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Designing for Sustainability: Key Issues of ICT Projects for Ageing at Home

Johanna Meurer, Claudia Müller, Carla Simone, Ina Wagner & Volker Wulf
University of Siegen, Siegen , Germany (Email: Johanna.Meurer@uni-siegen.de; Email: Claudia.Müller@uni-siegen.de; Email: simone@disco.unimib.it; Email: ina.wagner@tuwien.ac.at)

Abstract. Achieving the sustainability of IT-based solutions is a challenge. We will argue in this paper that it is helpful to conceptualize designing for sustainable IT-based solutions as taking place in a multi-dimensional space. It requires thinking about how a project is framed; the perspectives and commitments of the project partners; the type of innovation that is foregrounded; the motivations and needs of the user group; and the level of sustainability a project or research program may achieve. The paper describes some of the challenges and possible solutions by revisiting a portfolio of projects that developed IT support for elderly people who continue living in their own homes.

Keywords: ICT design, Sustainability, Elderly people, Appropriation, Capacity building, Funding schemes, Collective learning

1. Introduction

Designers and researchers that engage in project work are often led by a strong motivation to create a workable IT-based solution that will make a difference for those people, communities or organizations that appropriate it, helping them to develop their practices: for them sustainability is about how to achieve a lasting effect in the target setting that may even stimulate further developments. In discussing health interventions Altman (1995) articulates this goal by defining sustainability as 'the infrastructure that remains after a research project ends': this infrastructure includes 'consideration of interventions that are maintained, organizations that modify their actions as a result of participating in research, and individuals who, through the research process, gain knowledge and skills that are used in other life domains' (p. 527). Hence, different levels of sustainable outcomes can be distinguished: *individual-level* outcomes, including new participants, clients or consumers (of a service) in terms of access, learning, and sustainable practices; the *community-level* capacity to sustain program activity as well as to take further initiatives and innovate; and, finally, the *organization-level* implementation of activities: whether the organization itself is maintained through adequate funding, staffing and other types of resources (Scheirer 2005).

Our motivation for this paper is that achieving the sustainability of IT-based solutions is a challenge, irrespective of the efforts made to this goal, as most of the effects end when a project is over. Partially, and this will be one of our main

arguments, this is due to the particular conditions of working in IT design projects. As Randall (2018) state in a paper that reflects on research practices, these projects 'are mostly funded by public sources and follow a specific (Central) European approach to the institutionalization of research'. European funding agencies

> try to foster IT-induced social innovation by funding research projects in which academia, IT industries, and often application partners submit joint proposals in a competitive manner. In case of success, research is often conducted in consortia of partners representing different interests and perspectives (p. 492).

IT design projects that operate under the conditions of funded research have to reconcile conflicting social worlds – the one of researchers and the one of practitioners; they have to struggle to create the space for implementing a robust design result and to be able to observe real use over a longer period of time. Moreover, when research projects engage with practitioners this engagement is almost always a temporally limited endeavor.

Research that demonstrates the sustainability of IT-based solutions is scarce, with some exceptions (e.g. Müller et al. 2012; Stevens et al. 2009). CSCW research focuses on the appropriation of IT-based solutions in organizations studying the work that users carry out to make an IT artifact work in their environment (e.g. Orlikowski 1992; Bowers et al. 1995; Pipek and Wulf 1999; Pipek 2005; Havn and Bansler 2006; Draxler and Stevens 2011). But sustainability is a larger issue that also requires studying *the conditions within and beyond a research project* for a design result to be appropriated, maintained and eventually further developed. We will argue in this paper that it is helpful to conceptualize designing for sustainable IT-based solutions as taking place in a multi-dimensional space. It requires thinking about: how a project is framed; the perspectives and commitments of the project partners; the type of innovation that is foregrounded; the motivations and needs of the user group; and the level of sustainability a project or research program may achieve. Other research communities, notably those interested in community development and/or community-based health programs, have studied the conditions for sustainability from this broader perspective.

The purpose of this paper is mainly conceptual and it takes two complementary perspectives. It, in the first place, focuses on issues of sustainability that arise in the context of IT design projects targeted at a specific domain: the development of IT support for elderly people who continue living in their own homes. This focus on elderly people and their 'ageing well' (Light et al. 2015) emphasizes the 'social dimension' of sustainability (Standing and Jackson 2007) and interprets the issue of sustainability as the possibility for them to appropriate the technology so that they are in control of its current features and its future evolution. How elderly people appropriate technologies has also been studied by others (e.g. Storni 2010; Procter et al. 2014; Giaccardi et al. 2016), however with no or only little attention to issues of sustainability. The second perspective is on understanding how the framing of IT

design projects by funding agencies, project calls, timelines and budget rules shapes and constrains the possibilities of achieving sustainability.

In addition to developing the issues of sustainability on the basis of existing literature, the paper also revisits a portfolio of projects in support of elderly people that involved the 'Inclusive Ageing Group' at the University of Siegen: the design of a portal in support of community building in a city quarter; a platform for assessing mobility services for elderly people that live in a rural area; as well as a platform for fall prediction and prevention to be installed in the homes of elderly users. While taking these projects as a useful empirical basis, we are aware that the issues we identify need to be further elaborated using a larger and more diverse set of projects and target domains.

Given the lack of a systematic discussion of sustainability in the CSCW literature, the first part of the paper provides an overview of the research literature, which is grounded in a diversity of academic discourses, including CSCW, Participatory Design (PD), as well as health and community development. In the second part of the paper we work more closely with the empirical material:

We first examine different forms or degrees of sustainability that a designer-researcher team may aspire to or be able to achieve, distinguishing between: the (individual) appropriation or domestication of an IT-based solution; building the capacity for continuous and evolving use; and the scalability and transferability of the design outcomes (distributing the solution to additional users or other sites). We then discuss some of the 'dissipating forces' that may make sustainability difficult to achieve: the heterogeneity of the involved actors and their potentially conflicting interests; constraints that stem from funding schemes and structural aspects of a project, including its temporal framing.

The paper concludes by describing the multi-dimensionality of sustainability, outlining some of the open issues that need to be explored to arrive at a fuller picture of sustainability as an important design outcome.

2. Key issues and concepts

2.1. Some background

The issue of sustainability is still strongly connected to the debate about the environment and the original statement by Brundtland (1987) but has developed into a topic of interest common to different application domains. Very soon, the ecological dimension was complemented by the economic and social dimensions that are nowadays considered as closely entangled although quite difficult to measure (Norman and MacDonald 2004). As a result it 'seems clear that sustainability can mean a number of things to a variety of constituencies and, while there may be no objection to the sentiments expressed in the respective definitions, they are far from holistic' (Johnston et al. 2007, p. 62). As a matter of fact, IT-based systems and

applications are not part of this debate on sustainability: they are viewed as an ancillary although important tool to collect, elaborate and share the (huge amount of) data pertinent to each application domain for the sake of sustainability (Watson et al. 2012).

Computer scientists and engineers have started debating the sustainability of the solutions they develop, exploring different views on the problem but paying little attention to the social dimension. In analogy with the ecological debate, themes such as energy consumption, pollution and waste/reuse of materials dominate (e.g. Hilty et al. 2011; Schwartz et al. 2013). From the point of view of software engineering, sustainability is defined with respect to the production, maintenance and usage of a software system, with the aim of 'preserving the function of a system over a defined time span' (Penzenstadler 2013, p. 1184).

The view of the IS (Information Systems) community on sustainability has evolved from maintaining the competitive advantage of the adopting company in terms of its increased efficiency (Kettinger et al. 1994; Wade and Hulland 2004) to somewhat more comprehensive views that overcome the purely economic dimension. In this research literature, the 'social dimension' includes not only the impact of the products and services of a company on the overall society; it also problematizes the IT development process arguing that participatory approaches should be considered (Standing and Jackson 2007). However, participation here mainly refers to management and external stakeholders. There are exceptions to this mainstream position (Heeks 2002; Baskerville and Myers 2004) but with limited impacts on it.

The perspectives of HCI on sustainability are summarized in DiSalvo et al. (2010). Also this discourse is dominated by the ecological and environmental dimension; the role of ICT is mainly to encourage better lifestyles or to correct behaviors toward the environment, a perspective that has recently been criticized (Brynjarsdottir et al. 2012; Dillahunt 2014). A complementary topic that HCI shares with IS (Avgerou 2008) is the design in and for developing countries where sustainability relates to difficult contextual conditions and the scarcity of resources (Tomlinson et al. 2012).

2.2. Defining the sustainability of IT-based solutions

From a CSCW perspective, Wulf et al. (2015) draw attention to 'sustainability beyond a (funded) design research activity' as an important topic, arguing:

> When we examine the appropriation of IT, we must take the post-research phase into consideration. When people start integrating the technology in their everyday life to leverage specific problems, the technology can become an important part of their social practices […]. A sudden withdrawal could disrupt and challenge the newly established practices […]. Therefore, researchers have to carefully consider the sustainability of their interventions in practice (p. 132).

Theargument could be read as an appeal to designers to act in a socially responsible way by paying heed to what happens after a project. It also points to the fragility of a solution if it is not anchored in people's practices and the organization or community they are embedded in.

2.2.1. *Sustainable participatory design*

These concerns are not new, as the principled commitment to sustainability of the Participatory Design (PD) community indicates. Reflecting on the classic 'Iron and Metal Project' Nygaard and Bergo (1975) emphasized the importance of the design result, asking:

> But how are we to decide what is to be regarded as a result? We feel that the right thing to do is to initiate a self-accelerating activity within the MWU [Metal Workers Union]. … Measured by this standard, research reports are only useful to the extent they are releasing central and local action within the MWU (p. 7).

A design outcome is not 'a result' if it remains without consequences in the participating organizations. 'Central and local action' in this context meant steps towards increasing workplace democracy (Bratteteig and Wagner 2016).

