# Supporting People to Age-in-Place: Prototyping a Multi-sided Health and Wellbeing Platform in a Living Lab Setting

**Wally J.W. Keijzer-Broers, Lucas Florez-Atehortua and Mark de Reuver**

**Abstract** A key challenge elderly people face is the ability to live independently. Losing their everyday independence is a major concern for the elderly, partly because they fear this could lead to an involuntary move to an assisted living facility instead of living independently. Since 2015, the Dutch government encourages their citizens to age-in-place, but at the same time struggles with how to implement new healthcare regulations. To support both government and citizens, we propose a digital platform to match supply and demand in the health and wellbeing domain. Such a platform should not only enable end-users to enhance self-management, but also support them to find solutions for everyday problems related to aging-in-place. To illustrate our Action Design Research we established a Living Lab in a metropolitan area in the Netherlands, and developed a prototype of the proposed platform in a real-life setting.

**Keywords** Smart living · Age-in-place · Living lab · Health and wellbeing platform · Action design research

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## 1 Introduction

The world's population is growing older and, as in many other countries in Europe, the Dutch government is aiming for better integration of health and social care to support elderly people and patients with chronic conditions in the community [1]. An aging population can be explained by the increasing life expectancy due to improved public health and a declining fertility rate. Both trends are expected to continue in the coming decades. Life expectancy at birth will increase globally by ten years, to reach an average of 76 years by 2045–2050. In the same timespan the average global fertility rate will drop to the replacement level. Next to that, the United Nations predict that within thirty years the elderly people will even outnumber children under the age of 15 [2]. One policy to reduce healthcare expenditures is to encourage people to live longer at home (i.e., aging-in-place) [3]. Whilst, most elderly prefer aging-in-place instead of living in an institution [4] and want to maintain a certain quality of life [5], it is a challenge to make this happen. Decrease in cognitive and functional abilities, social exclusion, digital divide as well as time pressure on the caregivers, are typical hurdles. Besides these general difficulties end-users are not aware of what products and services are available to fulfill their needs at a certain point of time. Societal issues related to health, wellbeing and comfort come together in the home-environment of people, but if elderly become more vulnerable, it becomes harder to take responsibility themselves. This requires solidarity from society and especially from voluntary caretakers, friends and family to support active aging [6]. To assist the elderly, considerations need to be given to housing, transportation, social interaction, cultural engagement and activities [7]. Aging-in-place also implies that elderly maintain social connections to the neighborhood and the community, as well as in socio-cultural contexts [8].

Next to that, ICT solutions can help to arrange daily activities in a smarter way. It is not about a smart home per se (i.e., with advanced automated appliances) but how to integrate smart solutions in our daily life. This is related to the concept of smart living defined as an integrated design of our homes and neighborhoods in which functional and non-functional requirements come together in an integrated value-sensitive design. Smart living is related to the quality of life [9] and involves connecting our daily activities at home, along the way, or anywhere else, that can be supported by integrated ICT. Smart Living services are related to the Internet of Things (IOT) that can be interpreted as 'a worldwide network of interconnected objects uniquely addressable, based on standard protocols' [10]. Because of advanced sensor technologies and integrating sensors, devices are transforming into smart objects [11]. Next to that, smart living services can be seen as mediator between providers and customers in the process of value creation [12].

Therefore, we propose a digital platform for health and wellbeing to match supply and demand in the smart living domain. This service platform should not only create awareness among end-users about what services and technologies can help them, but also assist in mediating between (latent) needs and (yet unknown) services.

Ultimately, such a platform should enable end-users to enhance self-management (i.e., independency) by the provision of relevant information and support in matching between different stakeholder groups (i.e., consumers, providers, and government). Eventually the platform has to enhance the quality of life of end-users.

This paper describes the prototyping phase of a health and wellbeing platform in a real-life setting. In Sect. 2 the Action Design Research method is explained and how this is integrated in a Living Lab environment. Section 3 gives insight in the prototyping phase of the health and wellbeing platform. Finally, before the conclusion and future work is discussed, the first usability test of the platform is described in Sect. 4.

