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Travelling Artefacts: Lessons Learned from Interventions in a Regional Innovation Ecosystem

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Abstract. Regions and their innovation ecosystems have increasingly become of interest to CSCW research as the context in which work, research and design takes place. Our study adds to this growing discourse, by providing preliminary data and reflections from an ongoing attempt to intervene and support a regional innovation ecosystem. We report on the benefits and shortcomings of a practice-oriented approach in such regional projects and highlight the importance of relations and the notion of spillover. Lastly, we discuss methodological and pragmatic hurdles that CSCW research needs to overcome in order to support regional innovation ecosystems successfully.

Introduction

In the last decade interest in the role of projects within regional political, cultural and economic developments within the CSCW and wider HCI community has grown. This includes for example research into the notion of innovation in different geographic contexts and its relation to economic development and national identity (Avle and Lindtner (2016)) or exploration of the collaborative creation of visions for manufacturing in Taiwan (Freeman et al. (2018)). The importance of rural areas has also increasingly come into focus of CSCW research (Hardy et al. (2019b,a)), exploring the specificities of HCI in rural areas in a series of workshops(Hardy et al. (2018)), papers (e.g. (de Castro Leal et al. (2021))) and Special Issues of journals (Makoto Su et al. (2021)). We build on this literature by contributing an investigation into regional learning processes about digitization issues with small and medium sized enterprises in a rural-industrialized area in Germany. While previous studies have consisted predominantly of empirical investigations into the role of regional ecosystems for CSCW and HCI, this paper describes an attempt to intervene and shape such ecosystems through practice- and action-oriented research and design projects, in a rural yet industrialized area in Germany.

Germany is characterized by a considerable number of rural regions, which at the same time exhibit a high level of industrialization. They provide skilled labor, the necessary space and affordable real estate, making them home to the majority of Small and Medium-sized Enterprises (SMEs) which characterize German's industrial sector. Thus, they constitute an important part in the country's economy. This leads to the fact that some of the country's areas are rural yet also highly industrialized. While these regions are typically still prosperous, they are confronted with increasing pressure to modernize their traditionally energy-intense industries.

Despite the importance of rural regions for the local economy and the fact that "equality of quality of life" between urban and rural areas is included in German constitution (Art. 72(2), GG), they are facing significant challenges. The population of many rural areas is shrinking: birth rates are decreasing, youth is moving to urban areas, rural areas do not manage to attract and welcome people from outside or create sufficient access to the labor market (Swiaczny (2015); Vogelgesang et al. (2018)). Amongst others, responsible factors are a lack of educational opportunities, restricted employment opportunities, especially for university graduates and a general cultural closedness (Bundesministerium and für Ernährung und Landwirtschaft (BMEL) (2015)). A variety of options might be available to counter the potential negative consequences for rural regions. One option that the German government actively promotes is to support SMEs in their efforts to digitize their organization, process and products through a network of so-called 'Centers of Competency'. These centers offer a variety of support mechanisms to companies, from low-threshold informational events to trainings, consisting of several in-depth workshops, to hands-on projects which introduce

and appropriate digital technologies in a prototypical manner into the company context. This paper reports on the experiences and insights gained from work in one of these centers.

To succeed with our initiative, we anticipated to require a 'broad' stakeholder and context-sensitive view, to receive a more holistic picture (Ogonowski et al. (2013)) not only of the individual companies we would interact with but of the regional innovation ecosystem. This seems important for several reasons in our context: While the different activities and services the center offers are usually directed at specific companies, the regional innovation ecosystem they operate in consists of a broad variety of actors. Especially in rural regions, such actors always have close and long-standing relationships. Important roles are filled by various unions and their representatives, employer associations such as chambers of commerce and craft, government organizations and other public administrational institutions that offer resources and support to companies. Any project attempting to address and positively shape an ecosystem would need to take this constellation of actors and the relationships between them into account. This is why, the center under investigation employs a practice-based and open co-design-oriented approach to achieve this (Følstad et al. (2009)), where relevant stakeholders are involved in innovation activities (Chesbrough et al. (2006)) and that allows long-term cooperation (Wulf et al. (2015)). Such a 'practice-based approach' aims at fulfilling societal needs, triggering social change by addressing 'real world problems' (Wulf et al. (2018)). The paper presents early results from this intervention and reflects on however such an approach is appropriate for the attempted goal to intervene in a region, instead of single company, department or context, and the perceived benefits and challenges of it.

To describe our activities within the field, we adopted a meta-research or 'research on research' approach (Dachtera et al. (2014); Randall et al. (2018)), building in the internal evaluation activities of the Center. Our contribution to the CSCW discourse is two-fold: Firstly, we expand on the current discourse on regional innovation in HCI by reporting on an attempt to not only analyze but intervene in and shape a regional innovation ecosystem through practice-oriented CSCW activities such as co-design workshops, which we describe below in more detail. This, we believe presents a potentially fruitful and new line of investigation and intervention for HCI research, with effects beyond single organizational contexts. Secondly, by building explicitly on a practice-oriented approach to HCI, we outline the benefits and challenges of such an approach when focusing on a region instead of an individual practice-context. We find here that 'spillover' is a crucial element of regional activities, as the effects of CSCW interventions 'travel' between departments, companies and even sectors and are not bound to the specific practice context where they originated. The question for CSCW projects that wish to address regional contexts then becomes how such spillover effects can be supported.

In the following, we will briefly discuss the existing literature on regional development and innovation, with a specific focus on the study of such constellations in HCI.