While the drive to produce design results that make a difference for people's lives remains one of the aims of PD, few researchers have taken up the challenge of engaging in systematic research on how to make this possible. Bødker (1994) has framed it as the challenge of empowering the organization to use experiences from PD beyond the project: 'For the use organization, the more the work methods of the project have become a part of the everyday life, and the less they "miss" the researchers, the better' (p. 17). And more recently, Bødker and Zander (2015) in discussion of a PD project with a Danish municipality, argue that 'long-term issues of sustainability and political strategy must be addressed' (p. 55). From a more methodological perspective, the MUST approach (Kensing et al. 1998), defines sustainability as a new IT system's 'fit with preferred work practices', suggesting to 'support the organization in an up-front uncovering and dealing with conflicts arising in relation to the introduction of IT' (p. 18). More recently, Kyng (2015) took up the origins of PD by identifying ways to make health care systems sustainable. He stresses the importance of 'sustaining democratic control beyond initial design and implementation' and suggests the notion of 'software ecosystems' as building blocks supporting the construction of the sustainable systems.

Simonsen and Hertzum (2012) have formulated a strategy for 'sustained PD' which rests on the integration of design and development with organizational implementation. Using the example of an EPR (Electronic Patient Record) that was developed and implemented in a participatory process in a Danish hospital, they point to the importance of being able to observe relevant changes of work practices, emphasizing the need to evaluate real use of a system after a longer period of time 'to allow system errors to be corrected, users to gain proficiency, work practices to

stabilize, use situations to reach their true level of heterogeneity, emergent and opportunity-based changes to develop, and long-term outcomes to emerge' (p. 14).

The concept of 'living lab' which Ehn et al. (2014) define as a kind of participatory laboratory 'in the wild', has been developed with a view onto sustainability. The idea behind is to provide a context as well as resources for use and re-design that an individual project may have difficulties to establish. On the basis of three projects in different domains (home entertainment, energy monitoring, and ageing at home), Ogonowski et al. (2018) developed the PRAXLABS framework to reflect on and implement elements of sustainable design in living lab situations. It includes intensive stakeholder and end-user participation and fosters a long-term orientation in IT design projects. It supports the transfer of experiences and technologies developed in one context to other, similar contexts.

2.2.2. *The work to make an IT artifact 'work' in practice*

Within CSCW the debate on sustainable IT-based solutions is dominated by a focus on appropriation, a term that stands for the types of work designers and different types of users have to perform to embed an IT artifact in a particular context, make it work and benefit from its use. This may involve many different activities depending on the specific context, the technology, people's skills, and so on. We may think of 'appropriation work' as one of the conditions of sustainability. Different authors use the term appropriation in slightly different ways; they also have introduced additional concepts in the debate that highlight particular aspects of the appropriation processes they observed, such as configurability, alignment work, domestication, and infrastructure.

One of the earliest studies of users appropriating a technology was Orlikowski's study of the adoption of Lotus Notes, where she argued: 'If people have a poor or inappropriate understanding of the unique and different features of a new technology they may resist using it, or may not integrate it appropriately into their work practices' (Orlikowski 1992, p. 364). She also sought to understand how Lotus Notes was used to enable organizational changes over time, highlighting a distinction between changes that were 'anticipated, emergent, and opportunity- based' (Orlikowski and Debra Hofman 1997). Balka and Wagner (2006) have looked at the work that needed to be done to make a technology (a wireless call system) fit the environment of a newly built hospital wing in terms of 'configurability'. They argue that in order to successfully install the technology, issues concerning organizational relations, space and technology relations, and people's connectivity need to be taken into account.

In media and culture studies the term 'domestication' is used to describe the work of integrating digital technologies with the daily routines in the home (e.g. Silverstone and Haddon 1996). Verhaegh et al. (2016) have used the notion of domestication in a study of user-initiated innovation in 'Wireless Leiden' where they describe the various kinds of work that went into making the network work in users' homes. Domestication is a process of 'taming technology', giving it a place in daily

life. Although this concept comes from a different research tradition, we think it is helpful as it allows distinguishing the integration of technical devices into everyday life from the appropriation of IT-based solutions in work organizations where rather complex issues have to be resolved to fit a technology into work practices, eventually changing them.

Dourish (2003) has drawn attention to the characteristics of the technology that is to be implemented in an organization, arguing that 'appropriation relies on flexibility in both practice and technology, and in particular, flexibility in the way in which the technology can be mapped onto user needs' (p. 467). The questions he asks are: '[…] what features of technological design support appropriation? And so, how could systems be designed in order to accommodate, support and encourage the process of appropriation?' (p. 467). Stevens et al. (2009) have taken a step further, suggesting to develop 'appropriation infrastructures' that support the design of flexible technologies. Stevens and Pipek (2018) argue:

> Keeping a tool interaction simple, together with providing good manuals and help systems, is vital, but the appropriation of tools is very often more a social activity than a problem of individual learning and use. […] Appropriation support can address these social aspects of computing by supporting users as a '(virtual) community of tool/technology users', and by providing functional support for different appropriation activities that users can engage in to make use of a technology (p. 166).

One of the key arguments in the debate about appropriation is that it is a process that goes beyond the mere 'adoption' of a technological artifact:

> […] the term appropriation stresses the option of the appropriator to go beyond the rules and ideas that have been originally associated with the thing that is being appropriated. With regard to technologies, this stresses the options of technology users to go beyond the intentions that technology designers associated with a technology or a technological artefact (Pipek 2005, p. 30).

Thisalso reflects the experience of what Robinson and Bannon (1991) have described as 'the differences between premeditated support for work, and the facilitation of unanticipated use' (p. 231). In fact, appropriation suggests that nurturing the ability to go beyond what designers and users have envisioned as the design result may be an important aim of an IT design project. This is an ambitious goal and may not always be possible. This is why researchers have introduced the notion of different degrees of appropriation, based on observational work in a variety of projects. Henderson and Kyng (1991) distinguish between choosing between predefined alternatives, constructing new artifacts from existing pieces, and reprogramming the artifact. The research on 'end user development' defines these competences as the necessary conditions for sustainability (Lieberman et al. 2006; Paternò and Wulf

2017). Bossen and Dalsgaard (2005) suggest distinguishing between weak (just using a system, customizing it) and strong forms of appropriation. As an example of the latter, they describe the introduction of a *Knowledge Repository* in an organization, which met low acceptance by users 'despite of managerial support, extensive training and ongoing refinements of features and user interface' (p. 102). At the same time, and independently of these efforts, some skilled users constructed a series of 'parasitic systems' that were sustainable (and in the end tolerated by the organization) since they were easier to launch, with a simpler interface and meeting the knowledge sharing needs of users in a better way.

The idea that a project may aim at and achieve different levels of sustainability is an important insight from the literature that is helpful when thinking about how to design for sustainability. Based on a number of PD projects with school children, Iversen and Dindler (2014) reflect on the different 'ways in which the ideas, technologies or practices developed during a PD project may be sustained beyond the project' (p. 154): *maintaining* relates to activities that seek to support the integration of what has been developed into existing practices (inevitably changing them to some extent); *scaling* refers to efforts at bringing an IT artifact and the insights related to it to a larger group of users inside an organization or beyond it; *replicating* is a form of sustainability 'where the initiative, in the form of an idea, system, or way of working, remains relatively stable, but the context of this initiative is changed from one context to another' (p. 158); e*volving* means that what has been developed serves 'as a springboard' for further development and even new ideas. In practice, these efforts may overlap.

2.2.3. *Conditions for sustainable technologies and practices to develop*

Researchers that work in the area of community, health and development have studied and discussed measures to monitor the sustainability of programs from a long-term perspective. In many of these studies, sustainability was found to be influenced by the context in which particular measures were implemented and that 'different sustainability objectives may be appropriate in different contexts' (Shediac-Rizkallah and Bone 1998, p. 104). For example, while in some contexts investing in people in terms of capacity building may be an important objective, in others boosting a community's capacity to design follow-up programs may be in the foreground.

When thinking about the development of IT artifacts (systems or applications) in support of elderly people this suggests that the lens onto sustainability strongly depends on the context or environment in which these people live. For example, for elderly people who continue living at home the ability to use the technologies that have been designed without help, to be able to configure them for different uses, to enjoy learning new things but also to get support whenever they need it may be the main issues. In institutional care arrangements, the issue of sustainability embraces the commitment of caregivers to integrating the technologies in the everyday lives of elderly people, their resources for doing so, the institution's care philosophy and its

capacity to maintain and eventually further develop the technologies. Moreover, these distinctions express the ambition of going beyond what has been developed within the context of one particular project, extending a design result to other sites where it may be appropriated in similar or different ways (Wulf et al. 2015).

Looking at the sustainability of health programs, Shediac-Rizkallah and Bone (1998) compiled a whole list of issues that planning for sustainability needs to keep in focus. These include project design and implementation factors, the organizational setting and the broader (community) environment. Relevant aspects of project design and implementation that are discussed are the visibility of the project in the community, an extended funding period, financial sustainability, and training:

> What are the sources of funds for the program (internal, external, a mixture)? What are the community's local resources? Can the community afford the program (e.g. is it able to pay maintenance and recurrent costs)? How much are community members willing/able to pay for services? What strategies are in place to facilitate gradual financial self-sufficiency? (Shediac-Rizkallah and Bone 1998, p. 99)

Factors concerning the broader environment include 'market forces impinging on an organization, legislation affecting the program, support from external community leaders, and the availability of funding and other resources as inputs to the program' (Scheirer 2005, p. 325). In the context of IT design projects, the possibility of achieving sustainable design outcomes is influenced by the framing of a project: project calls and the objectives of the funding agency; budgets and time plans; and the perspectives of the participating stakeholders, including the interests of companies that may want to use, improve and market their products.

