Scaling Informal Learning: An Integrative Systems View on Scaffolding at the Workplace

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Abstract. While several technological advances have been suggested to scale learning at the workplace, none has been successful to scale informal learning. We review three theoretical discourses and suggest an integrated systems model of scaffolding informal workplace learning that has been created to tackle this challenge. We derive research questions that emerge from this model and illustrate these with an in-depth analysis of two workplace learning domains.

Keywords: Workplace Learning, Informal Learning, Scaffolding, Scaling

1 Introduction

Despite the recognized importance of informal learning at the workplace, most technological solutions are targeted towards a learning model based on the ideas of direct formal instruction [1]. In contrast to formal instruction that is organised along curricula, workplace learning takes place through work processes, is multi episodic, is often informal, is problem based and takes place on a just in time basis [2] and often involves the passing on of skills and knowledge from skilled workers [3]. Learning trajectories [4] emerge as a result of those learning episodes in the context of situated

learning, when individuals meaningfully connect them, reflect about them and advance their competence.

While this learning from individual experience is highly effective and intrinsically motivating for the individual [6], it does not scale very well: if individual experiences are not further taken up in systematic organizational learning practices, learning remains costly, fragmented and unsystematic. Scaling up informal learning would enable a learner to receive meaningful, relevant and individualized support for his learning needs in the context of his work, and take better advantage of the multitude of learning opportunities that are available around him. A number of learning technologies have been suggested to scale learning, but each focus only on a single aspect of informal learning. *Adaptive Learning Technologies* scale guidance by codifying some of the strategies and rules that a human tutor would use. *Social Networking Technologies* scale personal interactions by extending and augmenting the reach of personal network. *Semantic Technologies* scale the representation and generation of meaning.

With this paper, we suggest an integrative model for scaffolding informal workplace learning that integrates these technological perspectives, and suggests new research directions to scale informal learning at the workplace.

2 Towards an Integrated View of Scaffolding Informal Learning

The technologies briefly discussed in the previous section have each originated from one of three distinct theoretical discourses on learning and its support (see Figure 1). The first of these is the *Pedagogical Perspective* which deals with scaffolding self-regulated learning. Scaffolding as a metaphor refers to the provision of temporary support for the completion of a task that a learner might otherwise be unable to achieve [7]. This perspective, therefore, looks at the effects of temporary support structures on learning with the aim of facilitating self-regulative processes. Scaffolding is an approach to providing relevant guidance for learning by grounding the task between a more capable peer or teacher and the learner, thus creating a shared understanding of the task [7,8]. This requires fine-tuned support based on an ongoing diagnosis of the learner's level of understanding and changing knowledge and skills [9]. There is a close relationship to adaptive learning technologies.

Whereas the pedagogical perspective puts a focus on the individual agent's learning, scaffolding in socio-technical systems is not restricted to interactions between individuals with differing skill levels, but it also includes interactions with artefacts, networks and peer groups [10]. A Community of Practice (CoP) [11] is a concept to systemize these interactions. CoP develop as a learning collectivity in situated workplace setting, in which persons have dense relations of mutuality based on social relationships (for example trusting each other based on expertise and support) and social bonds (based on working with each other or having virtual connections). Nardi et al [12] highlight the use of embedded intensional networks which are highly strategic personal networks to meet individual learning needs. Within the CoP, members share cognitive communality which is created while working on joint enterprise, using shared repertoire (tools, objects, artifacts, rules) and shared knowledge. Learning in a

CoP happens by a process of peripheral legitimate participation in which newcomers are encultured to the CoP. In extending CoP, the knowledge maturing framework [13] takes a closer look at how collective knowledge is developed along a number of discrete phases, and how the characteristics of knowledge change. We call this perspective the *Community Perspective*.

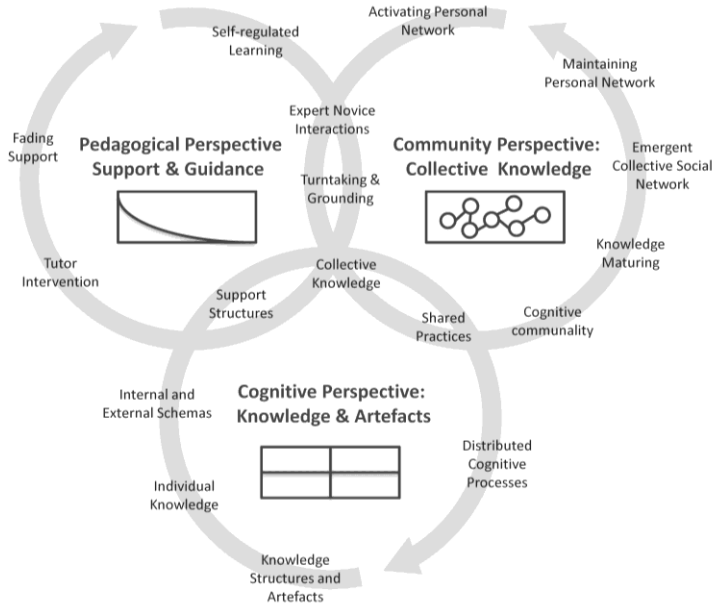

Figure 1: An integrated systems view on scaffolding informal learning at the workplace

Finally, a *Cognitive Perspective*, more clearly specifies how human performance in the workplace and its support relies on cognitive schemas. Schemas are knowledge structures, in which typical relations of the reality are represented based on previously made experiences reflecting a common way to make sense out of experiences, to represent typical tasks or problems [14]. Cognitive schemas possess a procedural component, in which bottom up and top down processes interact: i.e. specific environmental information activate a certain schema, which then determines further actions. Schemas may have conscious element during learning, but over time, schema application and use is automatized and enhances expert performance. Besides their function as internal knowledge representations, parts of schemas can also be explicated and represented externally in artifacts. In distributed networks of actors and artifacts that interact in a meaningful way, some knowledge is represented only in a distributed cognitive system [15]. Distributed cognition occurs when one cognitive task (e.g. solving a problem or making a decision) is distributed among people and artifacts that act as a single system [16] (e.g. in workflows and production chains).