Related Work - Innovation Ecosystems & HCI

Several studies have investigated the functions of regional innovation ecosystems from various disciplinary perspectives. An influential study was published by Saxenian, who investigated the innovation ecosystem of Silicon Valley, highlighting the very specific role of universities such as Stanford and Berkeley in creating a workforce highly skilled for local tech companies and in transforming the valley from farmland to a high-tech region (Saxenian (1994); Adams (2005); Tajnai (1996)). The dynamics of innovation processes in geographical regions has for a long time been the interest and focus the economic sciences. Here, interdisciplinary innovation network research has been a vibrant field of research (Ozman (2009); Bergenholtz and Waldstrøm (2011); Kudic et al. (2021)). This literature observes a broad variety of motives to collaborate in with other network partners in regional innovation ecosystems, such as cost savings and risk reduction (Hagedoorn (1993)), time savings (Mowery et al. (1996)), access to national and international markets (Hagedoorn (1993)), status and reputation building (Gulati (1998)), knowledge access (Grant and Baden-Fuller (2004)) and interorganizational learning (Hamel (2011)). Within this broader discourse the concept of the Regional Innovation System is perhaps most relevant to the goals of the paper. RIS can be differentiated according to Asheim (1998) and Pyka et al. (2019) into three types: (i) territorially embedded regional innovation systems, (ii) regionally networked innovation systems, and (iii) regionalized national innovation systems (Asheim and Coenen (2005)). The various approaches differ in the kind of relations they describe and distinguish innovation ecosystems according to these relations.

In recent years, international research within the wider HCI community has increasingly focused on the workings of regional innovation networks in various countries and the role of HCI projects within them. Several studies have for example highlighted a growing importance of “maker spaces” and other “innovation hubs” in Shenzhen, China (Lindtner et al. (2014)) or Taiwan (Lindtner et al. (2016); Freeman et al. (2018)). Such spaces play a role of increasing importance in the support of technological (and social) innovation outside of traditional research and development labs of firms or universities (Lindtner et al. (2014)). Similar developments have been studied in a variety of countries (Avle and Lindtner (2016); Csikszentmihalyi et al. (2018)). Through these studies it becomes apparent that attempts to transfer innovation models and methods such as Hackathons, “Design Thinking” or Start-Up Accelerators, that predominantly stem from California’s Silicon Valley and are portraited as universally successful across cultures, contexts and countries to places as diverse as Jamaica, Ghana or China (Avle et al. (2017)) or India (Irani (2019)), are highly problematic. As they do not

take into account local conditions and practices, they are either unsuccessful in the support of innovation or even hinder innovation as they impede the work of local innovators instead of alleviating it (Irani (2019); Irani et al. (2010)). Accordingly, these studies provide an important contribution to the HCI community in analyzing the wider ecosystems in which our work takes hold and is a crucial backdrop to our work. Several studies provide insights on what it might take, methodologically, to intervene in innovation ecosystems. This includes work by Dachtera et al. (Dachtera et al. (2014)), who discussed the opportunities and challenges of university-industry partnerships. They point out that such collaborations and their increasing frequency led to a new paradigm of knowledge production, labelled post-academic (Ziman (2000)) or Mode 2 (Nowotny et al. (2013)) knowledge production. They draw out several challenges to such endeavors, including organizational and epistemological differences between the partners, that need to be taken into account when targeting an innovation ecosystem, including the companies it entails. Some projects have explicitly focussed on the development of digital infrastructures that support collaboration between organisations within a region, such as shared mobility solutions (see e.g. Stein (2017)). Fischer et al. (2007) have further investigated the role of knowledge creation in collaborations between universities and regional innovation networks. Such partnerships, they argue, have the potential to be intensely beneficial to students, providing opportunities to be lifelong learners, as well as for regional innovation, if universities accomplish to take "the importance of industrial practice and social networks into account". Our study adds to this growing discourse, by providing preliminary data and reflections from an ongoing attempt to intervene, shape and support a regional innovation ecosystem.

Background & Context

The Region

Our activities took place in one of the oldest industrial areas of central Europe, characterized by small and medium-sized companies (250 employees or less), the so-called “Mittelstand”, with the exception of a few larger companies (several thousand employees and production sites in different countries). About half of the gross economic value created in this region comes out of the manufacturing sector, including areas such as automotive suppliers, machine tools, plant production and engineering, plastics processing, home as well as electrical equipment such as batteries, lights, wire and transformers. The regional economy is strongly oriented towards export, with about 160 companies in the region being so-called “hidden champions” in global niche markets.

Due to the climate crisis, a changing global economic landscape and the demands to digitize their products, processes, and services, the regional industry is in the middle of a transformation process. This comes with potentially far reaching social and economic consequences for the inhabitants. Since these traditional

industries are energy-intense, the region's companies are under pressure to rearrange their production and logistical procedures to reduce CO2 emissions – a change in which digitization can play a crucial role (Strüker et al. (2021)). However, the regional SMEs often lack the resources to make necessary and substantial investments in digitization. This runs the risk of dire economic consequences for local companies, which in turn could also negatively affect the region as a whole.

To overcome digitization hurdles which SMEs face nationwide, the Federal Ministry of Energy and Economy has financed 26 so-called "Centers of Competency" across the entire country, with either a regional or thematic focus on specific aspects of digitization. These centers are tasked to inform SMEs on digitization and actively support them in taking first steps towards digitization within their organizations by offering practical and context-specific support. Even though many of these centers are based at and run by universities, they are explicitly not *research* but "*transfer*"-oriented projects. Their goal is to support companies by 'transferring' knowledge to companies and to enable them to *apply* digital technologies, which means that activities need to be highly practical and deliver concrete results to the participating companies. In this paper we report on the activities of one of these centers.

The Centre of Competency

The Center of Competency under investigation in this paper consists of a large consortium, including several educational institutions and universities of the region and various research groups of the region's central university (located in the largest city of the region), providing expertise in Human Computer Interaction, Economics as well as various sub-disciplines of mechanical engineering. Each of the consortium partners conducts their own activities, focusing on adjacent yet different (sub-)regions, but naturally cooperation frequently occurs, for example when members of one institution run a workshop as part of a series organized primarily by another consortium partner. The focus of this paper, however, lies primarily on the activities of the city's university, acknowledging that it is embedded in the larger infrastructure of the center.