One issue that is closely linked to sustainability is the type and degree of innovation the funding agency as well as the different stakeholders may hope to arrive at. What innovation means is not uniquely defined (Anderson et al. 2004). Interpretations vary: from originality, that is a not existing technological solution and/or an organizational/social arrangement that has not yet been probed; to the adoption of a more consolidated solution in a novel setting or application domain. In the context of this paper, these opposed views can be expressed in terms of 'design-driven versus user-driven innovation' (Verganti 2008). When striving for a sustainable design outcome that can be embedded within an organization or community, existing technologies – what Aanestad et al. (2017) call 'installed base' – cannot be simply ignored. An example of a sustainable solution that was not necessarily innovative is described by Bratteteig and Wagner (2016). It was clear from the start that the technical solution of the *Sisom* system that supports very ill children to report their symptoms before they see a doctor, 'had to fit the already existing IT infrastructure of the hospital. This excluded other potentially interesting solutions from the beginning' (p. 145).

Research on information infrastructures has pointed at the importance of temporal issues for achieving a sustainable design outcome, distinguishing between the more

short-term concerns of developers who need to accomplish particular goals within project time and the longer-term perspective needed to build and maintain an infrastructure (Karasti et al. 2010). Ribes and Finholt (2009) have used Stuart Brand's notion of 'the long now' to express the need for linking short-term design challenges with a view onto sustainable development. Karasti et al. (2010) also point at the need to take account of the 'diverse temporalities of all the involved actors (e.g. scientists, information technology specialists, informatics researchers, data specialists, communities, funding agencies)' (p. 387).

The literature on infrastructures uses the term 'alignment work' that is the work needed to align the perspectives and skills of a heterogeneous network of actors so that they are able to coordinate their efforts. It goes back to Strauss (1988) who defined interactional alignment as 'the process by which workers fit together their respective work-related actions'. Bietz et al. (2010) extends this notion to describe the work that is 'necessary to create enough compatibility between entities so that the relationship can be productive' (p. 253). These entities may be organisational units, external stakeholders, policies or collaborating specialists. Altman (1995) discusses the, sometimes difficult, relationships between researchers and communities that are to do with conflicting priorities and goals, issues of ownership and control, and different time orientations. The key to sustainability, according to Altman, is the shift of ownership and control from the researchers to the community (or user organization). This implies that the community participates in the development of the research protocols and assumes responsibility for the design result.

In all studies concerning the sustainability of project outcomes, the ability of users to master the technology is considered a key issue. Apart from the training that people who are supposed to appropriate an IT artifact usually need, sustainability requires a type of learning that Ellström (2001) has termed 'developmental' or innovative and where the focus is on 'the creation of new practices and solutions' (p. 427). Activity theory makes a similar distinction between learning-in-practice and expansive-learning (Engeström 2001), which on the individual level is about acquiring new skills and competences and 'as a collective process […] refers to the establishing, reproduction or transformation of action systems where new tools, rules, routines, and division of labour find their place within the activity system' (Stevens and Pipek 2018, p. 144). In their work with communities Carroll and Rosson (2007) stress the importance of 'creating a self-directed and sustainable process of continuous learning' (p. 258).

The literature on sustainability with its different perspectives onto the issue suggests that it is helpful to conceptualize designing for sustainable IT-based solutions as taking place in a multi-dimensional space (Figure 1). 'Appropriation in real use' and 'Technology design' represent the classic perspectives of CSCW research and Participatory Design. They emphasize the work needed to make a design outcome 'work' in real use; as well as the features of technologies that are apt to 'accommodate, support and encourage the process of appropriation' (Dourish 2003). 'Context' and 'conditions' (in Figure 1) refer to a multiplicity of issues that need to

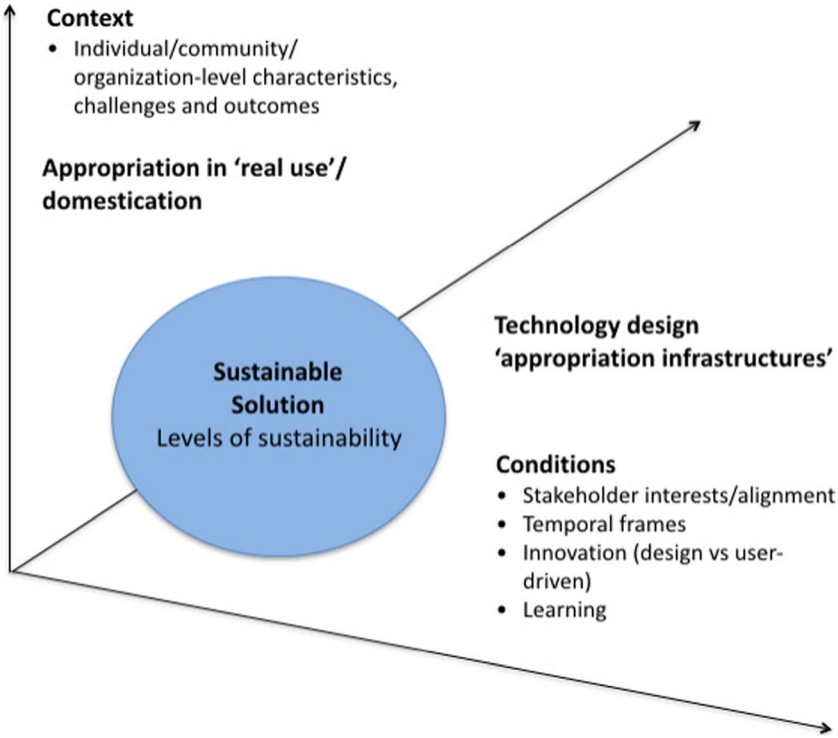

Figure 1. The multidimensional space of sustainable development.

be taken into account when designing for sustainability. As we point out in the conclusions, more systematic reflection is needed within the CSCW and PD communities about how to create the conditions for a sustainable design outcome in collaboration with the stakeholders in a project. Different contexts may suggest different sustainability objectives and outcomes, depending on the characteristics of the people, community or organization for and with whom an IT-based solution is developed. 'Conditions' directs attention to the characteristics of the project that influence how and to which extent sustainability may be achieved. The insight that a project may strive for and attain different levels of sustainability is addressed in Figure 2, which provides an overview of the different ways in which the technologies and practices developed may be sustained beyond the project (Iversen and Dindler 2014).

These concepts will be taken into account in discussing the projects that constitute the main empirical basis for our analysis of sustainability issues and will structure the final discussion.

2.3. The reference projects

The three projects that we will consider have collaborated with fairly 'fit' elderly users as participants. Their goal was to provide these users with ICT support in their

Figure 2. Ways to achieve sustainability.

daily lives through different kinds of applications: a socio-technical infrastructure in support of elderly tenants in a city quarter; a platform providing access to mobility services; and a platform for fall prediction and prevention. Common to the projects was that the intended elderly end-users all lived independently in their own homes. A particular challenge here is that these users are not necessarily connected with a community or organizations, which could support the maintenance of the IT infrastructure and may help them develop sustainable practices.

While the research group at the University of Siegen has the sustainability of the IT-based solutions it develops as one of its main goals, it turned out that the three projects reached different levels of sustainability using different approaches and solutions. A systematic observation of what happened after the projects, hence also funding, had ended was not always possible in the projects. This is why we can learn more from the projects about how to prepare for sustainability than about how sustainability after project end is actually achieved. The projects also shed light on the question why planning for sustainability may be difficult under current funding schemes and engaging a multiplicity of stakeholders with partially conflicting interests.

The *City Quarter* project (Müller et al. 2015a, b; Hornung et al. 2017) was a three-year project funded by the German Ministry of Family Affairs in the aim of promoting the research and development of ICT-based measures to support elderly tenants in maintaining an autonomous life in their habituated city quarter. The project partners were a local housing company and several interested tenants, a counselling agency that is an expert in participatory change management in the housing domain (in such as, e.g., tenant participation), as well as HCI university researchers. A

software development company was subcontracted to the university. The involved tenants were between 60 and 86 years of age and without initial knowledge in the area of new media and ICT. One of the main goals of the project was the development of a socio-technical infrastructure for the neighbourhood. A 'neighbourhood portal' was developed supporting three main functionalities: search for/offering help; flea market; and organizing common activities. Some project constraints limited their validation to a few tenants. However, the overall process resulted in a widespread appropriation of the tablets that also offered an instant messaging tool (telegram) by the elderly tenants. The tenants also contributed substantially to the design of the final portal. The project had put a strong focus on building up learning environments, which enabled the participants to get to know and use tablet PCs and smartphones in a bottom-up approach. This, in turn, was then the basis for co-design work with the elderly tenants. The group of participating tenants, which met regularly with the researcher-designer team in bi-weekly terms until 2015 in order to exchange their experiences with their new media, has evolved into a stable community and exists until today.

The *Sehr-Mobil* project (Meurer et al. 2014a, b; Stein et al. 2017) was funded by the German Federal Ministry of Education and Research (BMBF) to address demographic changes by sustaining the mobility of older adults. The project aimed to support inter-generational mobility with multimodal transport solutions that give access to public transport (buses and trains) and offer ridesharing options. It was located (like the other two projects) in the city of Siegen that has about 100.000 inhabitants and includes both urban and rural areas. The only public transportation option available is bus or train (mainly for inter-city travelling). Especially in the more rural areas the bus service is rather limited and due to the hilliness of the region, connections are often not direct. An intermodal mobility platform was developed which was made available on web, smart TV and smartphone. During the project smartphone use turned out as most important. The project worked over three years with a heterogeneous group of 19 elderly participants between 59 and 80 years of age, living in urban and rural areas, with mixed computer skills, and mobility preferences. Since all of them were not smartphone-savvy the project supported their learning processes in weekly 'assistant workshops' that were operated by the researchers and ran over two years. While the 'assistant workshops' stopped with the end of the project, most participants are still in contact with each other and contribute to an active social interaction using an instant messaging group chat (WhatsApp).

The *iStoppFalls* project (Vaziri et al. 2016, 2017; Gschwind et al. 2015) was EU-funded and involved partners in several countries. Its aim was to develop an innovative home-based technology to assist older adults that live at home in preventing falls and thus to improve their quality of life; reduce the costs of health care; and have a major impact not only on older people, but also on their relatives, health services and the community. The system was developed for exercise training sessions and fall risk assessment with discrete measuring technologies and adaptive assistance functions. One part of the project was conducted in a living lab

(Ogonowski et al. 2016) where the integration of ICT-based preventive 'exergames' into the daily routines of older adults was studied over a time period of six months in the home settings of 12 relatively healthy older adults aged 65 and more.

