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Scripting for construction of a transactive memory system in multidisciplinary CSCL environments

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A B S T R A C T

Establishing a Transactive Memory System (TMS) is essential for groups of learners, when they are multidisciplinary and collaborate online. Environments for Computer-Supported Collaborative Learning (CSCL) could be designed to facilitate the TMS. This study investigates how various aspects of a TMS (i.e., specialization, coordination, and trust) can be facilitated using a transactive memory script that spans three interdependent processes (i.e., encoding, storage, and retrieval) in multidisciplinary CSCL. Sixty university students were assigned to multidisciplinary pairs based on their disciplines (water management or international development). These pairs were randomly assigned to a scripted or non-scripted condition and asked to discuss and solve a problem case. The script facilitated construction of a TMS, fostered learners' knowledge transfer and convergence, and improved the quality of problem solution plans. Specialization and coordination aspects of the TMS were mediators for the impacts of the script on joint but not individual problem solution plans.

1. Introduction

For solving complex problems, professionals often need to collaborate in multidisciplinary teams. The main advantage of such teams is that their members benefit from one another's complimentary expertise and bring various perspectives to bear on a problem to create new ideas. Such a knowledge integration in two or more disciplines may raise new questions in such a way that would have been impossible through single-disciplinary thinking (e.g., Boix-Mansilla, 2005). However, newly-formed multidisciplinary group members have little meta-knowledge about one another's knowledge, hence, they may encounter difficulties during collaboration, such as coordinating joint problem-solving activities (Barron, 2000), establishing common ground (Beers, Boshuizen, Kirschner, & Gijselaers, 2005), pooling and processing unshared information (Rummel, Spada, & Hauser, 2009), and converging towards shared knowledge (Roschelle & Teasley, 1995). This lack of knowledge can negatively affect the exchange of unshared information especially in newly-formed groups (Schreiber & Engelmann, 2010). Encoding, storing, and retrieving knowledge in the group whilst building on and expanding knowledge about learning partners' expertise is named Transactive Memory System (TMS) (Wegner, 1987, 1995).

Recently, some studies (e.g., Schreiber & Engelmann, 2010) have shown that Computer-Supported Collaborative Learning (CSCL) can be designed to overcome barriers for establishing a TMS. Using concept maps to visualize collaborators' knowledge structures can initiate construction of a TMS, which in turn benefits group performance (Schreiber & Engelmann, 2010). In this paper, we present another innovative approach to facilitate construction of a TMS using a transactive memory script. Scripts have shown to be a promising approach to orchestrate various roles and activities of learners, to facilitate interaction and task coordination, and ultimately to foster learning (see Fischer, Kollar, Mandl, & Haake, 2007; Noroozi, Weinberger, Biemans, Mulder, & Chizari, 2012; Weinberger, 2011). This study examined the extent to which a TMS could be facilitated by a transactive memory script in a multidisciplinary setting. In addition, the extent to which this specific script influenced learners' knowledge transfer as well as joint and individual problem solution plans was studied.

1.1. Transactive memory system

The TMS theory (Wegner, 1987) originally described how families coordinate their memory and tasks at home. It refers to the interactions between individuals' internal and external memory

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systems while communicating (Wegner, 1987, 1995). Meanwhile, TMS has also been studied in educational settings (e.g., Engelmann & Hesse, 2010). In collaborative learning, not only one's own knowledge as an internal source comes to play but also the learning partners' knowledge as external sources. In a TMS, group members need to look for external memories to identify the existence, location, and mechanisms for retrieval of knowledge held by other group members. A TMS thus combines the knowledge stored in each individual's memory with knowledge structures of the learning partners for developing a shared awareness of who knows what in the group (Moreland, Argote, & Krishnan, 1996, 1998). A TMS refers to group members' knowledge awareness, the accessibility of that knowledge, and the extent to which members take responsibility for providing knowledge in their own area of expertise and for retrieval of information held by others in the group (Lewis, 2003; London, Polzer, & Omoregie, 2005). These processes could result in forming a collaboratively shared system of encoding, storing, and retrieving information for enhancing group performance (Wegner, 1995).