## 2 Action Design Research Method

Our research is part of the design research tradition, which is a well-established sub-branch of information systems e.g., [13, 14]. To be more precise, we draw on Action Design Research (ADR) that stresses the relevance circle of Hevner [15] by providing guidance for combining building, intervention and evaluation of an IT artifact in a concerted research effort [16].

Fundamentally, ADR is a study of change and particularly appropriate for our research because: (1) it combines action research (AR) and design research (DR) to generate prescriptive knowledge (2) it is problem-driven and (3) it aims to build design principles based on iterative cycles (see Fig. 1).

The problem formulation in the ADR design mainly adheres to two principles: practice-inspired research and a theory-ingrained artifact. The first principle is

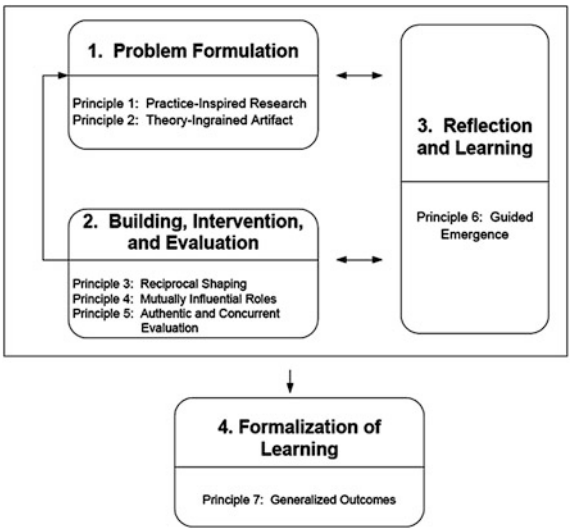


**Fig. 1** ADR design stages and related principles according to Sein et al. [16], p. 41

focused on field problems as knowledge-creation opportunities, instead of theoretical puzzles, as in the second principle the artifact can be seen as the carrier of theoretical traces and iterations, based on the theoretical insights that have been obtained.

The second block focuses on the building, intervention, and evaluation (BIE) of the artifact, based on three principles. First, the reciprocal shaping, which means that it should be emphasized on the influences from two domains the IT artifact and the organizational context. Mutually influential roles, refer to the fact that all participants of the ADR team should learn from each other. The principle that is part of the third block: reflection and learning is the guided emergence. This consists of three types of reflections: (1) on the intervention results, (2) the learnings in terms of theories selected, and (3) the evaluation of adherence to the ADR principles. It provides a reflection of the seemingly incongruent perspectives. The last block of ADR is the formalization of learning. It has the principle that the learnings should be abstracted to a class of field problems that should be communicated well.

To reflect on the ADR process and to track the iterative design steps, the action design researcher kept an observation log on a daily basis over the period 2013–2015 amounting up to 700 pages. Next to that, the logbook is used as a scientific record [17] and contains the decision steps related to the design process.

## *2.1 Earlier Research on the Platform*

Earlier research on the health and wellbeing platform covered the first stage of the ADR design cycle: 'problem formulation' ([18–21]. In this part of the research we structured the problem and identified the possible solutions to guide the design [22].

As a result of the first design stage, we categorized the suggested features extracted from 70 interviews and 2 focus groups for the health and wellbeing platform before moving to the second stage: the 'Building, Intervention, and Evaluation' phase.

Table 1 illustrates the multiplicity of requirements for platform functions, ranging from basic information exchange towards active recommendations for services and matching, and from pure focus on transactions towards inter-active communication with end-users. Based on the aforementioned features, the platform would be a first mover in the Netherlands to combine and offer; (1) matching between providers of smart living products and services and end-users, (2) finding local activities, (3) connecting with others (e.g., family, caretakers), (4) information about aging-in-place and, (5) integration of successful, existing platforms in the health and wellbeing domain.