The three projects were primarily selected because they offer a wide spectrum of experiences in designing for and with elderly people in different contexts, allowing to examine different aspects of sustainability. The main aims and settings of the three projects are summarized in Table 1.

3. Steps towards a sustainable design result

A major insight from the three projects is that considerable effort was needed to, together with the elderly participants, build their capability to use the design result in the future. Working with elderly people that continue living at home provides a particular context and poses particular challenges for an IT design project. Re-reading the project material through the lens of sustainability has allowed identify and contribute to an understanding of in particular three issues that are pertinent to achieving sustainability. Hence, the three points we address in this section result from an analysis of the projects which has been inspired by the conceptual framework (summarized in Figures 1 and 2):

- 'Domestication' – giving a technology a place in life – as a key activity to support in view of sustainability;
- Building the capacity for continuing and evolving use (appropriation) as a condition for more complex levels of sustainability;
- The scalability and transferability of design outcomes to other groups of users or sites.

3.1. Giving technology a place in life

Domestication, a concept which has been developed with respect to people integrating modern technologies in their homes, is a significant aspect of the *monitoring* level of sustainability: it seems particularly apt at describing the steps needed for people without any previous experience – in our case elderly people – to become familiar with IT artifacts and ascribe 'value, purpose, role and identity' (Harwood 2011, p. 90) to them. It emphasizes how use changes people's relationship to the outside world, including family and friends, enabling them do things in a different way and engage in new types of activities. In the context of an IT design project, the domestication of digital devices is a precondition of their ability to actively participate in designing for new possibilities.

Researchers have to prepare the grounds for domestication to happen. A key instrument in the *City Quarter* and *Sehr-Mobil* project were regular training workshops for the elderly participants to support their skills in tablet and smartphone use. Later the assistance and learning sessions gradually also incorporated co-design

Table 1. Main project aims and settings.

	City Quarter	Sehr-Mobil	iStoppFalls
Funding agency	German Ministry of Family Affairs	German Federal Ministry of Education and Research	EU, FP7
Duration	2012–2015	2012–2015	2011–2014
Research setting; Living labs	Housing complex with 144 small apartments in a low-income area in a German city	Local area with poorly integrated transportation modes in and around a German city	Two field settings in two countries (Germany, Spain) (This paper only refers to the German setting)
Project partners and stakeholders	Housing company, counseling agency, SW company	City of Siegen, German Red Cross, SW company, senior citizen organization, gerontology experts	Research partners from Germany, Austria and Spain in the fields of IT, sports sciences; an institute for neuroscience research from Australia; a large company (NL) and an SME (G) from the field of IT development; a local seniors' association as application partner in Siegen
Project aims	Support elderly people by fostering social interaction/ access to new media practices	Support elderly people's mobility with assistance tools and smartphone appropriation	Development of an embedded AAL system to predict and prevent falls by monitoring mobility-related activities and other risk factors of falls in real-life.
ICT development	Outdoor display and platform and learning environment for mobile media & internet appropriation	Multimodal mobility platform to support mobility in older age	PC/Kinect-based fall preventive exercise game (Exergame) and iTV application: eHealth platform and the included Knowledge Based System for Fall Prediction & Prevention

activities. In both cases the participants were provided either with smartphones (*Sehr-Mobil* project) or with tablets (*City Quarter* project). In the *Sehr-Mobil* project the team also had to upgrade users' contracts with their personal mobile providers to guarantee mobile Internet. Like in the *iStoppFalls* project, the elderly users were equipped with Wi-Fi in their home; an ITV and set-up boxes were installed in their living rooms.

At the beginning of the *Sehr-Mobil* project much effort was spent on getting the elderly participants acquainted with mobile phones and build confidence as well as a 'habit' of using them. After some initial training sessions, the researchers created a 'wish box' for users to define things they

wanted to learn, triggering their interest with apps that might interest them. Examples were photo functions and synchronization options with their PCs or laptops, listening to radio and downloading podcasts, deleting and downloading new apps, information about security issues, and so on. Those apps and functions became anchor points that gradually fostered their interest in smartphone usage until it developed into a stable pattern of their daily lives, as they found out how useful it could be for navigating through places unknown to them, for using public transport and communicating.

In the *City Quarter* project researchers identified anchor points for bridging the current practices of the elderly participants with new media applications. Some of the users had brought pictures of their family or places they liked, such as their favorite (former) holiday destinations or their former hometowns. The researchers built on this material, starting the presentation of the tablets by introducing the photo and video features, i.e. how to take pictures and videos, how to save and find them on the device. With their confidence increasing the participants opened up to a diversity of uses, such as: trying to get a Wi-Fi connection when travelling so as to be in contact with family and friends per email; or performing Internet searches for baking recipes, Christmas decorations or products that may be cheaper on-line than in the local store.

The description of this domestication process that Haddon (2003) provides, reflects these experiences. Once a technology has been

> acquired, there are then the processes of developing the above noted understandings about 'appropriate' usage (e.g. about how much TV to watch, what to use a PC for) - understandings which can themselves be challenged. There are the processes of fitting the ICTs into routines or creating new ones. And there are the processes by which usage of technologies spreads both among household members (which may mean lending out a personal phone to others) and in terms of what the technology is used for (e.g. from emergency use of the mobile to its role in organising logistics) (p. 46).

While the observations from the projects are not new or surprising, it is noteworthy how much time and effort it took the researchers to arrive at a stage where the elderly participants felt confident with the technologies and found them sufficiently engaging to be interested in participating in design activities. An example from the *City Quarter* project is the concern of the elderly participants with security, which Hornung et al. (2017) describe as 'part of the territorial behavior of managing boundaries – securing boundaries by locking doors and deleting or destroying addresses and customer IDs on the envelopes before putting them into the wastepaper bin' (p. 7065). This confirms the experience Light et al. (2015) describe as support tools having to be 'in balance with capacity and confidence' (p. 302).

3.2. Building the capacity for evolving use

The fact that the technology domestication process was rather successful in all projects made considering further steps possible. In the following we highlight several sets of activities that are crucial for preparing the grounds for more complex levels of sustainability, that is going from domestication to a more substantial appropriation:

- Involving the elderly participants as co-designers;
- Providing continuing technical support;
- Making the step from individual to collective forms of use and community building;

3.2.1. *Involving the elderly participants as co-designers*

Some outstanding PD projects have demonstrated how to involve elderly people as co-designers as a step towards a sustainable solution (e.g. Aarhus and Ballegaard 2010; Grönvall and Kyng 2013; Joshi and Bratteteig 2016). Also, the *City Quarter,* and *Sehr-Mobil* projects had a strong participatory design component. Their approaches to involving the elderly participants in design were somewhat different. When introducing the idea of the 'neighborhood portal' to the participants in the *City Quarter* project the researchers became aware that some of the elderly tenants were reluctant to make parts of their lives visible to their neighbours. They also realized how sensitive the elderly tenants were to the ways physical and virtual habitats were interwoven and that this influenced their appropriation of the 'neighborhood portal' (Hornung et al. 2017). This is why the researchers started reflecting with them which kind of messages they would be willing to share with whom:

> In talking about this tension, the participants described subtle categories regarding the question of trust in another person from whom they would accept help or to whom they would offer help themselves. […] For example, one lady likes to sew and could imagine offering a sewing service. All in all, the tenants' categories centred around 'circles of trust', starting with well-known neighbors in their own buildings and gradually widening to encompass the neighboring buildings in which some people are known, some only from sight, and so forth (Müller et al. 2015a, p. 2301)

The resulting design is the outcome of a rather complex participatory process of defining categories for 'offering and asking for help' as well as 'organizing common activities'. Working on the design of the portal motivated the elderly participants to actively build a network of social relations: while to some parts of this network they would only send invitations and notifications of events, to others they would offer specific kinds of help (e.g. 'I can do some kinds of repair/sewing work') or ask for services (e.g. 'I am looking for a ride-share to the supermarket').

From the very beginning, the *Sehr-Mobil* project was organized around several design workshops together with the participants that strengthened their ability to report on their use experiences and to make suggestions regarding how to improve the process and also influence the design decisions. A strong mutual trust relationship was created in these workshops. Moreover, becoming familiar with the smartphones allowed users access to commercial mobility applications and to test them. This helped them imagine the opportunities opened up by these technologies (see also Güldenpfennig and Fitzpatrick 2013; Vines et al. 2013) and also to identify potential additional features that might be useful, such as a regional event scheduler or having more detailed information about alternative routes or a destination, so as to be able to make informed choices. By the end of the project, there were plenty of ideas of how to possibly enrich the mobility platform, based on the experiences and ideas of the elderly users who felt sufficiently competent to use the application in the future (Meurer et al. 2018).

The *iStoppFalls* project put less emphasis on learning as the use of iTV-based solutions is more intuitive, hence easier to learn in comparison to tablets or smartphones, as most elderly people already have their own TV. However, events, such as walking tours adapted to the abilities of the group were organized in which also the team members participated. Events such as these fostered the exchange of information about the participants' mobility and health behavior, their perceived problems and preferences and acted as source of idea for the design of the system.

What makes participatory engagement so particularly important when working with elderly people is that these are in a period of transition where they make gradual adjustments to changing life circumstances and capabilities and also have to prioritize: 'As energy dwindles and the time taken to achieve tasks grows, selectivity becomes more marked. More demanding and less valued tasks and pleasures are let go, as are the more onerous aspects of their coordination' (Light et al. 2015, p. 302). Involving elderly people as co-designers supports this slow process of seizing new opportunities and selecting what seems most enjoyable and/or useful, hence may become part of daily life. Moreover, it is particularly important for elderly people to improve their 'engagement with life' (Boudiny 2013). The co-design activities in the *City Quarter* and *Sehr-Mobil* projects enabled them to address concerns with how they live and experience technologies as opening up additional choices.

