Scaling informal learning at the workplace: a model and four designs from a large-scale design-based research effort

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Scaling informal learning at the workplace: a model and four designs from a large-scale design-based research effort

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Abstract

Workplace learning happens in the process and context of work, is multi-episodic, often informal, problem based and takes place on a just in time basis. While this is a very effective means of delivery, it also does not scale very well beyond the immediate context. We review three types of technologies that have been suggested to scale learning and three connected theoretical discourses around learning and its support. Based on these three strands and an in-depth contextual inquiry into two workplace learning domains, Healthcare and Building and Construction, four design-based research projects were conducted that have given rise to designs for scaling informal learning with technology. The insights gained from the design and contextual inquiry contributed to a model that provides an integrative view on three informal learning processes at work and how they can be supported with technology, (i) task performance, reflection and sensemaking, (ii) help seeking, guidance and support & (iii) emergence and maturing of collective knowledge. The model fosters our understanding of how informal learning can be scaled and how an orchestrated set of technologies can support this process.
Introduction

Workplace learning takes place through work processes and often involves the passing on of skills and knowledge in problem-based context (Attwell & Baumgartl, 2008). It is informal, multi episodic, and happens on a just in time basis (Kook, Ley & DeHoog, 2007). To advance their competence, individuals need to meaningfully connect these episodes and reflect about them in situated contexts (Eraut, 2000).

While informal learning from individual experience has found to be highly effective and intrinsically motivating for the individual (Hague & Logan 2009), it does not scale very well beyond the immediate context, and remains costly, too often fragmented and unsystematic. Our initial explorations into two workplace learning domains have revealed several critical challenges that professionals face in informal learning, such as applying norms in work context to make them part of practices, cascading new knowledge and experiences about good work practices or problems among professionals and across organizations, capturing learning needs as they emerge in practice, and documenting and reflecting about learning experiences, and many more. Despite the recognized importance of informal learning at the workplace, however, most technological solutions support the learning model of formal instruction organised along curricula (Kraiger, 2008).

Scaling up informal learning at work with technology would require managing learning and support simultaneously from the individual, organizational and cross-organizational perspective. Such an approach would enable individuals to receive and provide relevant and meaningful support for learning needs arising in the context of work, and take better advantage of learning opportunities about emerging methods, materials and tools, or of the valuable experiences of others. In this paper, we report results of four design research projects conducted in two domains, healthcare and building and construction, to address some of these challenges. These have led us to suggest an integrative model that describes the role technology might play to support and scale informal learning at the workplace. Before we present the design-based research we conducted, the next section presents several approaches for scaling learning with technology which we took as an initial point of departure.
Scaling Informal Workplace Learning with Technologies: An Initial Framework

An early, and simplistic view of the use of technology to support learning, was that scaling of learning could be achieved by removing the restrictions of time and place (Zemsky & Massy, 2004), but there are now several theory-guided approaches for the use of technology to scale learning. For example, Adaptive Learning Technologies, informed by models of scaffolding self-regulated learning, build on providing support for a task by a more knowledgeable other(s). By doing so, they codify some of the strategies and rules that human tutors have been shown to use (Aroyo, et al. 2006). Scaffolding requires creating a shared understanding of the goal of the task between the more capable peer and the learner, in order to adapt and calibrate support to the learner’s state of competence, fading out when some level of competence is reached (Stone, 1998). Responsibility is transferred to enable the learner’s productive participation without replacing their self-regulative efforts (Lipponen, 2001). Adaptive learning systems have been introduced in workplace contexts for enhancing work-integrated learning (Lindstaedt et al., 2010; Ley, Kump & Gerdenitsch, 2010), creating personal workplace learning solutions (Dolog, et al., 2007) or facilitating self-regulated learning (Nussbaumer, et al., 2012).