**Table 1** List of main features for the platform

| | Domestic | Health | Wellbeing |
|---|---|---|---|
| Products | Security<br>Home automation | Nursing aids | Entertainment<br>Comfort products |
| Services | Renovation (i.e., installer)<br>Maintenance (i.e., gardner) | Personal care<br>Health care | Comfort services (i.e., grocery, cooking, housekeeping) |
| Local activities | Every day activities<br>Education | Daycare<br>Care related activities | Sports and entertainment<br>Cultural<br>In/outdoor activities |
| Contacts | Family<br>Friends | Patient bonds<br>Health care | Elderly bonds<br>Municipality |
| Information aging in place | Advisors<br>Renovators | Municipality | Advisors<br>Caregivers |
| Integration existing platforms | Radio and broadcasting<br>Restaurants and takeaway | Governmental | Caregivers<br>Volunteers |

## *2.2 Living Lab Setting*

To enter the stage of 'Building, intervention, and evaluation' we moved from a pure academic environment to a Living Lab setting. The Living Lab approach represents a research methodology for sensing, prototyping, and validating complex solutions in real-life contexts. Studying behavior in a real-life context allows researchers to gain a better understanding of how the creation of artifacts fit into the complexity of daily life [23]. Living Labs thus can be considered as user-centric environments providing open collaborative innovation. For a successful societal deployment of the proposed platform we needed to address end-users' as well as external stakeholder needs in concert. Feedback from end-users in an early stage of the technology development phase, on elements like relevance and usability are crucial to give a boost to both utilization and delivered value of the application [24]. Understanding the (potential) user can help minimizing risks of a technology introduction. For this reason potential end-users were included in the Living Lab from the start.

To acquire commitment from stakeholders to enter a Living Lab required a lot of effort and resilience of the ADR team. Healthcare related systems are extremely complex and it takes a lot of time to gain understanding, especially when there is no subsidy or financial compensation involved related to the stakeholders' efforts. After several attempts and initial failures related to time, money and priority constraints, we managed to assemble a consortium with multiple stakeholders from

eight different disciplines (i.e., municipality, multinationals, SMEs and end-users) that committed itself to the Living Lab. Important drivers for the stakeholders to invest in this pilot were: (1) market access to the health and care domain (2) competitive advantage and (3) business opportunities [23].

Our Living Lab can be described as a Quadruple Helix: a co-operation between large and small to medium size enterprises, the university, public organizations and end-users [25]. In most Living Labs end-users are often consulted 'after the arrow has left the bow', but there are clear benefits to the inclusion of, for instance, citizens in a preliminary stage of the design [26, 27].

The focus of our public sector-centered Living Lab is on the development of public services, so that the municipality can function better and offer new and better products and services to the citizens. To do so, we incorporated user-centered design (UCD), an approach that involves end-users (i.e., the elderly and caretakers) throughout the development process, to ensure that the proposed platform technology meets their needs.

## 2.3 *Building Intervention and Evaluation Phase*

The second stage of ADR uses the problem framing and theoretical premises adopted in stage one carried out as an iterative process in a Living Lab setting. This phase interweaves the Building of the IT artifact, the Intervention in a real-life setting and the Evaluation of the IT artifact (BIE) (Fig. 2).

During the first BIE iteration, the ADR team challenges participants' existing ideas (i.e., end-users) and assumptions about the platform's specific use context in order to create an alpha version of the prototype.

