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Supporting learning using external representations

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ABSTRACT

External representations can be powerful for supporting learners in both individual and collaborative learning scenarios. They encourage learners to focus on important instructional elements. In this study, we investigate two different forms of external representations: textually represented collaboration scripts and graphically represented content schemes. Fifty-three triads of university students are assigned to four experimental conditions involving the factors *collaboration script* and *content scheme*. Results show that learners particularly benefit from the content scheme. Its graphical elements help focus the learners' collaboration and they therefore achieve better outcomes.

1. External representations in learning scenarios

The term external representation is very broad and can be described as knowledge and structure which is displayed by physical symbols, objects or dimensions (see Zhang, 1997). External representations can consist of textual information, such as a book or a written guideline. They may also contain graphical information as visualizations and structures (see Löhner & van Joolingen, 2001; Suthers & Hundhausen, 2003; Zhang, 1997), for example in the form of tabular templates.

External representations are of particular importance in computer supported collaborative learning scenarios (Fischer & Mandl, 2005). In videoconferencing, learners can share external representations through application sharing. This provides a *permanent display* of knowledge and structures (Larkin, 1989; Pächter, 1996) and *open access* to its contents for each learner (Dennis & Valacich, 1999).

2. Instructional support using external representations

External representations serve as a focus for learners' attention. This allows an instructor to introduce specific aspects to the learning process. Suthers and Hundhausen (2003) call this "representational guidance": the creator of an external representation provides several aspects upon *which* learners should focus. This may encourage learners to work on specific aspects that might otherwise have been neglected. Possible applications may be, for example, a procedure for working on the task and for collaboration (Pfister & Mühlpfordt, 2002; Weinberger, 2003) or particular content categories which should be considered (Brooks & Dansereau, 1983; Ertl, Fischer, & Mandl, 2006; Suthers & Hundhausen, 2003). Furthermore, the instructor can suggest *how* instructional elements are implemented. He may use a more textual implementation in the form of cues or prompts (O'Donnell, Dansereau, Hythecker, & Hall, 1988; Rosenshine, Meister, & Chapman, 1996) or scripts (King, 2007;

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O'Donnell & King, 1999) or a more graphical implementation in the form of schemes (Bransford & Johnson, 1973; Brooks & Dansereau, 1983; Ertl et al., 2006), tables (Suthers & Hundhausen, 2003) or visualizations (Fischer, Bruhn, Gräsel, & Mandl, 2002; Jonassen, Beissner, & Yacci, 1993; Suthers & Hundhausen, 2003). Both forms may contain the same instructional elements but use a different representational structure. In addition, the representational structure of the instruction may have an effect on learners' performance with a task. Zhang and Norman (1994) characterize this representational structure by the degree to which it makes particular instructional elements salient to the learners. The salience of the elements is rather low when learners receive more textual guidelines for solving a task. In such cases, the learners determine how they follow these guidelines and, if they choose to follow them, they have to do this consciously. The degree of guidance in such cases is rather low (see Weinberger, Ertl, Fischer & Mandl, 2005). When instructional elements are presented in a more graphical form, learners may perceive them as an essential aspect of the task. The degree of guidance is rather high and learners use the elements automatically when working with the representation. By doing so, learners may use the representational structure as a cognitive tool (see Resnick, 1989) and this may influence their ability to solve the task (Mayer, 1994; Zhang, 1997; Zhang & Norman, 1994). In this paper, we will use textual guidelines for collaboration-specific support and graphical elements for content-specific support.

2.1. Collaboration-specific support

External representations which provide textual guidelines for collaboration-specific support are usually called *scripts*. Scripts describe a sequence of activities that the learners use to solve a task and often introduce methods derived from scripted cooperation (see O'Donnell & King, 1999) or cooperative teaching (O'Donnell & Dansereau, 2000). These scripts offer learners a structure for their collaboration process and present learners with different stages that include specific activities and strategies. For example, the script developed by Ertl, Reiserer, and Mandl (2005) assisted learners during collaborative theory teaching. It introduced stages for explaining, clarifying, making notes, reflecting and discussing and was presented as a time sequenced guideline. Learners focused on theoretical concepts by applying the routine described in the script. It helped learners explain theoretical concepts more comprehensively and they achieved higher scores in this category with respect to their collaborative learning outcome (see Ertl et al., 2005). Furthermore, they received higher scores in an individual post-test. Other studies found beneficial effects of scripts in face-to-face scenarios (O'Donnell & Dansereau, 2000; O'Donnell & King, 1999; Palincsar & Brown, 1984; Rosenshine & Meister, 1994) and in videoconferencing (Ertl et al., 2006; Rummel & Spada, 2005). However, some studies carried out in the context of text-based computer-mediated communication were not able to prove a beneficial effect of scripts (see Weinberger, 2003). Therefore, the beneficial impact of scripts on collaborative learning has not yet been found universally and may be subject to influencing factors.

2.2. Content-specific support

In cases where external representations provide content-specific support, they often use graphical elements. These graphical elements provide a means of illustrating important aspects. They make these aspects salient and thereby modify the representational context of a task. This may be realized either by providing facilities for concept mapping (e.g. Fischer et al., 2002; Suthers & Hundhausen, 2003) or by providing tabular structures (e.g. Brooks & Dansereau, 1983; Ertl et al., 2005; Suthers & Hundhausen, 2003). Until recently, the effects of such representational structures were often studied within the context of individual learning (Brooks & Dansereau, 1983; Kotovsky & Fallside, 1989; Kotovsky, Hayes, & Simon, 1985; Larkin, 1989; Zhang, 1997; Zhang & Norman, 1994). Less is known about the use of graphical elements in group learning. However, the results of some studies show that they also have an effect when used in collaborative learning situations (see Ertl et al., 2006; Fischer et al., 2002; Suthers & Hundhausen, 2003). Ertl et al. (2005) presented learners with a tabular content scheme for collaborative theory teaching which contained the categories of theory, evidence and elaboration. They were able to show that the scheme specifically focused learners' attention on the categories of evidence and elaborations, which were neglected by learners without the scheme (Ertl et al., 2005). Fischer et al. (2002) investigated the effects of structural visualization similar to mapping. They found that the structure was able to focus learners' discourse and also had beneficial effects on collaboration outcomes. Suthers and Hundhausen (2003) reported similar results with respect to tabular structures. However, these content schemes did not affect learners' individual outcomes.

3. Learning scenario and subject area of the study

In the previous sections, we have seen that external representations can have different forms. They can be either collaboration-specific or focus on a particular topic. Consequently, applying external representations to facilitate learning is highly dependent on the learning task and the subject area. To demonstrate our expectations about the effects of support, we will describe the task and subject before formulating our specific research questions.

The learning scenario in this study involved case-based learning. Three learners were assigned the role of school psychologists and were given the task of finding reasons for a pupil's problems in school. Each of the learners received an individual set of case information which contained the framework of the story and statements about the pupil's learning behaviour.