Another way to scale learning in professional contexts is social networking and community technologies (e.g. Wenger, White & Smith, 2009). A Community of Practice (CoP, Wenger, 1998) is formed as a learning collective that is situated in a workplace setting, where members work on a joint enterprise, using a shared repertoire (tools, objects, artifacts, rules) and shared knowledge. Collective knowledge in a CoP matures along a number of discrete phases (Schmidt, et al., 2009; Braun, Kunzmann & Schmidt, 2012) that requires workers’ contributions. Scaling up knowledge and learning support in a technology-supported CoP builds on the assumption that workers can draw on this collective knowledge to meet their learning needs: having access to collective knowledge can enhance workplace learners’ interactions with artifacts, networks and peer groups (Puntambekar & Hubscher, 2005), and enable them to extend and augment the reach of personal networks in an effective and informed way (Cook and Pachler, 2012).

Thirdly, Semantic Technologies have been used in socio-technical systems to promote scaling of meaning generation and representation by encoding part of the domain language and understanding (Siadaty et al., 2012). This is based on an understanding that humans develop expertise in the workplace by acquiring domain schemas which categorize typical tasks
or problems by a set of underlying principles or features and reflect a common way to make sense out of experience (Schank, 1999). Often these schemas are part of a distributed cognitive system (Halverson, 2002), and internal resources (memory, attention, executive function) are coordinated with external resources (objects, artifacts, materials and tools) to support action (Barab & Roth, 2006).

Each of the aforementioned perspectives suggests partial technological solutions for scaling learning at the workplace, which have not been integrated into a common framework. We took these perspectives as a starting point for a design-based research approach, in order to come up with an integrative view of supporting informal learning at work.

Methodology: A Design-based Research Approach

In the design-based research approach taken in this study, the initial framework on scaling informal learning as described in the previous section was used to analyse challenges and opportunities in workplace learning settings, and to constrain the solution space for initial design solutions (Plomp, 2009). Introducing the initial design solution into the context of work was seen as a starting point for further iterations, where (a) design solutions, (b) domain understanding and (c) theoretical concept could be developed further in a balanced and iterative way (see Figure 1).

![Figure 1: Design-based Research Approach balancing design solution, domain understanding and theoretical concept](image)

Here, we report results of a first iteration of this ongoing process that has produced four design solutions, and understanding of problems and possible scenarios in two workplace learning domains, as well as first refinement and validation of the initial framework on scaling informal learning. In the healthcare sector, we were particularly working together with three General Practitioner (GP) practices in Yorkshire in the UK. Our partners in the building and construction sector were one regional training centre for apprentices and professionals, and a
network of SMEs for sustainable building and construction in the north western part of Germany.

The process started with an in-depth contextual inquiry with staff at those partner sites. This included observations and 47 interviews partly at the workplaces, and four focus group discussions, and these resulted in user stories, contextual factors and personas that captured their working and learning practices (Thalmann et al., 2013). A co-design process was then initiated in four design teams consisting of researchers, developers and representative professionals from the pilot domains, promoting end-users’ democratic collaboration with the researchers (Bødker, Ehn, Sjogren & Sundblad, 2000). The co-design process in this first iteration encompassed nine months of diverse activities resulting in 107 pages of rich material in a wiki: visits to staff at their workplaces, a large-scale design workshop where researchers and end-users discussed artefacts and ideas, 40 co-design meetings (partly at the workplaces), where paper prototypes, wireframes, use cases, functional requirements and low and high fidelity software prototypes were developed and tested. Feedback from end-users was collected in interviews and observations of the use of the tools, and participants were invited to co-design particular artifacts to better fit their needs and practices. An example is given in Tomberg, Al-Smadi, Treasure-Jones, and Ley (2013). Across all activities, 120 professionals from the two sectors were involved and we take this as strong evidence for the validity and generalizability of our results.

Results

Design solutions to support workplace learning

Next we present the results of the four design teams, two of which were particularly focusing on the healthcare domain (PANDORA and BITS AND PIECES), and two on the building and construction domain (CAPTUS and SHARING TURBINE). Figure 2 presents an overview of the five prototypes developed and their current status in the design process.