3.2.2. *The need for ongoing technical support*

An additional activity towards sustainability is to do with the need for providing ongoing technical support. Technologies need care and attention so that they function well and there are many occasions where elderly users need help in order to master new or unexpected challenges.

In the *City Quarter* project, various efforts were undertaken to weave continuing support structures after the project had ended. During the last trimester of the project, the researchers started brainstorming with the tenants about how to identify people that might be willing to provide support. Some of the participants contacted a near-by

church community as well as a volunteer agency; in both cases the outcome was negative. A temporary solution involved a student who lived in the city and was willing to help out for a couple of months. Although all participants were quite poor, they decided to collect a small amount (€ 5) per person in order to reimburse the student. At some point, the tenants succeeded in engaging the local volunteer agency that made a person available that is still offering assistance to the group.

Dependency on technical support was also an important question after the *Sehr-Mobil* project ended. Thinking about sustainable alternatives, the researchers connected the users with two places to ask for support (such as *ALTERAktiv Siegen-Wittgenstein e.V.*, a place where elderly people can acquire ICT-based skills from other elderly people or the *Neuland* project where school kids teach elderly people), with which relationships had already been built during project time. However, when the project stopped, none of the users made use of these alternative offers. Moreover, the *WhatsApp* communication channel was kept open, enabling participants to ask questions whenever they needed help. Researchers also made sure that the participants could keep their smartphones after the end of the project for as long as they wished (but they had to pay the Internet fees on their own). This solution was much more appreciated, as the relationships with the academic researchers had become part of their weekly routine. Ongoing technology support for elderly people may be difficult and also costly.

This aspect of how to establish more permanent support structures for the daily problems elderly people may have with IT-based artifacts has been largely neglected. This is confirmed by Hyysalo (2004) who studied the introduction of 'Wristcare', a seemingly simple device, into care situations, observing how most elderly users did not know

> how to determine if the device still worked. In practice, to keep a Wristcare device up and running reliably, somebody had to check regularly the condition of the Wrist-device and how it was actually worn, and to perform test-alarms to ensure that the messages went through from the device to the transmission unit and onward to the care givers. Such an alignment did not take place automatically (p. 28).

Intheir study of the 'Wireless Leiden' project Verhaegh et al. (2016) observed individual citizens taking care of the network, 'based on their local attachment to individual pieces of the infrastructure, mirroring maintenance and repair' (p. 207). Gregson et al. (2009) studied the diverse practices of object maintenance in the home, without special attention to technologies and elderly people; Oudshoorn (2008) describes patients' maintenance work that is necessary to make devices such as an ambulatory ECG (electrocardiogram) recorder work. This research confirms that one important condition for an ICT-based solution to be sustainable is that they are taken care of -maintained, repaired, updated, etc.

3.2.3. *From individual to collective use*

Much of the literature stresses the importance of capacity building in a community as a step toward sustainability (e.g. Scheirer 2005; Shediac-Rizkallah and Bone 1998). Interestingly, although only one of the projects – *City Quarter* – had explicitly approached a community of residents, the interest in sociability in use and/or need for becoming part of a community emerged also in the two other projects.

In the *City Quarter* project the researchers, with the elderly participants as co-designers, developed a rich set of self-learning and social learning tools which were implemented in the learning environment used for the bi-weekly workshops. The tools were intended to help the users to solve some of the problems they encountered with their tablets and smartphones, such as update alerts, problems with sending emails or with the Internet connection, independently (Müller et al. 2015b). This strengthened the participants' autonomy in using their mobile devices beyond the end of the project when the researchers would no longer be available.

In the *Sehr-Mobil* project being part of a user community became a key aspect of the project. User-participants stressed how much they enjoyed meeting and they are still continuing to communicate with each other through *WhatsApp*. In spite of some small personal conflicts, personal friendships evolved over time. For example, some of the elderly people started meeting outside the project and fostered ridesharing co-operations. Others met from time to time in a café to discuss technical issues related to their smartphones. All users were interested in continuing these meetings, such as the 'user-cafés', in the context of the follow-up project *Innolab*.

Maintaining social participation of older adults was not directly in the focus of the *iStoppFalls* project. However, during the six-month living lab situation in which the participants tried out the 'exergames' it turned out that their primary motivation to use the system was not so much to be physically more active – they felt attracted by its socializing potential. Users enjoyed social activities, such as playing the 'exergames' with their grandchildren, meeting with researchers on a regular basis or exchanging experiences with other participants during workshops or social events. Based on these insights, the researchers developed the idea that older adults, who are interested in social and physical activities, could build or join a community for physical activities such as hiking, biking or running, in a social media platform. *iStoppFalls* would be part of these communities in providing a IT-based system for doing exercise homework to prepare for community activities. When most participants stopped using *iStoppFalls* after the study ended, this was mainly due to the fact that they no longer had the benefit of being visited by the young researchers or exchanging experiences with others.

All projects show that sociality and becoming part of a community can act as a strong motivator to continue practices that have been built up in a project and eventually develop them further. Getting involved and making choices, sharing technologies and practices with others, and getting practical support do not 'automatically' lead to more active forms of appropriation. However, as Light and Akama (2012) demonstrate, active use and the potential for new forms of use are best

achieved in projects 'where transformation locates agency in embedding and entangling people's lived paths and experiences with others' (p. 158).

3.3. The scalability and transferability of design results

A more challenging level of sustainability concerns bringing the insights from an IT design project from a small group 'to bear on a wider group of people' (Iversen and Dindler 2014). The basic question is: would the positive experiences of a rather limited number of active project participants be sufficient for building a bridge into the future? A strategy that takes a step further is transferring a design result into other contexts, eventually adapting and modifying them.

3.3.1. *Reaching a wider group of users*

One challenging issue in the *City Quarter* project was how to deal with those tenants in the housing complex that did not want to participate in the project. Many of the housing company's tenants did not accept any of the numerous invitations to join the project. Hence, the researchers did not have the chance to develop a relationship with them and to make them aware of the possible benefits of the 'neighborhood portal' for their own lives. The fact that these tenants were confronted with the set-up of the outdoor displays that were installed in front of their apartments was the only feasible way to involve them. However, they only saw the initial hardware and software problems about which they complained to the housing company. In this way, the non-participating tenants became a potential threat to the long-term sustainability of the design outcomes.

Another problem was that some of the developed functionalities require a critical mass of users to become interesting. This is one of the reasons why the participants did not immediately take up all of the co-developed portal features. While the 'offer and request help' feature seemed to address their actual needs motivating them to make immediate use of them, they were much more hesitant to take up the 'organizing common activities' feature since it becomes more attractive when more tenants join the portal. The experience in this project was that community-building measures should have been planned for the design outcomes to extend to larger parts of the city quarter and also embrace more and more of the designed functionalities.

Also the *Sehr-Mobil* project had problems to reach a wider user group. In the last year the mobility platform was officially launched for public use and the researchers organized several events to promote the platform in the region. At the end of the project the platform had at most about 200 active users. Currently, the city operates the platform, but since neither the city nor the university are commercial operators, further promotion and development of the platform is not affordable.

3.3.2. *Ensuring the transferability of design outcomes*

Braa et al. (2004) make an important point about going beyond a successful intervention, distributing it to other sites. Their case is the HISP project – a large

initiative to introduce health information systems in developing countries. They propose a shift from local interventions to interventions involving multiple sites, arguing:

> This shift has emerged more out of necessity than by design, through the recognition of the relative failure to institutionalize and make changes sustainable. This, the argument goes, is because local interventions need to be part of a larger network to be robust. In short, scalability[1] is a prerequisite 'not a luxury' for sustainability of local action. Establishing networks creates opportunities for sharing of experience, knowledge, technology, and value between the various nodes of the experience (p. 341).

Transferability may be a strategy to strengthen the theoretical and empirical basis of particular design results and/or insights. Reflecting on the transferability of their experiences with rural communities in Namibia Winschiers-Theophilus et al. (2013) argue:

> operating within a single context for a longer term, resulting in the mutual learning that is a necessary and desirable consequence, can obscure the transferability and recoverability of the results. Thus 'moving away' becomes a necessity to explore cross-contextual validity for theory building and explicit lessons learned (p. 372).

Although it may be critical for a project to anchor design results not just in one organization or community but to replicate or evolve them (Iversen and Dindler 2014) to serve other settings, this step may be beyond the scope of a single project since it would imply to connect to other organizations or communities with their own local conditions: the dimension and set-up of the project have to be designed accordingly. More feasible is the transferability of results across projects that might involve the same participants or have a different set of target users. In the first case, transferability is more the continuity of an experience from a possibly different and broader perspective; in the second case, transferability involves the research team only. It is also open what is to be transferred: a designed IT artifact with particular functionalities, an approach to solving particular issues (such as community-building, health, mobility), or a component of a technological infrastructure.

The *Sehr-Mobil* project took the first path to develop the project outcomes. When the researchers presented the follow-up project *Innolab* which aims at enriching the mobility platform by an eco-feedback component (Meurer et al. 2016) to the elderly participants in *Sehr-Mobil*, many of them were eager to continue. They strongly identified with their role as co-researchers and enjoyed their visibility in the local

[1] In the terminology adopted in this paper the right term here would be *transferability*: this shows how the discourse about sustainability is far from a consolidated systematization.

community as 'smartphone experts', a visibility that the researchers supported by organizing 'user-cafés' in public locations, inviting the other project partners and public relation-partners, like the developer company and the city partner, as well as the regional radio or newspaper. This was done to strengthen the participants in their identity as co-developers. Beyond that it was possible to leverage the long-lasting relationship established with some of the partners involved in the *Sehr-Mobil* project: the city and the ICT partner both agreed to be part of *Innolab*.