The main goal of the specific Competency Centre is to decrease the "digital gap" of regional SMEs compared to large companies, in line with the requirements of the region and the funding objectives of the project. Despite that, the Center occasionally also works with the larger companies of several thousand employees. The publicly funded initiative began its work in late 2017 and since then has been implementing measures towards the creative, economically sustainable and technologically innovative digitization of regional SMEs. Crucially, in all its activities the center aims to shape a form of digitization that embodies the spirit of "Industrial Relations" (Haipeter (2012)) and is therefore largely employee-centered. Furthermore, and especially important for this paper, the activities of the Center are grounded in the assumption, that digitization projects

should support qualified human work, rather than attempt to standardize or automate it (Ludwig et al. (2016); Wulf et al. (2018)), which is largely in line with the wider interest of CSCW into (work) practices ((Lanamäki and Väyrynen (2016))).

In its core, the Centre focuses on the implementation and application of digital technologies in companies, foregrounding Human Computer Interaction. Its interest lies not in the technologies themselves, but in their application and appropriation, and the accompanying changes in the work practices within the organizations and the wider innovation ecosystem. This means that the Center is characterized by the conviction, that workers need to play a central role in digitization measures and should be included in all steps, as their knowledge and practices are crucial both to the performance of the company as well as to the design and appropriation of technological artefacts. Specifically, the creativity, existing expertise, knowledge and competencies of employees, that in this specific region have often been working in a company for many years, are considered crucial to the companies' success. They should not be replaced but augmented by digital technologies, thereby supporting a digitization in the tradition of Industrial Relations (Ludwig et al. (2016); Haipeter (2012)).

Epistemological and Methodological Foundations of the Center

As indicated in the introduction, underlying all activities is an epistemological and methodological commitment to the central role of practices, following the practice-based paradigm of CSCW and HCI research (Schmidt and Bannon (2013); Bjørn et al. (2016); Kuutti and Bannon (2014)). Following such a practice-oriented paradigm, technological artefacts are not simply used, but appropriated by users to their specific context (Pipek and Wulf (2009)). Technologies thus become embedded into human action and practices, a process which is highly dynamic, nuanced and contextual (Ackerman (2000)). Technological artefacts are necessarily abstractions, as they are created based on assumptions of designers and developers and are shaped according to the situative requirements known to them. In practice then, such artefacts are appropriated by their users, and thereby re-contextualised (Rohde et al. (2017); Pipek and Wulf (2009); Stevens et al. (2009, 2010)). 'Use' is therefore an active and creative process, as artefacts are given meaning in their specific context of application by those that apply and appropriate them (Suchman (1993, 2002)). If the use-context, as understood and imagined by the designers, diverges too much from the actual use-context of the users, these will face considerable difficulties to integrate the new tools into their work practice. To minimize this discrepancy, one way to conduct a practice-based approach to design is to structure research into "design case studies", each of which includes an iterative combination of empirical investigation into the specific practices at hand, a participatory co-design-intervention in the form of a technological artefact, and investigating and supporting processes of appropriation of the created artefact to the specific

context (Wulf et al. (2011, 2015); Stevens et al.). This iterative and participatory process aims to overcome the asymmetry of knowledge (Fischer (2000); Rittel (1984)) that exists between the different actors, such as academic researchers and practitioners, and create shared knowledge about the practice context at hand and the design possibilities, a symmetry of knowledge (Fowles (2000)). The aim of the Center's activities is an intervention in such practices, mostly via the deployment of socio-technical artefacts, although, as we shall make clear, interventions often also take other forms, and a description of practices is not the central concern of this paper. Underlying all the interventions is not a commitment to the format of a design case study, but to the understanding of technologies as socio-technical artefacts, given meaning in use, and to the requirement that members of the contexts we intervene in participate in the digitization process.

Knowledge exchange is furthermore central to the works of the center, as it is tasked to increase SME's competency to address and implement digitization measures successfully. Traditionally learning is associated with the idea of transferring knowledge from an expert to a learner, and this is perhaps the root of the idea of a 'transfer project,' which is at least common term for the kind of project we are discussing here. We divert from this idea, building on socio-cultural theories of learning (see e.g. (Lave and Wenger (1991))) following the example of Fischer et al. (Fischer et al. (2007)). Learning in the center of competency is understood as a process of co-creating knowledge between different actors, without pre-defined and static roles of expert and learner. In this understanding, knowing is situated, specific to contexts and mediated by artefacts and distributed within the social environment, without any single individual holding all the relevant knowledge. Following this understanding, there is a commitment to participatory and action-oriented approaches. This follows the ascribed central role of the expertise of members of practice contexts, as well as the orientation to a region, which includes many actors, connected to each other in various ways. Via participatory approaches we aim to include these manifold perspectives and knowledges into the socio-technical interventions. This aim is embodied in the various activities and formats the Center offers (see section 4.2). All this, and this is crucial to note, requires a 'broad' stakeholder and context-sensitive view, to receive a more holistic picture of the problem situation in complex (socio-technical) systems (Ogonowski et al. (2013)). Such kind of studies are then to be understood as action research (Hayes (2011)), aiming to generate knowledge through intentional, directed intervention into practices. In such action research-oriented collaborations researchers learn from practice and vice versa (Baskerville (1999)). Even if such studies do not produce generalizable results (and do not intend to do so), they do result in an in-depth understanding of specific contextualized practices which provides a foundation for the design of IT artefacts (Rohde et al. (2017)).

Such a practice-oriented and participatory approach for HCI and CSCW research makes it a suitable framework for a technology transfer project as the one under investigation, where the primary goal of the project is not the creation of

scholarly knowledge but the creation of value for practice partners such as the regional rural SMEs in focus here. Again, from a practice-based perspective these formats and activities are located at the intersection between research and academia on the one hand and companies as well as other institutions on the other.