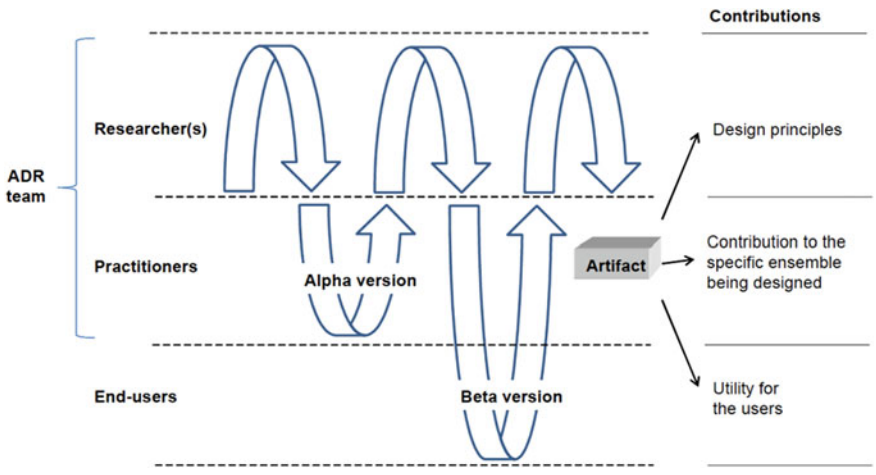


**Fig. 2** BIE iterations according to Sein et al. [16], p. 43

## 3 Building the Alpha Version of the Prototype

In order to track real-time problems during the design process we are using the agile scrum method based on flexibility, adaptability and productivity [28].

As a first step, the ADR team elaborated on the main features (i.e., marketplace products and services, contacts, local activities, information exchange and the integration of existing platforms) for the prototype (see Sect. 2.1) and translated these features into a navigation map from an end-user perspective (Fig. 3).

Based on the main features, the Alpha version of the platform captures basically three core functionalities: (1) a social environment for local activities and contacts,

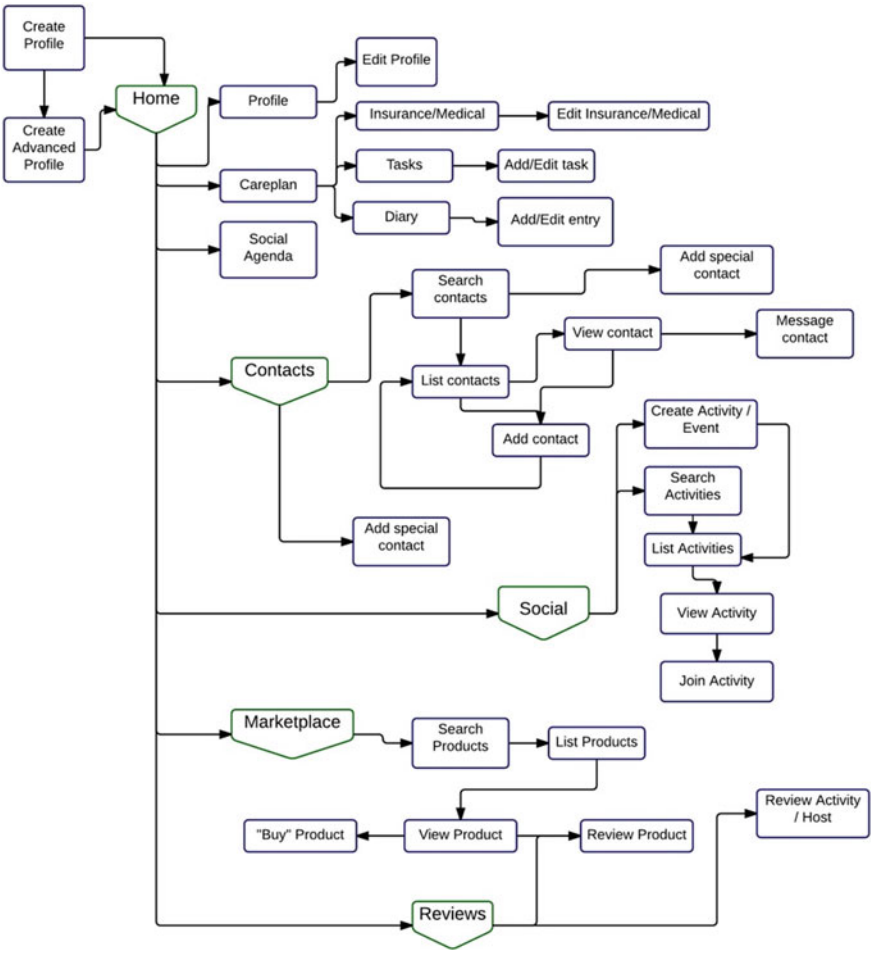


**Fig. 3** Navigation map of the alpha version of the platform

(2) a marketplace for smart living products and services with reviews, and (3) a health and wellbeing profile which can be extended with a personal Care Plan.

