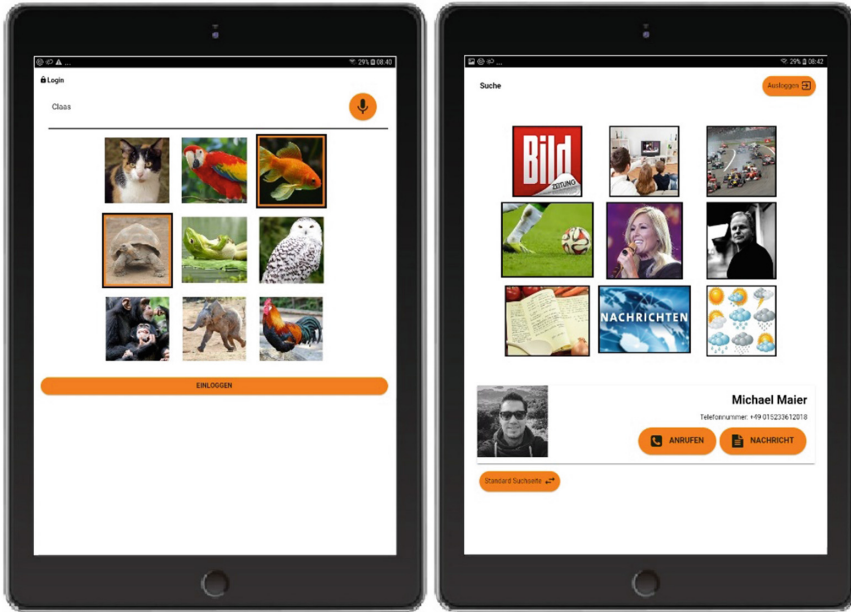


Fig. 1. Mediata-App – image-based login and Easy User Mode

during the iterative development processes. This was considered necessary due to the special characteristics and needs of the target group [21].

During the iterative development of the Mediata app, user tests were carried out at regular intervals. In larger intervals, the current status of the development was thoroughly evaluated and it was jointly decided which changes to the design and functions should be made and which functional enhancements would be useful.

There is no doubt that the results of the participatory development of the Mediata system and the results of the user-centred development accompanying tests have resulted in a product that is beneficial for the target group. Nevertheless, there were a number of difficulties in the development process which affected both the testers and the developers in their work. The testers had difficulties in understanding the test protocols and giving feedback that was comprehensible to the developers. Despite intensive support from the test team, some tests could not be carried out at all or only to a limited extent because functions and design aspects that had not yet been implemented distracted the testers from the functions that should be tested. Another complicating factor was that some of the testers had problems remembering information and test steps already explained or carried out several times. These actions had to be explained or re-executed repeatedly. In addition, some development steps suffered from communication problems between testers and developers, which led to frustration on both sides.

2.2 Easy Reading

A lot of webpages are not accessible for people with cognitive disabilities. But everyone should be able to use the same webpages as everyone else. In the scope of the Easy Reading project a software framework that supports people with cognitive disabilities in understanding web content is developed. The framework provides personalized access to web content and uses tracking technologies to decide if and when the user needs help. The aim of the Easy Reading project is the participative research and development of an open-source based framework for individual adaptation of original websites and other digital content [22].

The inclusive research and development teams in the Easy Reading project have two central research objectives. Firstly, a method is to be developed with which people with cognitive impairments can take an active part into software development projects on the basis of a participative approach. Secondly, an open source framework is to be developed that provides various tools that can be used to adapt any website to the current support needs of the user.

Similar to the previously described project, a comprehensive user needs analysis was conducted in the agile Easy Reading project before the start of the actual implementation. This analysis showed that the ‘Read aloud’ function was considered to be particularly important. The functions ‘adaptability of the layout’ and ‘additional information on words that are difficult to understand’ were also regarded as relevant.

In the Easy Reading project three different inclusive research teams are involved, one German, one Swedish and one Austrian group. Some of the functions requested by the inclusive research teams have already been implemented and integrated into a software environment that can be installed as a browser add-on in Firefox or Safari browsers.