Figure 2: Five Prototypes Resulting from Design-based Research

PANDORA

1 Current versions of these prototypes are available through http://developer.learning-layers.eu
Domain Problem. PANDORA addresses the process of seeking and developing opinion and information (and the transition between the two). An example is clinical guidelines, which are currently developed and disseminated in a top-down way. Guidelines need translation into the GP work practices. Currently, the adoption of guidelines and their intended changes are rather slow and unsystematic. In part, this is because guidelines are based on strong clinical evidence (e.g. standard treatment for a particular illness), which may not be directly applicable to individual and highly contextual medical cases. In such cases, professional opinions to validate, confirm, or challenge the GP’s opinion would be needed.

Design Solution. The key idea of PANDORA combines professional help seeking and knowledge maturing (Schmidt et al., 2009) to bridge the chasm between formal and informal knowledge. On the one hand, clinical guidelines are represented in stable documents, while the appropriation of those guidelines on a practice level involves knowledge at earlier stages of maturity. PANDORA that was developed as a web-based application therefore supports conversations along stable documents (termed “Living Documents”) where through development of consensus the outcomes may again feed into the guidelines. These conversations are made persistent and can be annotated with the maturity of knowledge they express (e.g., individual opinion compared with agreed guidelines). To promote adoption and conversations, the system can also take an active role of notifying the user about changes in a specific guideline. Users are made aware of the maturity of these pieces so that they can judge how useful and reliable they are for their own practice. These conversations take place within Personal Learning Networks, and therefore PANDORA supports seeking support among professionals in those networks (see Figure 3) and ensures that question and answers provided are easily accessible. To support the further development and extension of personal networks, the system tracks the conversations as networks of people and data and makes recommendations for trusted experts, conversations or documents.

Figure 3: PANDORA Seeking Support
Domain Scenario & Evidence. When in the focus groups they were asked about how they dealt with different types of materials (such as guidelines or advice on single cases), it turned out that the varying maturity and context dependence presented a major barrier for professionals to make use of the knowledge conveyed in those materials. The design therefore distinguishes between different levels of maturity which contrasts it to other collaborative editing tools available. It was also found that relevant scenarios differ between practices (implementing guidelines, conducting significant event audits, and cascading training and implementing changes to work practice), but share the same systemic pain points, for instance lack of time and mobility issues, need for cross-organizational exchange, or the exchange of opinions and discussions. Trust has been found to be a key aspect when seeking support both from documented as well as from personal sources. Results from two workshops showed how participants tended to trust peers who are similar to them in terms of professional profile. 12 of 13 participants in one workshop wanted to organize their trusted contacts by groups to share information (such as Q&A).

As healthcare professionals mainly rely on face to face support and help seeking, and opportunities for taking time away from the clinic to attend cross-organizational training or networking events are limited, the proposed solution was received well in co-design particularly because it would open up opportunity to seek and develop opinion and information from “similar peers like me in other locations”, and one of the practice nurses reported she “didn't see the benefit of LinkedIn but I do for this.”

BITS AND PIECES

Domain Problem. Informal learning is episodic in nature, meaning that episodes of learning experiences are distributed over working time, and stored in episodic memory (Eraut, 2000). Healthcare professionals are usually working under high time pressure, preventing them from instantly making sense out of important experiences they have encountered. This lack of time to reflect may negatively influence the achievement of possible learning outcomes, prevent them from sharing them with others and eventually improve their practice.

Design Solution. As the quick and intuitive collection of bits and pieces of information (web links, media, picture recording, speech to text etc.) to capture informal learning experi-
ences is already sufficiently supported by tools such as Google Keep\(^2\), Osmosis\(^3\), or Evernote\(^4\), we initially relied on Evernote but will later include other collection services as well. To complement collection, our prototype provides support for remembering the corresponding informal learning experiences by the collected traces and making sense out of them. For remembering, the tool provides cues (e.g. time, place, topic, or person) connected to the collected pieces of information allowing users to retrieve and make sense of them at a later stage. This is shown in the upper canvas of Figure 4, where a user can scroll through a zoomable timeline and receive additional meta-data about the elements (resource, user, content etc.). In the lower canvas the collected elements can then be individually organized and sorted into collections, and tagged, annotated or named. This should promote the process of mental categorization and connection to other experiences, and transform experience into more generalized knowledge and influences future action (Eraut, 2004). Related approaches such as TalkApp (Prilla, Degeling & Hermann, 2012) focus on the collection and reflection of informal learning experiences, but do not provide support for organizing them. As opposed to this, sensemaking is supported by approaches such as Apolo (Horng, Chau, Kittur, Hong & Faloutzos, 2011) for visual sensemaking, but lack the focus on one’s own learning experiences.