The rationale behind the Care Plan is that people themselves can be the center of action-taking related to health and wellbeing, such as measuring, tracking, experimenting and engaging in interventions, treatments, and activities. A Care Plan can contribute to an increased level of information flow, transparency, customization, collaboration, and responsibility-taking aspects from the end-user perspective.

## *3.1 Building the Mockups*

As a second step, the ADR team elaborated further on the suggested features to visually represent them in mockups from the perspective of the end-user (see Fig. 4 for a mockup of the Care Plan). Several user-centric design principles were considered in this effort such as visual hierarchy, simplicity, and usage of familiar patterns from successful IT artifacts (e.g., Facebook, google calendar) during the design of the mockups.

Figure 4 is the mockup that represents the view of an informal caretaker responsible for an older person (i.e., Annie). This is illustrated in the top bar of the mockup where it is shown on whose profile the user is acting, self (My home) or someone else's (Annie's home).

There are five key elements in the Care Plan:

- The left menu gives access to the three main features earlier identified as requirements, such as contacts, activities and smart living products and services.
- The agenda contains the tasks assigned to the user (i.e., Annie) given by a doctor, caretaker or relative (or any other authorized user) related to Annie's health and wellbeing. In addition, the agenda contains activities/events, which are occasions that Annie (or someone else on her behalf) has voluntarily joined (through the Activities option on the left menu) as part of her social agenda.
- The diary keeps a record of events, observations, and experiences of Annie so others can have a traceable log of Annie's health and wellbeing.
- Insurance and medical info contains the insurance policy file of Annie and other medical information that is important for Annie and those surrounding her.
- The bottom notification section; this reminds the user to complete the profile (so relevant social activities can be suggested for Annie) and to review products and services acquired (in order to present the feedback to other users and to reduce the customer's perception of risk with the platform when purchasing products and services).

The Care Plan can be used by the end-user, or shared with relatives, a district nurse or even a care broker, but only if the profile owner allows this. In addition, the Care Plan is key in our design for user engagement and adoption; it is a differentiator in terms of meeting the needs of potential users in the context of health and

