Computer Support for Collaborative Reflection on Captured Teamwork Data

Kristin Knipfer, Knowledge Media Research Center, Tuebingen, Germany, k.knipfer@iwm-kmrc.de
Michael Prilla, Institute for Applied Work Science, University of Bochum, Germany, michael.prilla@rub.de
Thomas Herrmann, Institute for Applied Work Science, University of Bochum, Germany, thomas.herrmann@rub.de
Ulrike Cress, Knowledge Media Research Center, Tuebingen, Germany, u.cress@iwm-kmrc.de

Abstract: This paper describes the significance and peculiarities of collaborative reflection for the purpose of team learning at the workplace and presents accounts for computer-supported reflection on joint teamwork. The solutions we present provide support for collaborative knowledge construction and meaning making based on captured teamwork data. This includes support for articulation work and transfer of established scaffolding and guidance concepts for the generic scope of reflection. The integrative socio-technical framework intertwines technical support and intervention strategies to facilitate collaborative reflection and team learning. Considering existing support for CSCL, this approach transfers existing solutions to the real-world and evaluates their potential in the workplace setting.

Introduction: Reflective Learning at the Workplace

It is increasingly acknowledged that individuals learn far more from experiences than through formal training at the workplace (Eraut, 2000; Lave & Wenger, 1990). Reflection on one’s own work practice has been identified as one of the central mechanisms of learning at work (Argyris & Schön 1996; Boud, Koegl, & Walker, 1985; Dewey 1933; Kolb & Fry 1975). Reflection “in the context of learning is a generic term for those intellectual and affective activities in which individuals engage to explore their experiences in order to lead to new understandings and appreciations” (Boud et al., 1985, p. 19). Reflection leads to a better understanding of own work practice and work-related experiences and can guide future behavior (Järvinen & Poikela, 2001; Moon, 1999). Reflective learning enables flexible working routines and thus higher performance in a rapidly changing work context. Accordingly, reflection induces change and development as it leads to insights into working practices and identifies where working routines need to be modified. As most business organizations have implemented teams to face successfully the rapid changes and challenges in business life, we argue in this paper that research should consider team learning through collaborative reflection on joint work more comprehensively. Therefore, this paper investigates how the understanding of collaborative reflection can inspire the design of appropriate methods and tools to support collaborative reflection at the workplace. The research described in this paper as well as the design and the implementation of corresponding tools is embedded into the project MIRROR - Reflective Learning at work, which aims at engaging employees in reflecting on their own work practice and specific work-related experiences in order to learn from it. Besides the levels of individual and organizational reflection, collaborative reflection is a focal topic of the project.

The Significance of Collaborative Reflection for Team Learning at the Workplace

Although most models of reflection have a strong individual focus (see e.g., Atkins & Murphy, 1994; Boud et al., 1985; Gibbs, 1988; Kolb, 1984; Schön, 1983), the social dimension of reflection has recently been described by Dyke (2006), who highlights the role of sharing experiences for the purpose of learning (similar statements have been made by Hammond & Collins, 1994 and Orton, 1994). Joint discussion on experience is considered to stimulate and deepen individual reflection and to enable creative solutions. Social activities such as discussion on shared working routines, asking for feedback on own work practice, and social comparison processes are indicators of reflection that refer to the social dimension of reflection (Daudelin, 1996; Eraut, 2004; van Woerkom & Croon, 2008). Recent definitions of team learning thus include the notion of reflection explicitly, cp. Edmondson (1999, p. 353) who defines team learning as “an ongoing process of reflection and action, characterized by asking questions, seeking feedback, experimenting, reflecting on results, and discussing errors or unexpected outcomes of actions”. In accordance with constructivist theories of cognition, learning is considered to occur as collaborative construction of knowledge (Roschelle & Teasley, 1995). “Team learning occurs when individuals share their experiences thus, contributing their unique contextual knowledge to the team” (Kayes & Burnett, 2006, p. 10). In particular, the process of co-constructing knowledge leads to a deeper insight into a situation or problem, such that new and well-grounded knowledge can be achieved on the group level. Kayes and Burnett (ibid) describe the outcome of team learning as “a store of encounters and occurrences (knowledge) that shape and limit the repertoire of possible behaviors an individual and subsequently, the team,
may undertake”. Thus, team learning leads to team development for the purpose of improving team performance in the future.