**Figure 4: Bits and Pieces user interface**

*Domain Scenario & Evidence.* During design activities we found evidence for the importance of a tool that provides healthcare professionals with one place to record, develop and share informal learning experiences, and that allows them to further reflect outside the tight operational schedules. A practice manager felt it was good to encourage people to return and reflect on recorded experiences. The tool is in line with some of the existing practices we ob-

\(^2\) [https://drive.google.com/keep/](https://drive.google.com/keep/)
\(^3\) [http://osmosis.me/](http://osmosis.me/)
\(^4\) [http://evernote.com/](http://evernote.com/)
served around collecting notes for attending to them at a later date (e.g. two nurses storing resources in an email folder, one using a “box file” to store learning moments, others using paper lists for reminders). Five health care professionals in two co-design meetings indicated that there is interest in a corkboard style tool to organize these informal learning experiences. In particular, a timeline to remember on the collected learning experiences and an organizing view was highly appreciated by them when comparing them to other representations (such as locations). This was expressed for example by one of the practice nurses who wanted to add more abstract ideas to her collected materials. Furthermore, extensions of the tool in terms of the creation of learning paths were seen essential for demonstrating outcomes in learning portfolios. All wanted to export reports showing what they had learned for the revalidation process. Also participants requested functionalities for sharing and collaborative editing.

SHARING TURBINE

*Problem.* Sharing Turbine targets at a boundary object (the so-called White Folder) between formal training and informal learning at the workplace as part of dual system apprentice training in the building and construction sector. When introduced in 1999 in over twenty construction professions, the “white folder” was designed to bridge the gap between apprentices, their workplace company and their training institutions (Emken, 2002) and provide the missing link between formal and informal learning contexts. In the “white folder”, apprentices collect their formal training tasks in a project-based portfolio for later assessment by their trainers and also to provide proof of their learning to the supervisor at their workplace. The paper-based format, however, inhibits the immediate capturing of informal learning experiences at the workplace. That is, apprentices cannot easily physically access the folder when they are on the construction site, or share parts of it when demonstrating their know-how.

*Design Solution.* Sharing Turbine is developed as a mobile application, allowing direct access within the workplace. A learning task that is usually connected to a physical artefact can be associated to an individual or a group of learners. When a user performs the task, the tool *records experiences and learning whilst undertaking authentic work tasks* and links these to real world artefacts - both analogue and digital. The “white folder” provides a structure that links the experiences to the formal training curriculum, mutually enriching both contexts. The recorded learning experience can be reflected upon, again both in informal and formal contexts, and forms a *personal learning portfolio.*
Domain Scenario & Evidence. Apprentices liked the idea to document work results directly in context, and also trainers saw this as an opportunity to improve documentation of their learning. Moreover, a great potential was seen for the tool to create a community of learners where the training centre professionals can share their learning experiences, allowing people to share their practical knowledge such as ‘tricks of trade’. This would unlock knowledge and experiences that are currently mainly passed on unsystematically and in face-to-face situations.

CAPTUS

Domain Problem. CAPTUS was formed around the problems in sharing the learning about new methods and materials in ecological and sustainable construction. The network has SMEs with varying attitudes towards information technology, and the business opportunities are often limited by availability of skilled workforce for specific methods and how to make use of them in practice. In face to face settings, this sharing of practices makes use of nonverbal scaffolding activity through pointing, showing by example or undergoing some experience together and pointing out the important aspects of it. This makes scaling learning in this setting a particular challenge.