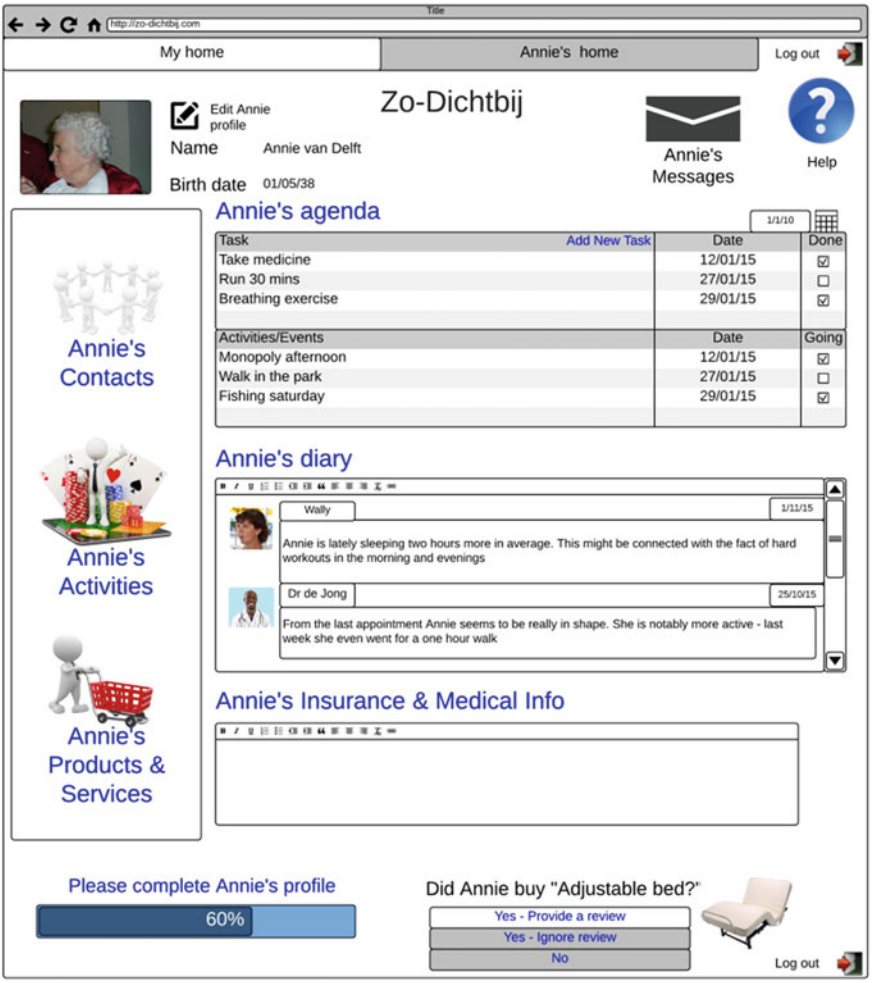


**Fig. 4** Mockup of the care plan

wellbeing. In other words, this functionality allows efficient handling of information for those involved in the care of others.

The proposed platform is a multi-sided platform offering services to individuals and to providers who offer services to the individuals. Such platforms require special attention to privacy because each transaction within the platform is somehow related to personal data of the individual. The platform will be compliant with privacy-by-design principles throughout all the development phases and the entire lifecycle. Consideration of appropriate use of existing Privacy Enhancing Technologies (PETs), as well as the EU Data Protection Directive (Directive 95/46/EC) will be made.

## 4 Evaluation of the Alpha Version of the Platform

To assess whether the ADR team was on the right track, a usability test was conducted almost immediately after the first clickable model of the platform was developed. Two important considerations when conducting usability testing are (1) to conduct a test in which representative participants interact with representative scenarios and (2) to ensure that an iterative approach is used [29]. In the test, data on the time that the participants took to complete the given tasks, as well as the satisfaction with their experience, had to be collected. These data are both quantitative and qualitative and are incorporated in a detailed report that can be used by designers to make changes and test the artifact again. Leavitt and Shneiderman [29] suggest that usability testing should be performed early in the design process with a small number of users (approximately six) in order to identify problems with the navigation and overall design issues. Once the navigation, basic content, and display features are in place, quantitative performance testing (e.g., measuring time, wrong pathways, failure to find content) can be conducted to ensure that usability objectives are met. Besides providing valuable input for the evolution of the artifact towards a usable tool, the role of the usability test is to measure the acceptance of the artifact in an early stage of the design.

The first usability test was in a controlled environment, which means the tester and the participants were gathered in the same location. The test was intended to determine the extent to which the user's interface facilitates the user's ability to complete key tasks. This was conducted with a group of six potential end-users (i.e., elderly, voluntary caretakers and professional caretakers) who were asked to complete a series of tasks with an end goal. Sessions were recorded and minutes were taken to identify critical areas for improvement of the artifact. Figure 5 summarizes the usability test tasks along with the criteria set.

These tasks are related to the three functionalities described in the mockup for which a clickable model was developed in this first iteration. Our benchmarking norm is 5 out 6 successful tasks by the participants as suggested by Leavitt and Shneiderman [29]. As a result only one task ('Create an entry in the diary') didn't fulfill the completion criteria, and two ('Create an entry in the diary' and 'Join activity') the time criteria. The diary concept/functionality in the artifact was not clear for everyone and needs to be revised and enhanced; participants were unfamiliar with the type of text input that we offered.

In a post-test survey participants were asked whether they would use/recommend the platform as well as their satisfaction with their experience; all the participants (6/6) agreed that they would use or recommend the platform if available and 4 out of 6 participants rated 4 or 5 in a scale of 1–5 the user experience of the artifact. The prototype tested was a simple HTML model with no efforts on visual design as yet. Participants also provided qualitative input during the usability test. Font and images size, simplicity and structure of the artifact were praised, whereas specific functionalities like the diary were suggested for improvement.