We argue that the process of reflection is often accomplished collaboratively by a team or working unit performing a joint task and thus sharing work-related experience. This is illustrated by the following scenario:

A group of software developers has just finished a large project. During the concluding meeting, the team notices that their experiences of the project are very heterogeneous. Some are satisfied with the way the project was done, but others complain about problems during the project. A senior member of the team proposes that the team might come together again the next day and reflect on their team work. At the beginning of this meeting, the project team's first impression that different members experienced the project work differently was affirmed when they shared and discussed the individual understandings and impressions. To further clarify this, they decide to reconstruct the project work together in form of a project timeline. The version control of their software development kit and of their project wiki serve as database which helps them during this process. Then, they add information about individual activities, critical incidents and achieved milestones. During the collection of such material, some developers mention that they could not contribute their expertise to some tasks due to mistakes in coordination and that some tasks were done twice. These and other comments and insights are annotated to the material. Based on the resulting set of material, the team then reflects on problems with regard to motivation, communication and coordination and, as a result, establishes new rules for future teamwork such as regular evaluation meetings every two weeks. The team agrees on a common documentation of these rules as well as on a process of implementing them.

The major potentials of collaborative reflection within a team include learning from advanced peers, mutual assistance/reciprocal sense making, knowledge elicitation and explication of individual understanding, and integration of multiple perspectives and distributed expertise. We consider collaborative reflection as emergent phenomenon where a shared team understanding about work practice and work-related experiences is established together which then allows for learning from past teamwork experiences. The availability of shared material which mirrors recent work practices serves as a catalyst for this mutual reflection and sense making.

Computer Support for Team Learning through Collaborative Reflection

Drawing in the importance of collaborative reflection for learning in organizations, designing computer support for reflection on teamwork practice for the purpose of team learning is of vital interest for most professional organizations. In this section, we will discuss constraints, initial insights and potential solutions for collaborative reflection support.

Many promising approaches have been developed to support collaborative learning by means of technology: Recent software applications provide prompts for elaborated explanations, offer external representations for co-construction of ideas, make cognitive conflicts salient, structure interactions by means of role distribution, etc. Similarly, in the past years, several tools have been created which are suitable for supporting collaborative knowledge construction, such as wikis (Cress & Kimmerle, 2008), collaborative tagging systems (e.g., Held & Cress, 2010; Viegas et al., 2007), concept maps or systems for group discussions (Nakakoji, 1999; Kerne et al., 2008). In the context of CSCL, features have been developed which support discursive learning and the contextual annotation of material (Herrmann & Kienle 2008) or the coupling of chat and graphical data (Stahl, 2009), guidance and scaffolding of knowledge building (Pea, 2004; Carell, Herrmann, Kienle, & Menold, 2005), or the negotiation of various views and standpoints (Prilla & Ritterskamp, 2006; Carell & Herrmann, 2009). These tools have shown to be beneficial in settings where both content and tasks are adapted to learning goals and participants’ prior knowledge. Notwithstanding the undisputed benefits stemming from CSCL solutions, workplace learning raises additional challenges which we outline in the following.

The Peculiarities of Team Learning at the Workplace through Collaborative Reflection

Our approach transcends and extends existing work on CSCL in at least two dimensions: First, our approach puts concepts and success factors of CSCL to the test in workplace settings. While many concepts such as scaffolding and guidance have been shown to be beneficial in educational settings, surprisingly little is known on their application in real work settings, which refers to the context dimension of collaborative reflection at work. Second, our approach is based on using recorded data from team work. This not only raises the question how to gather and make such data accessible. Furthermore, there have to be means enabling people to interact with these huge amounts of data and to make reflection results and corresponding data both sustainable and shareable. In what follows, we will elaborate on these two aspects.

The Context Dimension: Teamwork as Task and Social Processes

We must consider that teamwork at the workplace refers to aspects of team effectiveness with regard to the task the team is required to achieve - which has usually nothing to do with learning in the first place. However, team learning is strongly interrelated with task performance if we consider that learning from past teamwork experiences is crucial for enhancing future team performance (Edmondson, 1999). Team performance thus depends on a team's ability to learn from past teamwork experience by means of reflection on a team's own work practice. As teamwork includes two main aspects, namely the task-related (cognitive) demands and the
The social demands of coordination and communication during teamwork (West, 2004), any support for team learning through reflection must necessarily account for both aspects of teamwork and support reflection on task performance and on social interaction.

**The Data Dimension: Teamwork Data as the Basis for Collaborative Reflection**

While formal learning can be supported with material which has been extracted from its real world context for educational purposes, reflection at the workplace has to be based on material that "mirrors" real work practice. Recorded data from teamwork provide a comprehensive basis for a team's collaborative reflection on their work practice and thereby enhances a team's awareness on shared work practice. We consider different data sources - which produce data of different granularity on different semantic levels (see Table 1 for the context of a health care organization).