Activities of the Center

To realize these goals of regional knowledge co-creation based on a situated and practice-oriented approach the Center engages in a variety of activities for and with SMEs as well as other actors. Although the Center's program consists of a broad and diverse array of activities, they can broadly be summarized into the three categories of 1) Informational Events, 2) Workshops and 3) Implementation Projects. *Informational Events* are low-threshold activities, in which members of the center hold presentations about specific technologies or organise events where external experts speak, followed by an opportunity of attendees to ask questions. They can also take the form of a booth at an industry fair or the demonstration of a specific technology. They often are the first point of contact between the Center and SMEs. *Workshops* provide a more intense and hands-on introduction to specific topics. They are often combined into workshop series of 4-7 individual workshops, such as the digiXpert series.[1] Workshops usually center on real-world cases of the participant's companies. They focus on employees and the challenges they face in their work practices. *Implementation Projects* are cooperative design projects, in which a specific technology is prototypically deployed in a company context to create and opportunity to 'try it out'. These projects often build upon the challenges and ideas company employees brought to the workshop or voiced throughout. If no previous workshop experiences have been made to base design projects on, the specific topic to be addressed is decided jointly between company members and employees of the center, and subject to change after beginning the cooperation. Within small design projects these ideas are developed into socio-technical applications that can be applied and tested within the companies. Although these design projects usually do not take longer than a few months, they specifically follow a participatory and practice-based approach. This means that the experiences and perspectives of members of specific practice contexts take center stage, and any interventions start from ideas, challenges or wishes expressed by them. The primary goal of these design cases is not the development of large-scale systems to be applied within the company context, but to explore and illustrate IT-opportunities to support qualified work in a targeted manner and generate knowledge within the company to carry out their own digitization projects, in whatever form suits them.

[1] the name of the workshop series was changed for the purpose of this paper, to preserve anonymity as much as possible

Methodology - Doing Meta-Research

To describe our activities within the field, we conducted research on our own activities in the field (Dachtera et al. (2014)). As mentioned above, the Center of Competency under investigation began its work in late 2017. After an initial set-up phase, the activities described in the previous section began shortly after the inauguration of the project, within 2017. Overall, by 2021, four iterations of the digiXpert workshop series had been conducted, 28 design or implementation projects have taken place and members of the Center have organised or participated in 421 events. Since the beginning of the project, the researchers that are engaged in the project kept research diaries, taking short notes during specific events, steps and meetings which were later extended to detailed field notes (Argyris et al. (1985)). These include, for example, notes taken during the workshops of the digiXpert series, or transcripts of interviews with participants of the design projects as part of the collaborative investigation into specific practices in order to jointly plan design interventions. Secondly, qualitative open interviews were conducted with members of organizations that had participated in the activities of the Center, as well as members of the Center, as part of the internal evaluation of the Center's work. Such interviews are conducted periodically after the respective activities took place. Apart from identifying possible areas of improvement with regards to the program of the Center these interviews also served to gain a better, more detailed understanding of the measures of the Center, their perception by partners and participants, possible interdependencies and synergies. This evaluation is ongoing. At the current time it contains 21 interviews with a total length of 650 minutes. Nevertheless, it needs to be noted that data collection was somewhat opportunistic, as the funding organisation of the project explicitly rejects any engagement into 'research' by the employees of the center, and research activities therefore need to fit within the objectives of the center and its clients.

For the sake of this paper and the reflection of the Center's work that it entails, the data retrieved from the field notes as well as the interviews was combined. This data was then thematically analyzed (Braun and Clarke (2006)) in a collaborative manner. Authors compared and discussed their analysis and where necessary also sought clarification with members of participating organizations. Through this process, data was sorted into 'cases', with each case centering on one specific company, partnership or process and with a more or less central narrative.[2] Subsequently, a few cases were selected for this exploratory paper with the aim of providing preliminary insights into the work of the center, the regional focus and the associated hurdles. This process resulted in the narrative(s) presented in the section 'Case Studies'. To preserve anonymity, all names of actors, organizations, locations or events that could be potentially revealing have been altered. Names that are appear are pseudonyms

[2] Although it becomes clear throughout the following section that narratives are often connected and cases are not entirely distinct from each other, which we address in the discussion

Case Studies

In this section we describe four cases which illustrate the different forms the activities of the Center take and the different ways in which they manifest and intervene in the region. Case 1 describes an implementation project with a manufacturing company. Members of the Center worked with various employees of the company to develop a digital tool to support the work of the maintenance department. The resulting application later travelled to other departments and even to another company. Case 2 describes an implementation project in which members of the Center worked with an employee of a local company to develop an application to support quality management. Although never rolled out, for reasons we explain below, the co-design project served to create knowledge that enables the participants to make informed investment decisions about digitization efforts. Case 3 describes the evolving cooperation of the Center with an employee of the regional administration and her instrumental role in creating moments of knowledge co-creation. Case 4 describes how initial contact and exchange about digitization is established between various regional companies, and how these companies continue their exchange later without interference of the Center, co-constructing knowledge together.

Case 1: where an artefact is designed, put to work and then travels within the company

In the first case, a company worked with the Center of Competency on the co-design of an application to support the coordination of maintenance work within a specific department of the company. The system was applied in the company practice, appropriated, and even introduced by the company - without engagement of the employees of the Center - to other departments of the company. Later on, the system was also introduced to another company.

This co-design project was carried out with a medium-sized family-owned enterprise, typical for the companies in the region. Its business is the construction of appliances to equip factories, such as large cranes focusing on heavy duty lifting. This specific project addressed challenges regarding the organization of maintenance work within the company. The company has a small maintenance department, consisting of two employees, responsible for taking care of the machinery, tools, and facilities in a specific department of the company.

We began the project with a short inquiry into the maintenance work, via observations and conversations with maintainers and other staff over a few visits to the production site. These visits revealed that the department suffered from a lack of formal procedures to report maintenance issues and machine breakdowns, which created a variety of problems for carrying out the maintenance work. For example, issues would be reported to the maintainers unsystematically whenever staff spotted the maintenance workers in the construction hall. As maintainers do not always have documentation tools at hand, such sporadic reports were difficult

to keep track of. At other occasions little written notes or broken tools were simply left on their desk, without further information about the nature of the malfunction or the urgency of its repair. This made it difficult to keep track of issues and to prioritize the maintenance work appropriately, which affected both the maintainers work but crucially also production and resource planning. In the end the head of production often did not have a full overview of which machines were broken and to ultimately re-direct resources and orders to other machines and re-plan production accordingly. One maintainer explained this in the following:

"The broken tools are simply placed here on the table by the late shift just after they broke down. We find them in the morning. For example, we begin our work, and three small grinding tools are lying here on our desk, without any further information. [...] It could also be that someone tells you about a maintenance issue in passing and then you forget it. And when that happens perhaps twice, that we forget about an issue told to us in passing, at some point the topic gets taken to the foreman or superintendent and they then think that for six weeks the entire plant has not been run sensibly, as they were not aware about maintenance issues and breakdowns."