In the same vein, the learning space developed in the *City Quarter* project to support the workshops through an environment for acquiring media literacy and training for co-design activities (Müller et al. 2015b), has been transferred to a follow-up project *Cognitive Village*. It turned out that the quarter manager of the housing company in this follow-up project came to appreciate this approach to learning and co-design. She is now participating in the workshops in order to learn how it works and to be able to transfer the same idea to a sustainable program for a local neighborhood.

The *iStoppFalls* project took another path. Here the researchers' strategy was to focus on the transferability of the prototypal technological solution as the initial reference architecture in several follow-up projects (*my-AHA*, *Cognitive Village*, and *MobiAssist* (www.inclusive-ageing.de)). Hence, the technical infrastructure of the front- and back-end of the training system was transferred and adapted to the follow-up projects. The first set of 'exergames' was also used as a demonstrator in several public presentations: this helped communicate the outcomes of the first project and ideas for the follow-up projects to different stakeholder groups. This made it possible to further develop the *iStoppFalls* system in different settings involving end-users with a wider range of individual characteristics and (care) needs. One might say that while the project was not able to ensure the sustainability of use in the homes that had been included in the evaluation study, it took steps towards a solution that may be used in a variety of contexts involving elderly people in the future.

This project also illustrates that the transferability of the technology may be more problematic when the solution uses leading edge tools or platforms that are less robust and consolidated, and depends on how the adaptability requirement has been fulfilled. For example, testing the *iStoppFalls* prototype in people's home required an Internet connection. As not all involved households had such a connection, other technical solutions were found, such as the installation of amplifiers or repeaters, the use of other W-LAN connections (e.g. of a neighbor) or the establishment of a mobile data connection via UMTS-device. Moreover, the interplay of several technical components meant higher vulnerability to incompatibilities and, consequently, a higher burden for troubleshooting. These installations require a more advanced technical understanding and additional financial effort, making reuse and long-term sustainability more difficult to achieve.

These project examples demonstrate different understandings of the argument that 'local interventions need to be part of a larger network to be robust' (Braa et al. 2004). Our observations suggest: a larger network of users (e.g. tenants) may be

needed for particular design outcomes to become attractive and useful; a follow-up project may be needed to better realize the potential of a mobility platform for elderly users thereby extending it to other types of uses; the technical solution that has been developed in one project may need to be applied, further developed and tested in other contexts to become robust and flexible.

4. Dissipating forces

While the project teams, together with their active participants, were able to create some grounds for sustainability, they also encountered a variety of dissipating forces. While some of these were to do with the heterogeneity of the main actors and their potentially diverging interests, others resulted from the typical ways IT design projects are set up and the constraints this posed to the development of sustainable results. In this section, we identify a set of main issues that better take into account the nature of the IT- based projects considered in this paper and as such complement the concerns raised in the literature.

4.1. Heterogeneous actors – conflicting interests

The partners that are involved in project consortia all have their own roles and objectives that do not necessarily make them eager to collaborate and open to adapting their participation to the emerging needs of the projects. For example, an industrial partner may prioritize commercial interests; and a partner hosting the user community may focus on a publicly visible design outcome considering it more valuable than, for example, the learning process of individual participants. The individual participants, on the other hand, have for the most part their personal interests and longings in mind and not those of the community as a whole. The literature introduced the term *alignment work* to describe the work needed to align the perspectives and skills of a heterogeneous network of actors so that they are able to coordinate their efforts. These actors may be organisational units, external stakeholders, or collaborating specialists. In a research project the alignment work that is needed so that all stakeholders contribute to a sustainable outcome may absorb 'hidden energies' that are often not recognized as such and also difficult to measure.

In the *City Quarter* project the researchers were confronted with different sets of expectations and needs that made aligning the perspectives of all the involved parties difficult. With teaching the elderly participants taking up much time, an unexpected intergenerational conflict surfaced: between the younger, more experienced tenants who were faster and quickly started discussing technological options with the researchers, also putting up pressure; and the elderly tenants whose needs for intensive training assumed priority. While the younger participants got bored and subsequently dropped out of the training workshops, they were allowed to keep the tablets and smart phones provided by the project, in the hope to be able to involve them in intergenerational collaboration and exchange via the portal at a later stage.

But handling the different expectations and needs of people with different ICT skills and interests turned out to be one of the main challenges in the project that absorbed energy from other goals.

Another topic where the different perspectives of old and young participants came to the fore was the individual's visibility in the system. Some of the younger participants, who were committed to developing an atmosphere of mutual help in the neighborhood (e.g. they had set-up an emergency telephone number for the neighbors that they operated autonomously), asked for a feature to rate the helper after the activity (the 'offer and request help' functionality). The elderly tenants, however, strictly rejected this feature. They voiced a fear of being rated negatively if the recipient of an activity wasn't satisfied ('What if someone doesn't like my sewing? I'm not a professional, and some people might complain'). Moreover, there was a general feeling of unease about being put into spotlight, even when receiving positive evaluations of a service.

Another line of conflict opened up between the research team and the housing company. While for the researchers providing the elderly tenants with tablets and smartphones and teaching them how to use these was their main point of attention for the first part of the project, the housing company's vision of the project was focused on the outdoor monitors. The impatience of the younger tenants and the housing company's 'political' need to have an early visible outcome together with their unawareness of the need to engage in intensive preparatory work with the elderly led to modify the project plans and divide the prototype implementation into a two-step procedure that splits the portal into a simple and an advanced part. The first part consisted only of a static website with dedicated subpages for the bulletin board of the housing company, information about the community room and the provision of information about the whole project. The second part contains the more user-oriented functionalities.

Some problems arise from the different perspectives of researchers and other project partners. IT companies that provide software or hardware for a project may be not interested in keeping the construction and evolution of the technology linked to the project's methodological approach and may develop their own strategy. The *iStoppFalls* project offers a clarifying example. In the living lab situation, the researchers became aware of the need of functionalities in support of a more social use of the technology. As users were not so motivated to do the proposed exercises alone in their home, the idea of a combination of in-home and group class training in a gym came up. In the words of one of the participants: 'I think, it is helpful if you are a member of a training class. This is more pleasant than if you only do all the exercises every time on your own' (Ogonowski et al. 2016). Unfortunately, the system did not support multiplayer activities that would allow the elderly people to make their exercises in groups with others. The project partners in charge of technology development refused to modify the technology accordingly, since that was not part of their planned activities, and they did not appreciate this emerging requirement. Fortunately, it was possible to transfer the idea of linking home-based

training with a group class to the follow-up project *Cognitive Village*. Here, researchers contacted representatives of a local sports association at the beginning of the project in order to co-develop a more holistic concept for fall prevention, which worked out very well.

In *Sehr-Mobil* the question who would operate the mobility platform after the end of the project made the diversity of interests and perspectives visible. While the university partner lacked funding to operate the platform, the technical partner was interested in the developed code but not in the product itself. The participating dissemination partner that is running health and senior-orientated services thought of hosting the platform, developing it further in the context of a use case; but it did not find the financial and personnel means required for doing so. In the end, the mobility platform was hosted by the city partner without any financial capacities.

4.2. Project-related constraints

An IT design project usually needs funding and it often starts with looking through project calls, contacting partners to work with and writing a project proposal. As mentioned, in the European context, projects usually involve consortia comprising academic, industry and end-user partners. Project topics are dependent on the current calls of the funding agencies. The first step in getting funding is to assemble a project team according to the criteria put forward by the funding agency. This process is inherently political, since it involves negotiating not only the research topic, but also the distribution of financial means and tasks, the research approach as well as duties and responsibilities of each of the prospective project partners and the related timeline (Randall 2018). Vines et al. (2013) have described this for PD projects: 'If we continue tracing back initiation however, those who write research proposals (such as faculty members) or stakeholders and funding organizations that write the call for proposals and policy documents to which they respond heavily influence this process' (p. 433). The following sections describe some of the constraints that their framing as 'funded research answering to specific project calls' created for the three projects.

4.2.1. *Time issues*

In general, the project timeline that has been defined in the proposal constitutes a strict and rigid component of the contract established with the project funder and of the mutual commitments linking the project partners. It defines the pace of the project activities and influences how they are performed.

Some problems in the *Sehr-Mobil* project were created by the timing of activities. An insight of the long pre-study with which the project had started was that the elderly participants had rated privacy as a point. Hence, the first version of the technology was realized with strict privacy measures with the result that it was almost impossible to get a ridesharing match. When the participants were finally given the opportunity to gain practical experiences with an already existing mobility

application, the researchers had to revise their thinking, noticing a gap between 'saying' and 'doing' or 'talk' and 'action'. The idea came up to link rides to publicly available events that could be shared within others. However, the project frame did not provide the flexibility to implement this design idea; and the developer company was not willing to do the work on the basis of the assigned amount of resources. Another issue was that the researchers decided rather early in the project not to develop a native mobile solution because they thought that users would prefer smart TV or the web-solution for the PC. Collaboration with the elderly participants made them understand that the mobile device was the preferred option (even in the context of the home). Hence, in this project the time to take up new insights and design ideas proved to be too short.

As a general consideration, establishing a rigid timeline at the beginning of the project may create troubles and conflicts since it is not possible to anticipate all the characteristics of the target setting: the appropriate balance between the ongoing learning (that is especially crucial at the project start) and the need to make the users as soon as possible acquainted with some (prototypical) technology would require much more flexibility which may be hard to bring into accord with the rules of the funding agency.

Another time issue regards the limited duration of projects that in general does not allow the construction of a socio-technical solution that is robust enough to be installed and stay operative in the long run: often the solution remains at the prototype level. This was evident in the case of the *iStoppFalls* project where the complexity of integrating heterogeneous components undermined the robustness of the final solution. This challenged the user experience of its adoption.

Karasti et al. (2010) draw attention to an additional problem, pointing at a fundamental conflict between the ambition to have a product 'finalized in time' – an ambition that corresponds with the logic of many funded IT projects – and the need for a more open-ended temporal orientation that allows for sustainable development. In their study of an example of infrastructure development they observed the information managers assume such an open-ended time perspective:

> In the work of information managers the long term does not appear as an isolatable issue, rather it is a specific concern that is continuously attended to and accounted for as a part and parcel of their ongoing, everyday work (Karasti et al. 2010, p. 399).