Design Solution. The first CAPTUS prototype is an Android application for saving and annotating very short video clips. The application is called *Ach So!* and it aims to support rapid recording of situations arising in the workplace. It supports meaning making in the work context that is not dependent on linguistic representations, and instead focusses on aspects that look or feel wrong or right. While people are natural at giving assistance in dialogical situations, they are worse at chaining these scaffolding activities together without cues from a learner. We assume that by recording single scaffolding activities at a time, this shortcoming can be overcome. Popularity of services such as Vine and Instagram’s video sharing that support only very short clips, (6s. for Vine, 15s. for Instagram) suggest that very short clips can provide meaningful content for interested peers. For this reason, the recorded clips in *Ach So!* are scaffolded to specific genres ('problem', 'problem solved', 'tricks of trade' and 'don't do
this’) and this should help professionals to get used to short video clips for specific purposes instead of prepared videos.

In order to blend into working practices, Ach So! supports annotation by pointing and adding textual notes to interesting targets directly into the video picture (see Figure 5). This allows for pointing out objects and actions in the scene and enhancing the scene with specific knowledge, e.g. names of parts. The annotation is emphasized in playback by automatically pausing the video for three seconds per each annotation which also supports annotation of fast moving scenes. We expect that a video clip service is seen as useful if it is perceived to have necessary content vividness, richness, suitability to task and managerial support (Lee & Lehto, 2013; Son et al., 2012), and these criteria are easier to reach if the videos are short and the service is designed for specifically learning in construction.

**Figure 5: The CAPTUS mobile user interface**

*Domain Scenario & Evidence.* During contextual inquiry and co-design, the problem situations were often described to occur with specific work tools or at specific sites. Therefore, Ach So! makes use of the location services of the device to find nearby clips. Videos can also be tagged with any readable QR- or barcode in the vicinity, allowing to read the code with Ach So! and find resources that are linked to it. Experimenting with different types of recording devices during co-design, we came to the conclusion that the critical factors are the availability and quick access to a recording device, adequate quality of the recording, quick access and handling of the interface and the control and trust of what happens with recorded material. The app designed for this purpose can fulfil these criteria and it needs to be further explored whether this will allow workers to pause their work, and revisit and record an experience.

*The Integrative Model of Scaling Informal Learning*

By systematizing the diverse activities and technologies and relating them to the original theoretical discourses, the design-based research has enabled us to integrate the different perspectives on technology-enhanced processes around scaling informal learning in the workplace. We suggest a model of three intertwined processes of learning activity (see Figure 6)
that allows orchestrating the technologies described in the introduction and showing the role of the design solutions in the learning process.

Task performance, reflection and sensemaking describe the processes of experiencing, reflecting about, sharing and collectively validating the learning moments connected with task performance. While much of expert performance is based on tacit knowledge where developed schemas are fine-tuned without the need of much explicit reflection, sometimes the experiencing of learning moments triggers more explicit reconsideration of existing schemas. Having the possibility to record those experiences in the situated context for more extensive sensemaking and reflection later on may enhance individual practice in the long-term. Technologies that support these processes need to help the emergence of a shared understanding (e.g. through semantic technologies) and tightly fit into existing working practices. Hence, the design in the healthcare domain revolved around note taking and collecting (BITS AND PIECES), while in the building and construction domain recording of videos with mobile or wearable technology were considered (CAPTUS). Recorded experiences can be shared more widely and validated by the community via social networking and community technologies to make them useful for others (SHARING TURBINE).

Help seeking, guidance and support describe the processes in which individuals seek, provide and find support from collective knowledge (social networking and community technologies). Experiencing the need of help in the context of performing a task at work may trigger a process of seeking help from documented sources, or from other persons or from both (PANDORA). On the other hand, in providing help, experts may draw upon or create supportive resources. Materials generated or traces left of successful help-provision interactions can be utilized for others’ in need by recommendation mechanisms (adaptive technologies). In the building and construction sector, there is an opportunity to provide the support directly in the physical task context using video recording and QR tags to connect physical artefacts with scaffolds that collectively emerge around them (CAPTUS).