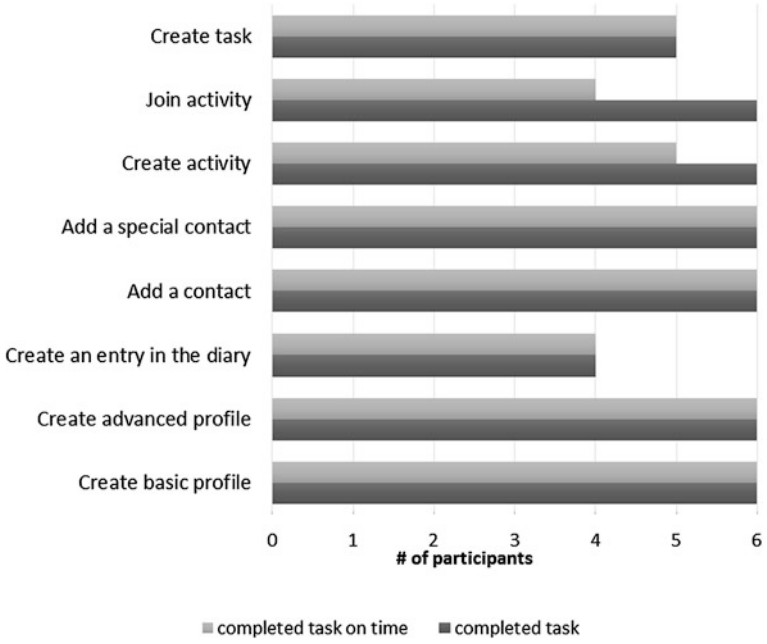


**Fig. 5** Usability test tasks and criteria (N = 6)

## 5 Discussion and Conclusions

Early acceptance of the platform is critical in this research; therefore the results given by the usability test suggest that the right steps are being taken during the design stage. Using familiar patterns when designing a prototype helps potential users to feel more acquainted with the artifact. Preparing a clickable interactive model for a usability test requires far less effort compared to when a fully functional artifact is provided. However, we consider that the effects of testing could be comparable. Although the participants are not provided yet with a full experience, the usability test can be designed in a way that really evaluates critical elements of the artifact based on specific tasks and goals given to the participants as in a controlled setting, creating the feeling of a finalized artifact. Therefore, the approach taken in this iteration step, for the evaluation of the design of the platform, is also suggested for the next iterations. Based on the recommendations of the first testers, we included the mock-up of the design in a large-scale survey (i.e., elderly and informal caretakers) for further data gathering on the subject. In parallel with the data-analysis of the survey, field tests of the clickable model of the platform are foreseen with different groups of informal caretakers, district nurses and potential end-users (age group 55–75). These evaluation moments, that ensure effective participation of end-users, are part of the iterative design steps of the overall ADR project.