Sustainable development requires a view onto 'continuing design' already during project time.

4.2.2. *The issue of 'innovation'*

Many funding agencies push for innovative project outcomes. This has an impact on the overall goals of a project and influences the preparation of a proposal, since 'innovativeness' is considered a key parameter in the evaluation of a project's

eligibility for being funded. Moreover, innovativeness is of prime interest to the academic and industrial members of a project team, as it also defines the scientific potential and commercial value of the project outcomes and the possibility to be published in academic venues or create a new market, respectively. Going back to the distinction between design driven and user-driven innovation (Verganti 2008), the point we want to make here is that innovation, however interpreted, has an impact on the degree of sustainability that the project is able to achieve. In fact, users, and especially elderly users, may be reluctant to accept novelties that change their habits and require a learning effort that they do not immediately perceive as rewarding. Or, a technologically innovative solution may not be the appropriate answer to the problem that designers and users identified in a project. A well-known example is the *Florence* project where the researchers made this experience:

> in the scientific community, technical challenges mean making computer systems that may be characterized as 'epaulets': they have technical, fancy features, but are not particularly useful. Making small, simple, but useful computer systems, more like 'utensils', does not give as much credit even if the development process may be just as challenging (Bjerknes and Bratteteig 1988, p. 258).

The three projects show different kinds of innovativeness. The *City Quarter* and *Sehr-Mobil* projects proposed simple and consolidated technologies and devices. They looked for user-driven innovation mainly in terms of the appropriation of the technology by a novel class of users for the sake of improving the quality of their life. In this vein, the two projects focused more on the practicalities of participatory design work with elderly people than on a more innovative technology. Their main achievement consisted in equipping the elderly users for the long-term appropriation of digital devices by fostering a combination of media literacy and co-design skills. Their focus was on the sustainability of practices with a view onto their evolvement in the future.

The *iStoppFalls* project aimed at innovative functionalities to monitor the users' physical moves and promote body exercises. These functionalities are based on a complex constellation of devices and of sophisticated software components and algorithms. The design-driven innovation is prevailing over the user-driven one that is nevertheless present and expressed in terms of system usability and the aim of helping users to improve their health and avoid the risks of falling.

When projects involve IT-based solutions, design-driven innovation seems to be more valued by the EU funding schemes. In so doing, they make the projects more difficult to manage and less sensitive to the issue of sustainability, as we discussed earlier. But even when user-driven innovation finds its space in how the project is conducted, the funding scheme may influence the negotiated assignment of the resources among the partners and some activities may lack the necessary funds because their relevance is not perceived or cannot be fully anticipated and changing the resources assignment cannot be easily implemented during the project. The effort

needed to help the elderly participants master digital devices in the *City Quarter* and *Sehr-Mobil* projects is a good example.

4.2.3. *Post project issues*

The sustainability of an IT-based solution heavily depends on how it can be implemented and maintained after the project funding stops. This issue concerns both the social and technical aspects of keeping a design outcome alive in 'real use'. On the one hand and irrespective of the success of creating a community dimension during the project, the community itself and/or the organization that supports it have to be helped to maintain the same initial impetus after the project team has left; in Bødker's (1994) words – 'the less they "miss" the researchers, the better' p. 17). The learning process that the *City Quarter* and *Sehr-Mobile* projects put in place is a necessary but not sufficient condition to keep the service and the related activities alive. The community and/or the organization have to be prepared to invest in the social and/or organizational infrastructure that is necessary for them to continue. The time pace of the projects hardly leaves time to plan for that and the funding schemes are in general more oriented to the transferability of the project outcomes to other contexts (usually named 'exploitation') than to make them sustainable for the community and organizations that were involved in the projects.

From the technical point of view, a similar argument can be made for the maintenance of the technology in the long run. An example is the *City Quarter* project in which the researchers managed to offer a temporary solution by engaging volunteers. But this cannot be an adequate solution to guarantee an acceptable level of service in the long run. Other apparently trifling factors can hinder the technical sustainability. In the same project, some institutional rules prohibited the researchers to have the users keep the devices that had been configured and used during the project after it ended. This is problematic from the psychological standpoint, as the elderly participants were accustomed to them and new devices would require an additional learning effort; and from the economic standpoint as most of them could not afford to buy a new device.

This problem becomes even more challenging when the technical solution is innovative and builds on components which are being developed and maintained by several project partners; hence, more complex and risky to be maintained. This was the case in the *iStoppFalls* project. The post-project service and maintenance level would reflect the commitments of the partners in the development of the various components; this would require a high coordination among the partners and their commitment for the future. Not all project partners were able to participate because the needed workload would have been too high in terms of personnel and logistics issues and because of coordination costs and the lack of resources. For example, the access to a central server system of a partner could only be guaranteed within the runtime of the project. Furthermore, the support of uprising hardware and software problems could no longer be provided by technical partners nor be solved by the other partners because of their complexity. Finally, innovative technologies

incorporate functionalities that are evolving too: sometimes different stakeholders have to be involved because they are the only providers of the needed functionality or infrastructural component. This is another example of how difficult is to reconcile innovativeness and sustainability, and of how limited is the sensitivity of the funding agencies to help in this endeavor.

5. The complex way to sustainability

Our approach to discussing issues of sustainability in this paper is informed by the literature and the experiences made in three IT design projects with elderly people. While much of the literature focuses on post-project issues, when an IT-based solution or a program is made use of by individuals, an organization or a community, the empirical material we presented describes how to prepare for sustainability as part of a project. Since our goal is to better understand the conditions that can make this happen we reflect on the multi-dimensional space (sketched in Figure 1) where sustainable IT-based solutions are developed within research-design projects. Each dimension (technology design, appropriation, and the various contextual conditions for achieving a sustainable outcome) can take different 'values' that cannot be fully known, defined or definable at the beginning of the project and that might vary during it: in particular in projects with a strong participatory component that are by necessity open, as the problem definition has to be developed in collaboration with users and other stakeholders. However, having all stakeholders have a clear perception of the current 'values' of these dimensions (and possibly others) is an important condition for them to be able to define a workable 'contract' and adjust its definition when faced with changing or new conditions.

An important aspect of this is to be aware of how a change in one dimension will influence the other ones. Bratteteig and Wagner (2014, 2016), in their analysis of design decisions, have made a similar point. They stress the importance of 'identifying choices as they evolve' and the need to understand the interdependencies that are created by particular design choices. Our focus in this paper is on the project decisions that affect the sustainability of a project outcome in the future and the transparency of their implications.

5.1. Design for sustainable IT solutions

Our analysis in this paper is based on concepts and findings from several research traditions that have sustainable solutions as a more or less explicit goal by focusing on complementary aspects. CSCW research has strong links with Participatory Design (PD), which focuses on the relationship between designers and prospective users of an IT-based solution, on the methods and tools that can make this relationship more fruitful in the aim to build a solution that fits the real needs of these users. The PD literature describes the role of field studies, of

'mutual learning', of scenario-building and cooperative prototyping in this process (Simonsen and Robertson 2012).

Other approaches stress more the fact that design continues after a solution is constructed in a given context (often within a research project) and has to live in the future in a changing context. For example, the Design Case Studies (DCS) framework described in Wulf et al. (2015) rests on three interwoven sets of project activities: a pre-study, a participatory development phase of a technical prototype, and a long-term evaluation of this prototype in the real-life settings of the participating target users. Then, design has to take into account 'the installed base' (Aanestad et al. 2017) and at the same time provide a technology that is 'evolvable', that means malleable and open to technological evolution to be extended and further developed in use (Pipek et al. 2008) with an active participation of the end-users (Cabitza and Simone 2017); and possibly starting with a limited set of functionalities and practices around them (Aanestad and Hanseth 2003). This 'infrastructuring' process (Pipek and Wulf 2009) combines technology design with those activities that ensure that an IT-based artifact is actually used within an organization or community.

In a recent paper, Lee and Schmidt (2018) have pointed at the ambiguities around the term infrastructure and its many different meanings in the research literature. In their critical assessment, they point at the need for infrastructure studies to undertake 'a great deal more articulation about the specific artifacts that are embedded and, furthermore, of the actual practices that are undertaken in order to embed these and keep them embedded' (p. 210). One of our points is that in order to strengthen the sustainability aspect of a project outcomes both, equally relevant, perspectives need to be combined in a more comprehensive view to understand how they influence each other: how to design with a view onto users' needs and 'real use' *and* how to 'infrastructure' in the sense of embedding the design result in the practices of the members of an organization or community and keeping it embedded. Research on information infrastructures has stressed the need to move beyond the focus on local uses of technology to include attention to its technological, organizational and political context, from a longer time perspective. For example, Monteiro et al. (2013) argue that an information infrastructure perspective 'would contribute by supplementing a local view with what might be thought of as an "extended design" perspective to capture how workplace technologies can be shaped across multiple contexts and over extended periods of time' (p. 576).

5.2. Contextual conditions

Since our focus is on sustainability in the framework of research projects, we concentrate on aspects that are strongly related to this situation and complement the considerations that can be found in the literature.

5.2.1. *The framing of the project*

We have stressed that the conditions defined by national and EU funding agencies are not necessarily conducive to achieving sustainability. Aiming at EU (and other) funding may require significant technical ambition. While this is obviously not problematic as such, it may exclude from the beginning the aim of a long-term appropriation and transfer of the technologies to be developed – in the households of the participating representatives of the target user group as well as beyond (e.g. in a city quarter). At least in Germany, the ministries' funding calls are diversified: sometimes inclusion of end-users and living lab approaches are requested, but many calls aim for only as much as is needed to generate an innovative product. However, they all use the same funding schemes and, in general, do not recognize the often-invisible work of relationship and trust building that designing in collaboration with the participants requires; and which is also of limited academic value.