1.2. Various processes of a TMS: encoding, storage, and retrieving

Establishing a TMS in a group involves three interdependent processes: encoding, storage, and retrieval (Wegner, 1987, 1995). In collaborative settings, group members work best when they first discover and label information distributed in the group, then store that information with the appropriate individual(s) who has/have the specific expertise, and finally retrieve needed information from each individual when performing the task some time later (Rulke & Rau, 2000; Wegner, 1987, 1995). In the encoding process, directory updating begins with the process of getting to know "who knows what" in the group (see Schreiber & Engelmann, 2010). During this process, group members gain an estimation of their partners' areas of expertise, and categorize this information by ascribing each knowledge domain to the corresponding persons (Liang & Rau, 2000). In the storage process, group members store information with the individuals who have the specific expertise on a particular topic. During this process, group members allocate new information on a topic to the relevant experts on that topic. In the retrieving process, group members retrieve required information from the experts who have the stored information on a particular topic (Wegner, 1987, 1995).

1.3. Various aspects of a TMS: specialization, coordination, and trust

Establishing and maintaining a TMS has mainly been studied along with three main aspects of a TMS in a group, namely specialization, coordination, and trust (see Lewis, 2003). Specialization represents the awareness and recognition of expertise distributed in the group. Trust or credibility represents the extent to which group members trust and rely on each other's specific expertise. Coordination represents the group members' ability to work together efficiently on a learning task with a low degree of confusion and misunderstandings (Michinov & Michinov, 2009).

For this study, it is important to describe the relation between various processes and aspects of a TMS in collaborative learning settings. In the following section, essential interdependent processes for establishing a TMS (encoding, storage, retrieval) are explained in relation to the main aspects of a TMS (specialization, coordination, trust).

1.4. Relations between various processes and aspects of a TMS

Specialization is the product of the encoding process, which reflects the differentiation of one's own expertise from the knowledge repertoire of other group members (Wegner, 1995). This explication of expertise (encoding) allows the group to acquire complementary knowledge and enlarge its collective knowledge (Michinov & Michinov, 2009). Specialization occurs when group members encode one another's expertise and label information as belonging to members whom the group trusts most as the source of expertise (Lewis, 2003). Encoding could be best achieved through proper interaction between group members as a first essential step towards specialization (Wegner, 1987, 1995). This explication of expertise helps learners initiate a productive discussion to pool and process unshared knowledge resources rather than engaging in discussions of information already shared among them (e.g., Rummel et al., 2009; Stasser Stewart, & Wittenbaum, 1995) or discussions to establish common ground (Beers et al., 2005). Speeding up the process of pooling unshared information as a way to heighten awareness of distributed knowledge resources in a group can be seen in the form of knowledge elicitation or externalization for the learning partners according to their areas of specialization. These transactions may further be followed by the exchange of specialized feedback in the form of enquiry, clarification, or elaboration of the learning materials (e.g., Rummel & Spada, 2005).

Specialization plays an important role during the storage process. Based on the estimation of knowledge awareness and recognition of expertise distributed in the group, learners can coordinate the distributed knowledge, assign responsibility to the expert in the group, and store relevant information that fits their domains of expertise (Wegner, 1987, 1995). Coordination also plays a key role during the storage process since group members need to assign responsibility to the individual who has the most expertise on a particular topic (Lewis, 2003; Rulke & Rau, 2000). Coordination in a group is best achieved in the storage process when learners share the task and collaboratively assign responsibilities based on the labelled information in the encoding process (Lewis, 2003). Trust is also important during the storage process since learning partners should make sure that the knowledge that is required for solving the task is stored by one of the credible group members.

Coordination comes to play during the retrieval process since group members need to turn to the relevant experts for the retrieval of information based on the members' expertise (Wegner, 1995). Retrieval coordination is best achieved when group members provide relevant information on the topic and analyse parts of the task based on assigned tasks and roles in relation to their specialized expertise. Finally, they can combine their analyses followed by discussions and elaborations on the basis of their own and the learning partner's specialized expertise (Lewis, 2003; Rulke & Rau, 2000). Trust also plays an important role during the retrieval process since learners need to make sure that the partners' stored information is credible when combining and retrieving knowledge and information for accomplishing the joint learning task. In problem-solving settings, learners may use their meta-knowledge for coordinating subtasks and the division of labour such that their individual contributions can later be assembled into a group product (Dillenbourg, 1999). In such an approach, learning partners typically split the task, and individually take responsibility for part of the task based on their expertise and then assemble the partial results into the final output. Learners may also use their meta-knowledge for elaborating on the material, integrating and synthesizing one another's perspectives and ideas in order to jointly make sense of the learning task (e.g., Schoor & Bannert, 2011; Weinberger & Fischer, 2006). This productive interaction followed by persuasive discussions would help learners revise, modify, and adjust their initial contributions on the basis of their partners' contributions. In this form of combining knowledge, partners use their meta-knowledge not only for coordinating