We then went on to organize a series of design workshops at the company, involving employees of all hierarchy levels, including the maintainers and managers. The workshops served to discuss, further elaborate on and analyze what we had learned about the processes and the associated challenges so far and to begin to imagine applications to address them. We developed several concepts to illustrate how a digital artefact could support different practices of reporting and addressing maintenance issues. During the discussions that followed, the company staff decided on a mobile application that would support more structured means of reporting and prioritizing breakdowns and maintenance work, which was subsequently collaboratively designed and developed. Once a working prototype status had been reached, the application was introduced into the work context together, which required all employees to change their procedures regarding maintenance slightly - which had been the goal of the intervention. After this, we left the company, as the objective of the center to provide opportunities to test digital technologies in a prototypical manner, not to develop working solutions, had been fulfilled and the company also told us that we would not be needed anymore, after almost a year of working together.

A few weeks later we headed again to the factory to conduct a small evaluation of the application's use. The software was found to be still in use and supporting the cooperation of production and maintenance workers, to adapt new maintenance and reporting procedures. Instead of an illustrative prototype, the application had become an integral tool. We were furthermore surprised to learn that members of the company had decided by themselves to roll out the application in other production facilities. While this was exciting, it was also a bit unsettling, as we did not anticipate this and did nothing to support it. It happened outside of our control.

Lastly, the application also travelled to an entirely different company, whose members faced similar difficulties. Towards the end of the cooperation with the

first company a regional fair took place, focusing on digitization for SMEs. The Center was exhibiting their work and included a few technological demonstrators, such as the application to support maintenance work. At this fair, the CEO of another company approached the booth and became interested in this specific application. He was initially interested, but not convinced. During the following presentation a member of the company in which we first implemented the software joined the presenter and acted as a mediator and advocate, convincing the CEO of the second company by sharing his experience of the project carried out in his company. He mainly repeated the summary of the project given by member of the Center of Competency. His account focused on the work processes of the members of the maintenance department and how they changed due to the project, towards greater transparency and prioritization. He mentioned furthermore that both the process as well as the resulting application were received very well by the participating employees. Only then the CEO agreed to carry out a similar project in his company using a similar approach with regard to maintenance work. This design project is currently being carried out, focused on the adaptation of the system to the new environment and its appropriation.

Case 2: where an artefact is designed and without application enables informed future decisions for company members

In the second case we present, members of the Center collaborated with employees of a regional industrial company on the development of a tablet-run app to assist in quality management. In contrast to the company in the center of Case 1, the company of this case is a large company with about a thousand employees distributed across various production sites around the globe and the main site in the region in question. While the collaboration resulted in a fully working prototype of the app, the application was never rolled out. Towards the end of the development phase the company's IT department voiced strong security concerns and blocked its implementation. Nevertheless, to our surprise this was not perceived as a disappointment by our collaborators. In their view, the knowledge gained during the co-creation of the application was a sufficient benefit. It enabled them to understand their own needs and evaluate commercially available applications better, from which they finally picked a solution.

The project began through the involvement with the local office of the union of metal workers[3]. An employee of the company, who was responsible for quality management of specific products, learned about the program of the Center at a local union-organized event. In an interview conducted after the end of the project for evaluation purpose he told us:

"The metal union always organizes a 'market of possibilities', where they present what is new in the area of automation and digitization, but also new laws or legal decisions by judges. It's a kind of educational event that is very popular. And at the last edition I met the coordinator of the Center, and we talked about the

[3] https://www.igmetall.de/

Center and all they can do – we talked for a very long time. I really liked what you presented."

After the event, the employee and the members of the Center stayed in contact via email, discussed challenges within the company and finally agreed to engage in a co-design project. The company employee and his supervisor, the head of the quality management department met with several members of the Center, to discuss which specific challenge to address and how they could be addressed. The company members were interested in reducing the amount of paper-based checklists in their assessment of the quality of specific large machine parts they manufactured. They had already very specific ideas what the tool they were setting out to design should entail: it should be a tablet-based app that would facilitate the completion of checklists to assess manufacturing quality and enable the inclusion of photos of the assessed part at specific items of the checklists. The inclusion of images was supposed to ease documentation of manufacturing faults.

The group of two company employees and three members of the Center now met regularly to work on the app. While the members of the Center took on the technical development, these meetings also included several visits to the shopfloor and discussions with other company employees, to gather further insights to inform the design. After several months a working prototype was ready, and the employee and his supervisor wanted to test it in practice with several further employees. To this end the company's IT department was contacted with a request for support, for example by supplying extra devices on which to run the application, who had so far been kept out of the project deliberately by the company members. The IT department however voiced concerns that the developed app violated some of their own security guidelines, such as running on the Android operating system instead of on Apple's iOS, which they exclusively used due to security issues. They blocked any further testing and development of the application. While this was of course an obvious source of possible disappointment, the supervisor did not think so - to our surprise: *"The idea was a good one, it gave us quite a lot of impetus - the work was in no way wasteful. It actually showed us quite clearly what we have and what we need. And we are now looking at what is available on the open market."* The project had seemingly enabled them to better understand their specific demands of a tool and now helped them make informed choices when evaluating commercially available applications.

Similarly, to the project of Case 1, the project of this second case was also not fully confined to the context in which it was developed and envisaged. During the development phase a member of the company mentioned the project in an article in the magazine published by the local chamber of commerce. He told us that he was subsequently called by a colleague from the sales department, who was interested in a similar check-list based tool but for a different use case, as they also complained about "too much paper". They met and discussed their possible options, but before this could develop any further the IT department put a halt to the entire project. After the end of the project, the application travelled further to an entirely different

context, the care sector, where it inspired further development. This is the subject of Case 3.