The software environment not only provides various tools and personalization options, such as a screen reader, a synonym indicator or structural simplifications, but also uses technical means to evaluate and analyze the current user behavior. If, for example, the analysis of the user’s eye movement patterns reveals that there are problems in understanding certain areas of the website, the system suggests further simplifications and adaptations.

Figure 2 shows the current functional scope and layout of the Easy Reading Framework.

Since the developments in the Easy Reading project have not been completed yet, it is not possible to make an exact statement about the challenges arising in the context of participatory agile software development at this point in time. However, the first user tests accompanying the development have shown similar difficulties as in the previously outlined Mediata project.



Fig. 2. Easy Reading Framework on an example website

3 Results

Based on the results of theoretical research on user-centered software development and successful practical applications of participatory research methods in general research and development projects, it was expected that participatory development of cognitively accessible software can be carried out in a comparable successful and target-group oriented way.

The two projects presented here, however, showed that the participatory development in agile projects together with people with cognitive impairments leads to a number of challenges.

During the participative development of the Mediata App, various challenges were encountered. In the user needs analysis the main difficulties related to communication and comprehension. During the discussions on user requirements, it became evident that additional support in the form of images and simplified explanations helped to reduce testers' comprehension and memory problems and improve communication and exchange between developers and testers. The use of written material and explanatory images led to a significant improvement of the situation, but resulted in significantly longer meetings than originally planned.

As customary in agile development projects, the first user tests accompanying the development were carried out with prototypes that neither functionally nor in design corresponded to the final state of the Mediata system. Due to the abstraction and concentration difficulties associated with a cognitive impairment, the testers were often distracted by functions that did not yet work or looked 'pretty' and had difficulties in concentrating on the functions to be tested.

In addition, testers had difficulties in focusing on the functions to be tested when other aspects seemed more relevant to them. For example, when testing the contact functions, the layout of the buttons and the poor image quality of the images were considered very relevant for the contacts, and the actual functions to be tested were only partly evaluated. Although the tests accompanying the development definitely led to important results, focused user tests in strict terms could only be carried out in the final test phases, in which the Mediata app was already mature in all functions and only minor deviations in the design existed.

In the Easy Reading project, the analysis of user needs revealed similar problems. In contrast to the Mediata project, however, a larger team with extensive expertise in inclusive research was available, allowing problems to be addressed more quickly and effectively. But again, the special conditions in the inclusive research teams resulted in much more time being needed for the project meetings and workshops than originally planned.

In the development accompanying tests similar problems as in the Mediata project were observed. Features that had not been implemented yet or did not function stable were experienced as very irritating by the inclusive test teams. Design features such as the size or color of the symbols used, which from the developer's point of view were not the focus of the first functional tests, were thoroughly evaluated by the testers, while the existing functional problems were not recognized or only partially evaluated.

Since the Easy Reading Team was significantly larger than the Mediata Team, team communication and the balance of power in the team played a greater role in this project. Here, too, difficulties were observed due to the special characteristics of the target group. The communication difficulties were mainly related to the use of difficult language and abstract terms and concepts. Frequently, it was necessary to translate the discussion content into simple language to allow all team members to follow. In longer and larger project meetings, the long duration of some discussions, the frequent and rapid changes of topics as well as the overall forms of communication not adapted to the target group led to incomprehension and frustration among the testers. Problems and misunderstandings on a personal level also led to problems in the Easy Reading project. In summary, it can be said that developers and researchers had difficulties adapting to the special needs of the target group both on the content level and on the communicative and emotional level. Most of the observed problems could be solved successfully, but resulted in a considerable increase in time and human resources.

Table 1 gives an overview of the challenges in participatory development of cognitively accessible software in the two featured projects.

In addition to the development of the Easy Reading Framework, the Easy Reading project aims to develop adequate solutions and methods for the participative development of cognitively accessible software. As additional important and complex tools will be developed and evaluated in the further course of the project, problems in participative cooperation that have not yet been identified will arise. These problems have to be analyzed and solved continuously.