## References


1. Rechel, B., Grundy, E., Robine, J.M., Cylus, J., Mackenbach, J.P., Knai, C., McKee, M.: Ageing in the European Union. Lancet **381**, 1312–1322 (2013)
2. UN: World Population Ageing 2013. United Nations, Department of Economic and Social Affairs, Population Division (2013)
3. Carstensen, L.L., Morrow-Howell, N., Greenfield, E.A., Hinterlong, J.E., Burr, J.A., Hudson, R.B., Wilson, S.F.: Civic engagement in an older America. The Gerontological Society of America, Washington (2010)
4. Wiles, J.L., Leibing, A., Guberman, N., Reeve, J., Allen, R.E.: The meaning of "ageing in place" to older people. Gerontologist **52**, 357–366 (2011)
5. Chan, M., Campo, E., Esteve, D., Fourniols, J.: Smart homes—current features and future perspectives. Maturitas **64**, 90–97 (2009)
6. Sixsmith, A., Gutman, G.M.: Technologies for active aging. In Technologies for Active Aging New York. Springer, Berlin (2013)
7. Wahl, H.W., Weisman, G.D.: Environmental gerontology at the beginning of the new millennium: Reflections on its historical, empirical, and theoretical development. Gerontologist **43**, 616–627 (2003)
8. Peace, S., Kellaher, L., Holland, C.: Environment and identity in later life. McGraw-Hill International (2005)
9. Giffinger, R., Fertner, C., Kramar, H., Kalasek, R., Pichler-Milanovic, N., Meijers, E.: Smart cities-Ranking of European medium-sized cities. Vienna University of Technology, New York (2007)
10. Vermesan, O., Friess, P.: Internet of things-global technological and societal trends from smart environments and spaces to green ICT. River Publishers, Denmark (2011)
11. Kortuem, G., Kawsar, F., Fitton, D., Sundramoorthy, V.: Smart objects as building blocks for the internet of things. Internet Computing, IEEE **14**, 44–51 (2010)
12. Grönroos, C., Ravald, A.: Service as business logic: implications for value creation and marketing. J. Serv. Manage. **22**, 5–22 (2011)
13. Hevner, A., March, S., Park, J., Ram, S.: Design science in information systems research. MIS Q. **28**, 75–105 (2004)
14. Gregor, S., Jones, D.: The Anatomy of a design theory. J. Assoc. Inf. Syst. **8**, 313–335 (2007)
15. Hevner, A.: A three-cycle view of design science research. Scand. J. Info. Syst. **19**, 87–92 (2007)
16. Sein, M., Henfridsson, O., Purao, S., Rossi, M., Lindgren, R.: Action design research. MIS Q. **35**, 37–56 (2011)
17. Alaszewski, A.: Using diaries for social research. Sage, London (2006)
18. Keijzer-Broers, W., De Reuver, M., Guldemond, N.: Designing a matchmaking platform for smart living services. Inclusive society: health and wellbeing in the community, and care at home, pp. 224–229. Springer Berlin, Heidelberg (2013)
19. Keijzer-Broers, W., Nikayin, F., De Reuver, M.: Main requirements of a health and wellbeing platform: findings from four focus group discussions. In: ACIS 2014. AUT Library, Auckland (2014)
20. Keijzer-Broers, W., De Reuver, M., Guldemond, N.: Designing a multi-sided health and wellbeing platform: Results of a first design cycle. ICOST 2014—Denver, vol. conference proceedings, pp. 3–12. Springer, Berlin (2014)
21. Keijzer-Broers, W., De Reuver, M., Florez Atehortua, L., Guldemond, N.: Developing a health and wellbeing platform in a living lab setting: an action design research study. In: DESRIST
22. Gregor, S.: The nature of theory in information systems. MIS Q. **30**, 611–642 (2006)
23. Niitamo, V.P., Kulkki, S., Eriksson, M., Hribernik, K.A.: Milan. State-of-the-art and good practice in the field of living labs. In Proceedings of the 12th international conference on concurrent enterprising: innovative products and services through collaborative networks (ICE2006), (pp. 26–28, 341–348). Nottingham, Italy (2006)

24. Abras, C., Maloney-Krichmar, D., Preece, J.: User-centered design. Thousand Oaks: Sage Publ. **37**, 445–456 (2004)
25. Arnkil, R., Järvensivu, A., Koski, P., Piirainen, T.: Exploring the quadruple helix. Outlining user-oriented innovation models. Report of Quadruple Helix Research for the CLIQ Project, Tampere: Work Research Centre. University of Tampere, Tampere (2010)
26. Holzer, M., Kloby, K.: Sustaining citizen-driven performance improvement: Models for adoption and issues of sustainability. Innov. J. Publ. Sect. Innov. J. **10**, 521–541 (2005)
27. Brand, R.: The citizen-innovator. Innov. J. **10**, 9–19 (2005)
28. Schwaber, K.: Agile project management with Scrum. Microsoft Press, USA (2004)
29. Leavitt, M.O., Shneiderman, B.: Research-based web design & usability guidelines. US Department of Health and Human Services, USA (2006)