The same holds for the necessity to collaborate with a multiplicity of stakeholders and partners: interdisciplinary and academia-industry based consortia often are a prerequisite for funding. The 'alignment' work needed to create a common frame of reference and make the collaboration work is not accounted for in project plans. In the case of conflicting interests and variegated contributions this may create problems; for example, when industrial partners are mainly interested in testing and further developing their own products, forcing the design choices in this direction. At the same time, an industrial partner may offer resources academic researchers would not be able to mobilize. Researchers on the other hand often have educational commitments, e.g. when working with PhD students, and they need to construct a solid academic record. Both goals can be in conflict with the industrial perspective.

Finally, projects with elderly users, such as the ones we discussed in this paper, usually benefit from having to involve community or user organizations, such as local authorities, care homes, or help organizations, since these are the ones that can offer the know-how and resources to make a design outcome sustainable in the future. But these types of organization often do not have experience with the rules and goals of academia or industry (see also Altman 1995).

A difficult situation is also created by project timelines and budget rules, as the three projects have demonstrated. In general, the project duration envisioned by funders is too short for an IT design effort to fully come to fruition and reach the stage of 'real use'. Budget rules often do not cover activities that seem too 'mundane' to be seriously considered but turn out to be critical to the sustainability of a project. The flexibility that is necessary to be able to (re-) assign resources and responsibilities and/or define new and unexpected tasks is often not compatible with funding models.

5.2.2. *The level of sustainability a project seeks to achieve*

The ability to achieve a sustainable project outcome is deeply influenced by the target user group since it shapes the basic conditions from which the sustainability discourse can start and the level of autonomy this group can reach at the end of the project. Many research groups have reflected on how to design with and for elderly

people as the target user group (e.g. Joshi and Bratteteig 2016; Leong and Robertson 2016). From the point of view of sustainability, we add several insights to this research. Much has been written about the fact that elderly people with little previous experience with IT-based artifacts need to be motivated and given time to learn how to use digital devices and to 'domesticate' them. What may be less obvious is how much time and effort this may take. Hence, to set apart resources for an extensive period of learning and convince all involved stakeholders and project partners of the necessity of such an 'investment' are among the key conditions for sustainability. In this respect, the type of 'innovation' that is foregrounded in a project is crucial. While for 'user-driven innovation' having sufficient resources for 'mutual learning' is critical, the challenge of 'design-driven innovation' is to match technical ambition with finding a role for the proposed technology in users' life. This may make planning for sustainability more difficult since it expects users, as well as the hosting institutions, to imagine the role of the proposed technology in their lives, although they have not been part of co-developing the project vision.

While domestication seems to be a condition 'sine-qua-non' for elderly users to be able to contribute to the design solution as co-designers, the ability to identify and contribute to the construction of new or additional functionalities (the 'evolving' level) is much harder to develop within the context of one project. Ballegaard et al. (2006) define 'evolvability' as a basic requirement for technologies for elderly people, arguing that in particular very old persons need much time to get used to technologies and only being deeply familiar with them will make them apt to accept new functionalities and think of new ways of doing things. The experience from our projects points at the importance of moving beyond the individual use of a technology to collective forms of use.

Sharing technologies and practices with others may lead to more active forms of appropriation. However, for this to happen support by an organization or community with resources and training may be needed. Scaling may be necessary in order to reach a critical mass of users and make particular design outcomes viable and sufficiently interesting for them. From the researcher-designers perspective, testing the transferability of an IT-based solution to other sites provides the possibility to enrich the solution and help make it responsive to different contexts. In the *Sehr-Mobil* and *iStoppFalls* projects the researchers chose this strategy. Betz and Wulf (2018) stress that 'transferability can be supported by a thorough documentation of the circumstances under which the results were generated' (p. 463).

These levels of sustainability are more likely the outcome of a series of projects that allow the stakeholders to consolidate and accumulate previous positive and negative experiences. In some cases, the full potential of a socio-technical solution may only become clear at the end of a project. For example, the conclusion that Müller and Wan (2018) draw from the evaluation of a GPS-based tracking system in dementia care is that the main design outcome of this project was not the technical solution itself but the insights gained in the process of collaborating with the carers of people with dementia.

5.3. Design for sustainability as a collective learning process

Constructing sustainable IT-based solutions in IT design projects is more a goal than a consolidated practice in design. Indeed, sustainability is not yet a key concept that would systematically inform how projects are funded, planned and conducted. Individual stakeholders might have an interest in designing for sustainability and/or receive a sustainable product at the end of a project but that does not guarantee that all project partners contribute to this goal. A way to overcome this situation is to see design for sustainability as a collective learning process that creates awareness about the value of sustainable projects outcomes.

The relevance of learning for the users of the socio-technical solution envisaged or constructed during the project has been already stressed and articulated in the previous sections and is widely referred to in the literature, which points to the need for expansive or developmental learning (Ellström 2001; Engeström 2001). When working with elderly people a critical point, which also has an ethical dimension, is how to prepare them for living with the design result after the project has ended and with this the continuous attention and support they received during project time. A community of users that has been created as part of a project may be helpful in this respect, but it would need a 'host', a supporting organization, to continue. But also the institutions hosting or supporting the elderly people have to learn how to define a strategy about how to manage and sustain the new situation if they want to steadily achieve the goals that motivated their participation in a project. Part of the design should be devoted to make them aware of what is required and, if needed, support them in defining the most productive and feasible strategy. An often-neglected issue is the need for technology support beyond the end of a project. Apart from the malleability, robustness and consolidated standards of the technology the solution is based on, this support may be difficult to achieve in the case of elderly people who continue to live at home and in the absence of an hosting organization or community that would guarantee and provide resources for maintenance, repair and further training as its responsibility. Third party organizations, if and when available, are not always aware of the specific kind of users they are called to support.

Since there is little experience with designing for sustainability in IT design projects, there is a need for researchers and, in general, the stakeholders that contribute to the IT-based solution to reflect on how the solution was conceived and constructed, the relevant choices made, the achievements and the failures. While reflection seems a 'natural' part of academic research, it does not necessarily focus on the details of how a design result is constructed in collaboration with the other stakeholders. Randall (2018) state: 'The need for this is reflected in the fact that a community dedicated towards analyzing and supporting practices has, to date, provided very few empirical accounts of their own research practices' (p. 500).

The CSCW research community is discussing various strategies to build a knowledge base from field studies and IT design projects on top of which to construct and compare new experiences and to do more comparative case study work.

Understanding how a design result is achieved and can be sustained would require specific attention. A knowledge base of methods and techniques in support of creating sustainable IT-based solution could be the basis for defining research endeavors that take sustainability as one of its main goals and create the conditions to make it happen. Moreover, a collection of concrete, well documented experiences can make the alignment work mentioned above easier. In a similar vein, Stevens et al. (2018) suggest the construction of 'e-portfolios' - 'digitalized collections of design case studies' that support a long-lasting memory of the design experiences, in terms of both raw data (recordings, transcriptions, field notes) and the emerging technical designs. Dalsgaard and Halskov (2012) present and discuss a tool designed to support design documentation, emphasizing not only its usefulness for 'shared reflection and discussion in on-going projects' but also for 'scaffolding longitudinal and cross-projects studies' (p. 428). We would add that such collections should pay specific attention to documenting design practices that aim at the sustainability of the design outcomes. We perceive this as a valuable and necessary support tool for the collective learning process that occurs during and beyond any single project.

6. Conclusions

We have applied the lens of sustainability onto three publicly funded projects of each three-year duration that aimed at developing socio-technical innovations for and with elderly people living in their homes. In contrast to the majority of research work which discusses sustainability mainly in regard to ecological issues, we have examined the sustainability of IT-based solutions in the lives of elderly people, having a critical look at the conditions that make this possible.

We have opened this perspective on the sustainability aspects of IT design projects in respect to the technologies that have been developed and to a number of social issues at the interface between the stakeholders that participate in project consortia: academic researchers, the particular user group, user and/or community organizations, as well as industrial partners. One of our arguments is that the sustainability of solutions cannot be discussed without carefully examining the interfaces of all parties that, from potentially divergent perspectives, have an impact on an IT design project, beginning with proposal writing in response to project calls, up to conducting the research work in a multi-stakeholder consortium.

One of the main tensions is that between having to develop innovations which are future-directed, while at the same time striving for a close collaboration with users or 'end-user integration' to use the wording from funding calls that often do not acknowledge the work that needs to be invested to make participatory design and interdisciplinary collaborative work possible.

Taking sustainability seriously requires reshaping the methods and tools supporting the design of a robust, maintainable and evolvable solution so that its domestication and appropriation by the users can be consolidated after it is released at the end of the project. To this aim the solution has to include the provision of

support to users, in terms of motivations, education, technical assistance, and monitoring of new demands together with the related resources: this is a particularly critical issue in case of elderly people.

Our findings have two important implications: On the one hand, they confirm the need to carefully document the design experiences that are pertinent to achieving sustainability and to, from that, construct a solid body of knowledge to be shared by all the involved stakeholders within and across projects. This opens a novel line of research: to define how cases are documented in an appropriated way; how they can be soundly and fruitfully compared; and how a solution might be adapted to another context, so that failures and successes might improve the quality of new design efforts. In other words, the goal is not a mere repository but a 'common information space' that can be accessed and traversed in many possible ways, according to different (research) questions.

On the other hand, the funding schemes supporting the research-design initiatives should create the conditions to achieve sustainable results, if not to have sustainability as a primary objective and assessment criterion. Already 20 years ago Altman (1995) proposed several measures concerning funding and evaluation of community projects, among them:

> […] (b) including sustainability as one criterion in the evaluation of research grant proposals and requiring that researchers have a detailed plan for enhancing sustainability, (c) earmarking funds for research on methods to enhance sustainability and to study the effects of sustainability, and (d) including community workers in the review process for research grants to help evaluate the sustainability plan (or the potential sustainability of proposed interventions) (p. 533).

These (and other) measures would inspire a new perspective on how to plan projects and how to orient the related consortia to sustainability.

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