Table 1. Challenges in participative software development

Project phase	Areas of concern	Description
Requirement analysis	Communication, technical expertise, capacity and strength, time constraints	Difficulties in conveying technical contexts and lack of adequate forms of communication, Inadequate consideration of reduced cognitive and physical resilience, increased expenditure of time due to unscheduled additional explanations and translations
Prototype testing	Communication, abstraction, relevance assessment, technical understanding	Insufficient consideration of difficulties in evaluating prototypes, problems in assessing the relevance of functions and features, and difficulties in performing functions due to lack of technical understanding
Functional testing	Communication, abstraction, relevance assessment, technical understanding	Insufficient consideration of problems in assessing the relevance of functions and features and difficulties in performing functions due to lack of technical understanding
Usability testing	Communication, capacity and strength, time constraints	Insufficient consideration of problems in understanding complex test scenarios, difficulties in describing and documenting test results in a comprehensible way, and the time required for additional explanations and assistance
Project meetings	Communication, capacity and strength, time constraints	Inadequate preparation for difficulties in understanding complex issues and complex communication situations, as well as the emotional distress due to misunderstandings and disagreements

4 Discussion

Empirical evidence from the described projects has shown that the participatory development of cognitively accessible software in agile development projects entails a wide range of challenges. Indisputably, the development of software products for the target group of people with cognitive impairments has to be participative. This is the only way to develop products that are optimally tailored to the needs of the target groups.

But in order to successfully develop a product, the challenges of working together with people with cognitive impairments must be anticipated and understood, and there must be solutions to the emerging problems. For most of the arising issues there are solutions that can be applied if necessary. But this method usually results in a situation in which the tightly calculated projects exceed the available funds and are either

terminated prematurely or user participation is reduced to a minimum. The reduction of user participation has particularly serious consequences for users with cognitive impairments, whose needs are often insufficiently taken into account.

A reasonable approach to improve the participative development of cognitively accessible software is the development of a methodological concept, as it is proposed within the Easy Reading project. The special characteristics associated with inclusive research and development teams involving people with cognitive impairments have to be taken into account prior to project planning in order to minimize the problems described in this paper. This allows the entire project team to prepare adequately for the challenges and to adapt the project calculation of development projects appropriately. The reduction of user participation, which is currently a more or less unintended consequence in many projects, causes problems especially for the target group of people with cognitive impairments. In many software development projects, the very heterogeneous needs of this target group are only insufficiently taken into account.

It should be noted critically that the two projects discussed here can only provide an insufficient insight into the complexity of participative software development. Some of the problems may have been caused by the people involved and therefore cannot be generalized. However, since a substantial part of the problems that have been identified within the presented projects were also observed in participatory development projects involving users without impairments, it can be assumed that they are of general relevance for participatory development projects. The development of an adequate methodological approach is therefore certainly beneficial for participative software development in various aspects.

References

1. Dobransky, K., Hargittai, E.: The disability divide in internet access and use. *Inform. Commun. Soc.* **9**(3), 313–334 (2006)
2. Convention on the Rights of Persons with Disabilities. <https://www.un.org/development/desa/disabilities/convention-on-the-rights-of-persons-with-disabilities.html>. Accessed 22 Jan 2019
3. Introduction to ARIA and HTML5. <https://webaim.org/presentations/2015/CSUN/IntroToARIAandHTML5.pdf>. Accessed 22 Jan 2019
4. The Times in Plain English. <http://www.thetimesinplainenglish.com>. Accessed 22 Feb 2019
5. Plain Writing Act of 2010. <https://www.govinfo.gov/app/details/PLAW-111publ274>. Accessed 22 Jan 2019
6. Norman, D.A., Draper, S.W.: *User Centered System Design. New Perspectives on Human-Computer Interaction*. Erlbaum Associates Inc., Hillsdale (1986)
7. Blomkvist, S.: Towards a model for bridging agile development and user-centered design. In: Seffah, A., Gulliksen, J., Desmarais, M.C. (eds.) *Human-Centered Software Engineering —Integrating Usability in the Software Development Lifecycle*. Human-Computer Interaction Series, vol. 8. Springer, Dordrecht (2005)
8. Chamberlain, S., Sharp, H., Maiden, N.: Towards a Framework for Integrating Agile Development and User-Centred Design. In: Abrahamsson, P., Marchesi, M., Succi, G. (eds.) *XP 2006*. LNCS, vol. 4044, pp. 143–153. Springer, Heidelberg (2006). https://doi.org/10.1007/11774129_15