Each perspective (Pedagogical, Community and Cognitive) looks at a system that in itself is self-contained (each of the three circles). For example, in the pedagogical perspective, a self-regulated learner enters into interaction with a more capable peer.

Through grounding, the two negotiate a common understanding of the task, and the more capable peer then uses support structures to adapt the support to the learner, transferring more and more responsibility to the learner. This in turn should influence self-regulative competence as well as acquisition of domain knowledge.

While each of the three systems is operationally closed and can therefore be analysed independently, we suggest that interactions between these sub-systems happen through structural coupling (see [17] for a similar argument) and this connects different levels of analysis: processes taking place in one of the systems trigger effects in another system. It is in these intersections where new research questions emerge.

3 Research Areas and Examples from Two Domains

From the discussion in the previous section, the following research areas emerge:

- Community and Pedagogical: How does collective knowledge emerge and mature in a community setting, and is then utilized in individual scaffolding interactions?
- Community and Cognitive: How do individual and collective knowledge influence each other, and how are these represented in digital or physical artefacts?
- Cognitive and Pedagogical: How do people appropriate and make sense of distributed knowledge representations and how are these utilized in scaffolding?

We have recently set out to tackle those questions[1]. Next, we illustrate our approach with results from an in-depth analysis of two workplace learning domains.

3.1 Health Care: Scaffolds emerge from collective knowledge processes

In the UK, health sector national guidelines are published by NICE (http://www.nice.org.uk/) in three areas: the use of health technologies, clinical practice and guidance for public sector workers on Health promotion and ill-health avoidance. The guidelines are a result of considering all available scientific evidence to be taken into account when making decisions about treating a patient (evidence-based medicine). They are interpreted locally by General Practitioners (GPs) and other Health workers, and used in local practices. This local interpretation is challenging because the guidelines are written for the average and most common cases. In actual practice, however, GPs deal with individual patients with very specific conditions where it is sometimes necessary to deviate from the guidelines. In such cases, they may seek validation from a colleague in their trusted network. This can be considered a much weaker form of guidance and scaffolding as it revolves around the discussion of individual cases. Social network technologies could make these trusted personal networks more readily available for the person seeking validation and lead to "living local guidelines" that are interpreted in practice and adapted to local conditions. How

[1] Project "Learning Layers - Scaling up Technologies for Informal Learning in SME Clusters" (http://www.learning-layers.eu), partially funded under FP7, grant no: 318209

trust emerges and is represented in such network settings is one of the questions that we set out to answer.

In the wider professional network these discussions that evolve around the existing guidelines could be accumulated using semantic technologies to show where adaptations to the guidelines could be necessary. For example, certain rare illnesses are being introduced by increased foreign travelling and become more common. As these are being discussed, this emergent collective knowledge can be used to scaffold learners before these conditions are actually introduced into the guidelines.

3.2 Building and Construction: Scaffolding in distributed cognitive systems

Advanced educational institutions in the German construction sector require apprentices to complete several projects alongside their further training. These projects always follow the same sequence of steps learners have to go through: preparation, execution and quality assessment. This structure has developed over years as part of the practice of the construction trade and has been transferred into formal learning processes. While experts have internalized these structures and follow them automatically, apprentices learn them by keeping a paper-based portfolio (called "white folder") of their training projects, where each project is structured in the same way.

Digitizing the "white folder" would enable apprentices to easily return to some of their learning when back at the construction site of their employers. There they soon discover that at the real construction site, things often deviate from the taught standards. This provides the starting point for informal learning situations and enrichment of formal learning experiences. The digital white folder could enable the learners to co-edit and share knowledge on projects and to exchange their experiences. Thereby a distributed cognitive system could be created through which learning can be scaffolded. How individual knowledge and collective knowledge interact in such situations, i.e. how learners appropriate the aggregated experiences of others into meaningful assemblies, and how this can be adequately supported will be a focus of the project.

A particular challenge in building and construction is the role that physical tools and materials play in the learning process. While there is a body of knowledge about the use of tools and materials that can be taught in educational institution, there is also a large amount of individual knowledge among workers about specific tools and properties of construction sites. If some of this knowledge can be captured into related objects and locations, these objects and locations can work as improved support structures for apprentices. This could happen through tagging physical objects with temporary, company- or site-specific information about their actual use. We are testing how various wearable recording devices are suitable to record the use of objects, and are developing mobile tools to annotate and edit the recordings into learning resources.

4 Conclusions and Outlook

Current technologies mostly facilitate formal learning in well-structured domains. To scale informal learning in complex and dynamic domains, we have suggested tak-

ing a systems perspective that integrates perspectives on individual actors, their cognition and interactions within a system of actor networks and communities. This perspective eventually suggests viewing scaffolding as an adaptive system, in which the individual learner and the network adapt to each other in the scaffolding process.

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