Case 3: where a partner initiates knowledge creation through her own networks, and an artefact travels from one sector to another

At the center of this case is the long-standing and evolving cooperation with an employee of the regional administration, which involves a variety of activities, from individual workshops and digiXpert workshop series to the co-creation of technological artefacts, which we will detail below. The application outlined in Case 2 also makes an appearance in this case.

A key partner of the Center is the regional development office of the county the Center is located in. Our key collaborator in that office, Ulrike, is both responsible for economic development as well as for the coordination of support for the health care sector in the region. The care sector is comprised of various organizations, including numerous smaller private care institutions which are SMEs. In this second capacity Ulrike organized an event on the "future of care" in the region, taking place in 2018, inviting various actors including care professionals from private and public institutions as well as technology providers and a member of our Center. Crucially, this event was initiated and organized by Ulrike, without involvement of the Center. She encouraged participation through her own network, inviting members of care companies as potentially interested participants via personal phone calls. Members of the Center then joined one of the workshops that were part of the event. While providing expertise on digitization in the workshop, their role was also to present the digiXpert workshop series, in order to generate interest for the series specifically within the care sector. Two employees of different care institutions signed up for the workshop, including Antje, a nurse at one of the participating care institutions, who was initially skeptical about the opportunities of digitization for her sector.

One goal of the workshop was to create an overview over available digital technologies that could support documentation needs within care practices. During the workshop it became clear that care professionals have a high load of documentation requirements, needing to, for example, regularly manually measure and document vital signs of patients several times a day. The member of the Center suggested that some of these tasks could be made easier by digital technologies and that the Center would be able to explore opportunities and maybe develop a prototype. This could build on technologies the Center had explored in industrial companies, such as an app to keep, manage and complete checklists, described in Case 2, which could be adapted for this context. Since this proposition was met with interest from several of the participants, one result of this workshop was a working group involving five regional care institutions and the Center, under the guidance of Ulrike and including Antje, the future ambassador.

The group began to meet regularly, albeit infrequently, coordinated by the Center member. In the first meeting the group was also joined by another member who had been a participant in one of the workshop series. In this meeting the

group decided that a smart watch might be a useful device to support the documentation tasks as it would eliminate the need to carry pen and paper around and digitize the data later. The smartwatch could include a checklist and enable fast and immediate recording of the data in digital form. To gather more information the group then organized visits to the respective care institutions. Here, it quickly became clear that a smart watch was not a feasible device to support documentation. Due to hygiene regulations, care practitioners in all institutions were not allowed to wear watches while working. A telephone would be more suitable device to run a checklist-like application, which was still considered the most appropriate way to address the documentation challenges. A first prototype was developed and discussed during another workshop, organized by Ulrike. During further visits to care facilities, however, the group discovered that many of the devices that were measuring patient-data and from which care practitioners copied the vital data manually, actually contained digital interfaces from which data could be taken automatically and sent somewhere else. This changed the task of the group considerably, as the goal was no longer the design of a checklist-app, but also the automatic incorporation of data from the devices that were able to send it. Ulrike then organized yet another workshop to narrow down the options and decide on one direction. During this final workshop the group sketched two further prototypes, in addition to the smartphone-based checklist-like app to facilitate digital documentation of patient data. These were 1) a hygiene-monitoring system that would access and gather data from the respective devices such as fridges, temperature- and humidity sensors in the care facilities to ensure proper hygiene or 2) the connection of a pulse-oximeter to continuously and automatically gather vital data of care patients. The covid-19 pandemic and the protective measures then forbid any further meetings, and the group has been somewhat dormant up to the writing of this account in mid 2021. Ulrike however carried the ideas and insights developed during this process also into another region, involving some of the group's members in the process, to spur similar developments elsewhere. She met at various points in time with leading members of regional chambers of commerce, unions as well as politicians from federal government to present and discuss these results and especially the benefits of the workshops series, for the care sector and beyond. Her goal was to inspire the development and uptake of such workshop series and participation of the care sector in other regions, even if the Center of Competency would not be involved, as she had witnessed the potentially beneficial role such workshops would pose for the sector. Similarly, Antje also began to present her experiences from the workshop series and the checklist app procedure at other opportunities, even in national events, but also regionally. Even though the process in the previous group lay dormant during the pandemic, Antje remained in contact with the Center, and initiated a cooperation with another care facility she was in contact with, who had previously not been involved in the group. In this new care facility, the previously sketched prototypes were put into action, and together several devices that measured environmental and health data, which care staff needed to record several

times a day, were connected to a locally hosted platform via their pre-existing interfaces. Staff then did not need to measure and collect this data manually, going around the facility, but the data was automatically sent to a dashboard which gives them access to an overview over all required data.

In the meantime, the cooperation with Ulrike was dormant for most of 2020, but began anew in early 2021, and is ongoing in various formats. As mentioned above, the core take-away of the case is not so much the design of technical artefacts and their effectiveness in practice, but the evolving cooperation with Ulrike and later on also with Antje. Both have been instrumental in facilitating the co-operation between the Center and regional companies and other actors in the care sector. They created connections through their own personal contacts, through which further projects with other actors evolved. Especially Ulrike stressed the importance of this cooperation: *"The two of us, Center and my office, playing together is crucial for the region. [...] It helps us and you and drives connections in the region. It has become a network and it is vital to carry it forward, as both sides can endlessly benefit from it."*

Case 4: where companies begin to create knowledge together

During one iteration of the digiXpert workshop series several participants expressed the wish to be in closer and more regular contact with other companies to exchange knowledge and learn together. It was important that companies should be similar in size and structure, for the experience to be more relatable and for needs, resources and constrictions to be more easily comparable, but should come from different sectors that do not pose any economic competition. This however was at first not easy to achieve. A participating employee from a rather large industrial company, in the team of production management, told us that he tried to engage with members of other companies he met at the workshop. *"A colleague from the workshop wanted to visit our company. And I said: yes, great! But I met him recently at an event and he told me that he just does not have time currently. They have similar processes [in their company]. We could both imagine to meet and exchange more often, but haven't managed due to a lack of time".* Through the work of the Center members got to know several companies with interest in similar technologies, facing similar challenges within their production, but without direct competition between them, and organized regular meetings.