9. Sanders, E.N.-B.: From User-centered to Participatory Design Approaches. http://www.maketools.com/articles-papers/FromUsercenteredtoParticipatory_Sanders_%2002.pdf. Accessed 26 Jan 2019
10. Schuler, D., Namioka, A.: *Participatory Design: Principles and Practices*. Lawrence Erlbaum Associates, Hillsdale, NJ (1993)
11. Zowghi, D., Rimini, F. da, Bano, M.: Problems and challenges of user involvement in software development: an empirical study. In: *Proceedings of the 19th International Conference on Evaluation and Assessment in Software Engineering*. ACM, New York (2015)
12. Bano, M., Zowghi, D.: A systematic review on the relationship between user involvement and system success. *Inf. Softw. Technol.* **58**, 148–169 (2015)
13. Nind, M.: *Conducting qualitative research with people with learning, communication and other disabilities: methodological challenges*. Project Report. National Centre for Research Methods (2008)
14. *Cognitive Disabilities – Something to think about*. <https://webaim.org/articles/cognitive/>. Accessed 8 Feb 2019
15. Chadwick, D.D., Quinn, S., Fullwood, C.: Perceptions of the risks and benefits of Internet access and use by people with intellectual disabilities. *Br. J. Learn. Disabil.* **45**, 21–31 (2017)
16. Brausch, C., Bühler, C., Feldmann, A., Padberg, M.: Supported Employment – Electronic Job-Coach (EJO). In: Miesenberger, K., Bühler, C., Penaz, P. (eds.) *ICCHP 2016*. LNCS, vol. 9758, pp. 142–149. Springer, Cham (2016). https://doi.org/10.1007/978-3-319-41264-1_20
17. Dirks, S., Bühler, C.: Participation and autonomy for users with ABI through easy social media access. In: Cudd, P., de Witte, L.P. (eds.) *Harnessing the Power of Technology to Improve Lives*. *Proceedings of the 14th European Conference on the Advancements of Assistive Technology*. *Studies in Health Technology and Informatics* 242. IOS Press, Amsterdam (2017)
18. Schaten, M., Lexis, M., Roentgen, U., Bühler, C., de Witte, L.: User centered design in practice – developing software with/for people with cognitive and intellectual disabilities. In: Encarnação, P., Azevedo, L., Gelderblom, G.J. (eds.) *Assistive Technology: From Research to Practice: AAATE 2013*. IOS Press, Amsterdam (2013)
19. Via4All.: *Via4All Project Website* (2018). <http://www.via4all.de/start>. Accessed 22 Oct 2018
20. Bühler, C., Dirks, S., Nietzio, A.: Easy Access to Social Media: Introducing the Mediata-App. In: Miesenberger, K., Bühler, C., Penaz, P. (eds.) *ICCHP 2016*. LNCS, vol. 9759, pp. 227–233. Springer, Cham (2016). https://doi.org/10.1007/978-3-319-41267-2_31
21. Dirks, S., Bühler, C.: Akzeptanz von assistiven Softwaresystemen für Menschen mit kognitiven Beeinträchtigungen. In: Eibl, M., Gaedke, M. (eds.) *Informatik 2017*, pp. 345–359. Gesellschaft für Informatik, Bonn (2017)
22. Heumader, P., Edler, C., Miesenberger, K., Wolkerstorfer, S.: Requirements engineering for people with cognitive disabilities - exploring new ways for peer-researchers and developers to cooperate. *ICCHP (1)*, Linz, Austria (2018)