Emergence and maturing of collective knowledge describe how individual learning interactions, their traces and related materials are made available to others (SHARING
TUBRINE, BITS AND PIECES). When others are made aware of these via social networking and community technologies, individual uptake or a broader negotiation in a community setting can occur. This can then trigger processes of co-creation and knowledge maturing in which materials are refined and developed into more mature cultural artefacts and made available for a wider target group, e.g. around “Living Documents” (PANDORA). A collective knowledge cycle can also start with the provision of cultural artefacts (e.g. existing normative guidelines) which then need to be adopted locally (PANDORA). Collective knowledge that emerges as part of this process, such as documents, aggregated trust or knowledge structures and their interrelations captured in semantic technologies, then provide the context for individual sensemaking or help seeking.

Figure 6: Integrative Model of Scaling Informal Learning

The model that has emerged from our design-based research effort can be used to more systematically design mechanisms to scale informal workplace learning. This is in contrast to similar models which are predominantly descriptive in that they seek to frame empirical research on how people learn in the workplace, such as Littlejohn, Milligan & Margaryan (2011) who suggest knowledge workers consume, connect, create and contribute to collective knowledge.

Furthermore, our model points particularly at the intersections between the three processes. For example, trusted sources that individuals draw upon in help seeking are the ones where trust or knowledge has accumulated in the collective knowledge process, or shared understanding that has emerged in co-creation provides the basis for guidance process or individual sensemaking. Other models that look at the interaction between collective and individual knowledge, such as the Co-evolution model of knowledge building (Cress & Kimmerle, 2008) or the model of Personal and Social Knowledge-Building (Stahl, 2000), have originated from the study of formal educational settings. These attribute collaborative learning to the interaction between individual, the group and collective knowledge that is mediated by shared artefacts. In our model, these would cover interactions between the individual sensemaking and the collective knowledge processes.

To put this model into practice, we have recently developed a software component that captures the representation and generation of meaning and facilitates the social processes around it. We call this cloud-base framework the Social Semantic Network and Services
(Kowald, Dennerlein, Theiler, Walk, & Trattner, 2013). It serves as a common basis for the four design teams and provides common services, such as sharing and tagging. It also tracks all activities with the connected tools to generate more meaningful relations between persons, artefacts, conversations and other resources. The network allows for discovering patterns that emerge from interactions of people with data and other people (such as who is trusted source, what is a mature document or which ongoing discussion is relevant for my current context). These patterns can then be used to recommend experts, documents, conversations and other resources related to the current problem. In this sense, the approach meaningfully orchestrates adaptive, social and semantic technologies that will play a key role in allowing professionals to draw on collective knowledge and to scaffold learning in a networked workplace context.

Conclusions and Outlook

Current learning technologies mostly facilitate formal learning in well-structured domains. To scale informal learning in complex and dynamic domains, we have suggested taking an integrative view on pedagogies and technologies. We have shown how four design solutions have emerged to address typical challenges in informal learning in such domains, and a model that captures key processes around the support of informal learning. In line with our focus on informal learning and based on an in-depth inquiry into the domains, the design solutions proposed here are all characterized by a low-barrier approach to blend into existing work processes and practices. A second design iteration is now ongoing in which the designs are refined and applicability of the designs across the sectors is explored. Through this, the tools together with the conceptual framework and a common integrative back-end will evolve into a new learning infrastructure that will help scale informal learning.

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References


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Practitioner Notes

What is already known about this topic

- Several technological means to scale informal learning at the workplace have been proposed, but each looks at only part of the problem.

What this paper adds

- We are suggesting four design solutions for challenges around scaling informal workplace learning that have been derived from a large-scale participatory design-research effort in the healthcare and construction sector
- We are also suggesting an integrative model that helps to understand all necessary aspects around scaling informal learning, how they play together and the technological means to achieve them.

Implications for practice and/or policy

- Practitioners can learn from some good-practice design solutions derived from a thorough understanding of the domains, and use the framework to map their own situation around the use of technology for informal learning
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237x163mm (96 x 96 DPI)
Integrative Model of Scaling Informal Learning

204x199mm (300 x 300 DPI)