In these meetings various application scenarios were subsequently discussed, as well as problems that remained open, such as the digital administration of tools and the associated standards. After some time, these groups became self-organized by the participating company members. An employee of one of the participating companies shared with us: *"We are now coming together in a small group. There is [name of other company], who were also in exchange at that time and who are also active in the Centre [of Competency] and are always at the events, and the other company is directly in [name of the same city]. The advantage is that there is a shared interest in the set-up process of machines, and we are quite similar as*

companies. [...] And here we have found a regular exchange of ideas for us, we try to meet once or twice a year and then we meet also in smaller groups where we talk in a more technical manner." The participating companies then also realized benefits of the work groups beyond the initial shared interest or topic. They found that they are investigating similar topics and technologies and are exploring ways to cooperate and share knowledge and resources in these efforts: *"We also want to try to bundle up a little, so that not everyone invests money in prototypes and everyone starts again from scratch to find out that we are trying to do this together."*

Discussion and Lessons Learned

Previous studies from within the HCI community have investigated and reported on innovation ecosystems as context for HCI work, such as work by Avle, Lindtner or Freeman (see e.g. (Avle and Lindtner (2016); Avle et al. (2017); Lindtner et al. (2016, 2014); Freeman et al. (2019, 2018)). Such studies have largely been empirical in nature. They are crucial work for the HCI and CSCW community as they initiated the discourse and investigation of innovation ecosystems and regions as context for design research work. Our work intends to develop this discourse further by providing a report on an attempted intervention in such a regional innovation ecosystem. The cases described in the previous section exhibit a variety of ways in which the efforts of the Center of Competency initiate change in the region, affect SMEs and involve a variety of actors, including company employees and middle managers, university researchers, representatives of chambers of commerce and trade unions as well as members of public administration.

The experiences described in the cases above hold three preliminary lessons for CSCW research targeting regional innovation ecosystems. Firstly, the cases contain elements of knowledge co-creation through activities rooted in a practice-oriented approach, thereby hinting that such an approach holds benefits for what is usually referred to as 'transfer projects'. Secondly, it becomes clear that the effects of our interventions extend beyond the borders of collaborative research and design projects with individual companies, which are arguably a common form of practice-oriented CSCW projects. This thus presents somewhat of a methodological challenge for a practice-oriented approach, as participants and their relations extend significantly beyond the borders of what is usually understood as a specific practice context. The question emerges how CSCW research and design projects can take the complexity of contexts into account, and account for their own role in them. Thirdly, and following from the second lesson, a regional focus seems to require increased flexibility from university and research staff in what are considered appropriate activities for university members, in order to deal with the necessary relations and reputation, which can pose further significant challenges.

Below, we will outline and discuss each of these aspects individually and summarize their possible implications for HCI work with SMEs in regional

ecosystems. Lastly, we will outline what we perceive to be limitations of this approach.

Co-creating Knowledge

Although they entail different actors and activities, in all cases presented above collaborative knowledge creation emerges as a shared outcome. Companies and researchers learn the possibilities digital technologies hold for a specific company practice, members better able to formulate their own requirements, etc. This knowledge creation happens often through joint practical work, taking for example the form of short design projects, where a specific technological application is created or appropriated for a specific context, but also through collaborative activities during a workshop that address real-world challenges participating members of companies face.

It is thus crucial to notice that this does not represent 'knowledge transfer' even if that is part of the funder's objectives and brief, but knowledge co-creation. Knowledge is not transferred from the university or the Center of Competency to a company context, it is not taught or otherwise communicated through writing or video, but newly created for the challenges at hand through collaborative activities, starting with members of practice contexts such as specific production lines as for example in Case 1, instead of only management. These activities require that the different expertise(s) of the participating actors are brought together and combined in the practical collaboration. For example, while members of the Center might have expertise necessary to create digital technology, such as coding skills, graphic design etc., they do not know exactly how these skills might be useful in a specific context. Company members know this. Together an application or a prototype is developed. Co-creation requires both kinds of expertise (and more). This echoes an understanding of knowledge and learning formulated by Fischer et al. (Fischer et al. (2007)), as "mediated by artefacts, situated and distributed in a social environment" (p. 3), as we mentioned before, and at least tentatively signals that such an approach is able to build up knowledge within the companies, relevant to digitization. The approach of the Center also seems to present a divergence from how some of the companies in our cases so far have approached digitization, as for example shown in Case 2, and new methodological knowledge is co-created. Here, the IT department of the company was explicitly excluded by the participants from the company, to avoid their usual top-down approach and enable a different experience for the participating employees. In another sense, knowledge co-creation also takes place through the designed artefacts, that are appropriated beyond their initial context of application. For example, the activities described in Case 2 and 3, take an artefact designed for an industrial context to the care sector, where it finds another use. It does however not simply travel to be applied, but it is collaboratively and actively altered, appropriated, via the working group that emerged during the initial workshop, to make sense and be of use in the intended new context of the care sector. Similarly, knowledge travels within the company in

Case 1, where the artefact is appropriated into another production line of the same company, or in Case 2, where it at least inspires a colleague from a separate department to engage in further digitization projects. Especially Case 1 therefore illustrates that a practice-oriented and participatory approach is suitable to knowledge co-creation, as the co-workers at the production site were able to transfer and adapt the application to another production line without involvement of the researchers - something which was not anticipated or explicitly planned for.

However, that the effects are not solely bound to a single location, but somehow 'travel' through the region in different ways is both beneficial as well as problematic for our chosen approach. We will reflect on the travelling nature of effects and artefacts in the next section.