**Table 1: Data base for reflection and its sources**

<table>
<thead>
<tr>
<th>Description</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensor data</td>
<td>Stress level measures, GPS logs of co-workers</td>
</tr>
<tr>
<td>Work flow data</td>
<td>Average response time to emails</td>
</tr>
<tr>
<td>Pictures and videos</td>
<td>Video recordings of cooperative care</td>
</tr>
<tr>
<td>System log files</td>
<td>Last modifications of shared files</td>
</tr>
<tr>
<td>Application content</td>
<td>Shared calendar entries</td>
</tr>
<tr>
<td>Explicit notes</td>
<td>Documentation of patients’ behavior for shift handovers</td>
</tr>
<tr>
<td>Work documentation</td>
<td>Meeting minutes</td>
</tr>
</tbody>
</table>

Using captured teamwork data for collaborative reflection not only needs sophisticated means of gathering and aggregation of the data, but people need to be supported in interacting with this data, e.g., in relating different data snippets to each other and in articulating their individual understandings. Collaborative sense making is needed to add shared meaning to the recorded data. A specific challenge lies in the need to combine multiple data sources meaningfully. Additionally, it needs a step beyond existing insights on the usage of visualizations for learning (e.g. Suthers & Hundhausen, 2002). Both extensions raise intellectual and representational complexity for corresponding organizational and technical solutions.

**Challenges of Designing Computer Support for Collaborative Reflection**

In our research on collaborative reflection in the larger context of the project MIRROR, we aim at evaluating recent CSCL solutions with respect to their applicability in real world contexts. As can be seen from the challenges described above, this will have to include discursive knowledge articulation and construction as well as guidance for shared meaning making based on multiple representations of shared work practice. We suggest a socio-technical solution for collaborative reflection and knowledge construction that combines organizational methods and processes with information technology and intervention strategies.

Collaborative reflection involves individuals’ own reflection, the sharing of preliminary individual understandings, discussion to establish a shared understanding of the experience, and the construction of "lessons learned" from past experience. This understanding is in line with Stahl’s cycles of individual and collaborative learning (Stahl, Koschman, & Suthers, 2006), the co-evolution model of Cress and Kimmerle (2008) and the considerations on distributed cognition of Salomon (1993, p. 134). Consequently, our approach focuses on three crucial processes to support this, namely the reconstruction of shared team experiences by means of articulation of individual understandings, support for negotiation of individual understandings and meaning making from a shared experience, and the convergence and construction of new knowledge:

1) **Articulation support:** As stated above, collaborative reflection and team learning relies on communication and discourse of the team members. We suggest that collaborative reflection on captured teamwork data can be facilitated by specific means to comment on such data material and to support individual articulation (Suchman, 1996). Individual annotations on teamwork data can then be used for joint discussion on this data material again. On the technical side, this will include enabling users to annotate the available data. Comments will be possible as textual comments and (semantic) tags as well as audio and video annotations. Through individual and collaborative annotations, a rich and comprehensive database to guide collaborative reflection will be made available. This will enable teams to make sense of captured teamwork data and to use it for further reflection through negotiation of individual understandings of past teamwork experience. Our research in articulation support will focus on the identification of articulation needs, the design of appropriate tools to support articulation of preliminary understandings of teamwork practice and the integration of various options for articulation mechanisms.
2) **Scaffolding and guidance support:** Collaborative reflection includes the identification of relevant material, the specification of concerns, a thorough analysis of information, the (re-)evaluation of teamwork experiences and drawing conclusions or making generalizations. These are complex cognitive and social processes which should be supported by scaffolds (Pea, 2004) and facilitation (Herrmann & Kienle, 2008). There might be factors that hinder efficient learning through reflection such as communication and coordination barriers, heterogeneity of backgrounds, or biases in group cognition (e.g., group think). As a consequence, solutions for guiding and scaffolding should include support for synchronous and asynchronous reflection processes such as the functionality of external referencing to parts of recorded material, visualizations of the process of communication and reflection, or summaries and control of the interplay between questions, answers and arguments. We will develop a portfolio of methods and corresponding applications enabling smooth transitions "from mirroring to guiding" (Jermann, Soller, & Muehlenbrock, 2001) in real work settings. This will facilitate the knowledge construction process and make its outcomes visible, shareable and sustainable within the organization.

3) **Synergy support:** Supporting articulation and guiding people through the collaborative reflection process intends to produce good reflection results. In order to help people reach such results and to make them sustainable, processes of convergence and the construction and explication of new knowledge have to be supported. For this, methods and tools for discussion support such as rating, structuring, negotiation etc. are needed as well as support for drawing conclusions from past teamwork experience to guide future behavior. Support is needed that helps the team to have more analytical insights into a problem and to find more creative problem solutions than the individual members. Synergy support will help to identify consensus but also conflict in understandings. We will implement voting and tagging to support structuring of reflection material and converging parts of the articulated reflection into new ideas which go beyond individual reflection.

To conclude, our research intends to provide a integrated solution for applying collaborative knowledge construction and meaning making to captured teamwork data by supporting articulation on shared team experiences and co-construction of knowledge for the purpose of team learning. Additionally, it aims at using concepts of scaffolding and guidance for the generic scope of reflection and integrating these solutions into a socio-technical framework, which intertwines technical support and intervention strategies. In order to accomplish these goals, further work will be focused on investigating processes of collaborative reflection and evaluating corresponding support in real world settings.

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