Effects travel through the ecosystem

The cases above also illustrate, that the consequences or effects of such work are not bound or limited to a specific place or a specific group of actors. The Center of Competency acts not only within a specific department or with a defined group of people, but targets the entire region, comprised of various cities and villages and various organizations. The region is then rather a complex network of actors, and actions within such a complex network have unforeseen consequences and effects "travel". Several cases illustrate this phenomenon of travelling effects. In Case 4, for example, the members of the Center worked with a specific, even rather small group of people in a few companies as participants in the digiXpert workshops. Yet after initiating exchange between these specific members of companies, the constellation of companies involved in the co-creation process changed, without the Center's interference, self-directed by the needs and interests of the company employees, and the circle of involved companies even grew. Similarly, in Case 1 the maintenance system is applied in other parts of the company, outside of the sphere of the Center, taking a more direct way than the newspaper. In Case 2 and 3, the effects travel between sectors, from the manufacturing of heavy machinery to the care sector. In Case 3 co-creation is initiated and continued by our collaborator from public administration with other stakeholders, building on and engaging their own personal and professional relationships, outside the realm of the Center of Competency, and later the Center of Competency is involved again.

These forms of travelling of artefacts and their effects can be understood as form of spillover. Spillover is a known phenomenon in other disciplines, such as economics and management studies (see e.g. (Mascarenhas et al. (2018); Scarrà and Piccaluga (2020); Alcácer and Chung (2007); Audretsch and Feldman (2004)) yet relatively unexplored in CSCW and wider HCI. Spillover also seems to create some problems for a practice-oriented form of research and design, as we will discuss. Even though the work of the Center strongly builds on the practice paradigm outlined above, the ways in which this work of the Center of Competency takes hold in the region expands the usual frame of research and design projects within this practice paradigm. While this is not necessarily a

diversion from the epistemological orientation towards practices, it presents a methodological challenge of how to address various, connected practices or practice contexts. The activities and effects transcend the localized nature of situated practices and become distributed across the network of actors of the region instead. Design and knowledge co-creation might initiate in the Center's activities, but continues in locations and through relations of which the members of the Center are not only not a part, but of which existence they might not even be aware. This makes it difficult to remain accountable for the effects of one's activities. Lucy Suchman has reflected on this phenomenon in her article "located accountabilities" (Suchman (1993, 2002)). In this work she shows how technology design, as the materialization of knowledge, is not located within the distinct group of designers, but distributed across various actors, where 'use' is an active, creative act of appropriating technologies, giving them meaning and making them fit. Taking this distributed nature serious, means accepting "the limited power of any actors or artifacts to control technology production/use;" (Suchman (2002)). The challenge thus becomes how to engineer for this kind of spillover from the initial site and context where a design project was carried out, facilitating the travel across various contexts, while also acknowledging that one has limited control or even access to the relationships that make spillover possible. A possible opening for such engineering for spillover could lie in the routinised nature of practices, and that such routines can be similar from one context to another. Identifying similar routinised practices in different context allows thus to apply similar technologies. At the same time, this only partially explains the travels beyond single contexts we describe here, as such travelling can be witnessed when similarities between practices seem absent. Further research is required that pays attention to the structures and practices involved in spillover in order to formulate approaches that might facilitate it.

A further challenge thus arises, that, in order to engineer for spillover, we need to access or build the relationships through which it takes place. In our experience, this requires activities that are often significantly different from what is usually considered research or design.

Necessary Work Beyond Research and Design

Apart from the activities outlined above in the section titled 'Case Studies', which constitute perhaps the core of the Center's work, members are also engaged in constant activities that constitute the building and maintenance of networks, relationships and reputation. Activities are carried out constantly to keep connections with partners alive and build new ones. Such activities include (of course) countless meetings, email exchanges and telephone calls to actively plan projects or simply engage in relationship building for future joint activities (see experiences from other scholars, such as (Ahmadi et al. (2020); Meurer et al. (2018)). Some of these activities are portrayed in what is above called "Informational Events", which can include presentations at events such as the

market of ideas mentioned in Case 2, the fair in Case 1, where the members of the two companies met as well as visits to companies and other organizations. Not all activities, however, are included in such work packages, and some activities thereby take place outside the project, at least in a formal sense. Through such activities however, relations are maintained and created which later become the foundation for the co-construction of knowledge, or at least the starting point for co-construction processes, and for which one can account as a HCI or CSCW designer-researcher. The point is, however, that these activities are not what is typically considered research or design. They nevertheless take up a central role in such region-oriented projects, more, we would argue, than in projects focused on a specific and more confined or bounded practice context, where fewer relations are involved. For a university-based project this constitutes some challenges, as it is not a trivial undertaking to translate such activities into what is usually thought of as research outputs, including the preparation of research publications or other academic activities such as teaching of students and other academic qualifications such as dissertations. Others, such as Meurer et al. (2018) or Krüger et al. (2021) have also pointed out the need for intensive networking activities as the foundation for participatory research activities, and especially to make such efforts last. This is reminiscent of work by Blomberg and Karasti (2013), who have highlighted the fact that 'field sites' are always designed. While we do not mean to highlight here the designed and thereby artificial nature of any field site, which is certainly also the true for our work, constructing a field site - for research and for design - takes work. In the case of the Center of Competency, this is not just a single field site, but multiple sites, across companies and departments. This is especially urgent, we believe, as the regional focus requires a constant creation and maintenance of relationships and reputation, which do not look anything like 'co-design', but create the foundation for future design or research activities.

Conclusion

To conclude, these three lessons begin to paint a picture of what we might call 'engineering for spillover'. Practice-oriented, collaborative research and design activities seem to be suitable to facilitate the co-creation of knowledge that enables SMEs to engage in digitization projects themselves. These effects of these activities and the artefacts that result from them are not always bound to specific contexts and locations but spill over into other departments, companies, sectors. This happens through connections, networks and relations, which one might or not might not be part of. Ultimately, addressing a region through spillover means accepting Suchman's lesson on the located accountabilities of technology designers that we have limited power to control technology use (Suchman (2002)). Nevertheless, it seems as if engineering for spillover is a possible way to support the wider effects of localized co-creation activities. This, we propose, includes a number of network and reputation-building activities which do not always look like research or design and are possibly quite mundane, but are nevertheless the

foundation for co-creation activities and their regional spillover effects. More research is however required to better understand the processes of spillover effects, the actors involved and their potential practices, in order to better engineer for spillover.

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