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Managing knowledge with computer-based mapping tools

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Modern computer-based mapping tools may be used to visualize not only concept knowledge like traditional concept mapping tools, but also content knowledge (annotations, text and multimedia cognitive artifacts), knowledge about knowledge resources (e.g. websites, WBT programs, tools), as well as links between knowledge elements. In addition they provide free interactive access to mapped knowledge elements and, thus, may enhance knowledge use. It is suggested that computer-based mapping tools, in particular hypertext-like tools, may augment the capacity of the human brain in managing knowledge when students cope in a self-regulated manner with complex cognitive processing tasks, e.g. problem-based learning, web-based studying, hypertext writing. The paper aims at analyzing the potential of computerized mapping tools for supporting individual knowledge managing in e-learning scenarios.

Introduction

In order to cope effectively with the growing amount and the complexity of knowledge and knowledge resources in many domains there is a need for effectively organizing, storing, and localizing knowledge and knowledge resources. Modern computer-based mapping tools may help students managing these tasks. They may be used to visualize not only concept knowledge like traditional concept mapping tools, but also content knowledge (annotations, text and multimedia cognitive artifacts), knowledge about knowledge resources (e.g. websites, WBT programs, tools), as well as links between knowledge elements. In addition they provide free interactive access to mapped knowledge elements and, thus, may enhance knowledge use. It is suggested that computer-based mapping tools, in particular hypertext-like tools, may augment the capacity of the human brain in managing knowledge when students cope in a self-regulated manner with complex cognitive processing tasks, e.g. problem-based learning, web-based studying, hypertext writing. It is a conception of advanced learning, as part of general knowledge management, which is gradually being fading into the field of e-learning (Maurer & Sapper 2001). The goal of the paper is to analyze computer-based mapping tools with respect to their potential to support processes of individual knowledge management in complex cognitive processing tasks.

The contribution of mapping tools to fostering processes of knowledge management

Based on a model of Probst, Raub & Romhardt (1999) the following interacting process categories of knowledge management may be identified which are relevant for students coping in a self-regulated manner with knowledge rich task situations: identification and evaluation of knowledge, locating information and knowledge resources, knowledge generation, knowledge representation (organization, storage), knowledge maintenance, knowledge use, knowledge communication. How can mapping tools add to fostering processes of individual knowledge management? Some possible roles and functions of mapping tools for fostering processes of knowledge management are outlined in the following:

Knowledge identification. Knowledge identification is a meta-cognitive activity. The focus is on checking the availability of knowledge in ones mind deemed necessary for effectively coping with the affordances of a particular cognitive task, e.g. attaining a particular instructional goal, solving a complex problem, acquiring expert knowledge. Knowledge identification may be fostered with a mapping tool if learners during the process of studying or problem solving have constructed their own knowledge map for representing externally what they did not risk storing in short-term memory because of its limited capacity. The mapped

knowledge may be visually searched, analyzed and identified as relevant or irrelevant for coping effectively with a particular task.

Knowledge evaluation. The potential of knowledge maps as means for diagnosing individual structures of knowledge as a result of instruction has been shown in a variety of empirical studies (Jonassen et al. 1997). In self-regulated studying the learners themselves may use their mapped knowledge and compare it with the affordances of a task in terms of the knowledge, which is necessary to cope with it effectively. Learners may also compare their knowledge with an experts' knowledge structure used as a means to operationalize the goals of learning.

Localization of knowledge and knowledge resources. If learners have mapped their knowledge by means of a mapping tool they may use this map to inspect their own knowledge. Maps may be used as navigational tools to help individuals visually searching knowledge and knowledge resources. In this sense visual search in computer-based knowledge maps resembles map-based navigation in hypertext environments (Boechler & Dawson 2002). In addition to visual search most computer-based mapping tools provide functions for content search, thus providing automatic access to pre-specified knowledge elements.

Knowledge generation. Concept mapping and mind mapping have been used effectively in instructional settings to foster processes of knowledge generation (e.g. Gaines & Shaw (1995; Wallace et al. 1998; O'Donnell, Dansereau & Hall 2002). The elaboration of existing knowledge may be supported by maps, e.g. when users in a brainstorming process associate new ideas to already mapped ideas. Most mapping tools provide functions for annotating nodes and for interactive tuning and restructuring visualized knowledge structures. They may also be used as cognitive artifacts to induce and foster cognitive processes on the basis of the external representation of knowledge**.**

Knowledge representation. In complex and knowledge-rich cognitive processing tasks it is necessary not only to represent the conceptual knowledge of a domain but also content knowledge (stored in local files) and resource knowledge (represented in the Internet) by means of linking the respective knowledge elements. Computer-based mapping tools provide functions for externalizing mental representations of knowledge in arbitrary formats. As opposed to traditional mapping tools computer-based tools also allow for mappings in a hypertext-like format by using sub-maps and links. When maps are used for representing individual knowledge they serve as cognitive tools to augment capacities of human memory. The problem with maps as external representations of knowledge is that maps must make sense to the user in order to be used effectively. Lacking intelligibility of maps hampers the localization and use of the mapped knowledge (Marshall 2001).

Knowledge communication. Computer-based mapping tools may contribute to foster processes of knowledge communication in several ways. They may, for example, be used to communicate the concept structure of a subject matter and enhance knowledge acquisition (McAleese, Grabinger & Fisher 1999; Fischer & Mandl 2001). They may also be used as a basis for fostering cooperative work. If a map is generated and owned by different users the map can take over functions in communicating and make explicit a particular knowledge representation of concepts, contents and resources and may serve as a shared knowledge space for both making argumentation more coherent and contributing to enhance the quality of a cognitive artifact. Tools that support cooperative work by means of map-conferencing via Internet are, for example, Mind Manager, Inspiration, and Smart Ideas.

Knowledge use. The ultimate ambition of knowledge management is to enhance the efficiency of knowledge use when coping with cognitive tasks. In order to facilitate knowledge use knowledge representations must easily be restructured and adaptable to different situations, tasks, individual interests and contexts of use (Spiro, Feltovich, Jacobson & Coulson 1991). A necessary precondition for a flexible use of mapped knowledge is that the knowledge is represented explicitly and knowledge elements may be accessible freely and trackable easily. Map-based visualizations have proven to be a valuable cognitive tool for supporting knowledge use in a variety of learning and instructional settings, among them:

- assessing structural knowledge (Jonassen. 1987)
- Concept acquisition (Novak 1990)
- brainstorming of ideas (Buzan & Buzan 2002)
- scaffolding cognitive processing in knowledge acquisition and problem solving (Fischer & Mandl 2001; O'Donnell, Dansereau & Hall 2002)
- modeling expert knowledge (Coffey, Hoffmann, Canas & Ford 2002)
- communication / knowledge sharing among learners (Coffey, Hoffmann, Canas & Ford 2002; McAleese, Grabinger & Fisher 1999; Fischer & Mandl 2001)
- self-regulated learning (Dees, Dansereau, Peel, Boatler & Knight 1991).

Modern computer-based mapping tools provide functions for a rapid and flexible access to different aspects of mapped knowledge within different contexts of use and according to different interests and task-requirements (Spiro et al. 1991). They may support the use of distributed knowledge during internet-based map-conferences and may be used as tools for writing and web-publishing.

Knowledge maintenance. Knowledge maintenance is claimed to be a central need for people using the World Wide Web for resource-based learning and problem solving. However, because of limited working memory capacities "students and teachers may become overwhelmed with too much network generated information" (Jacobson & Levin 1993, p. 190). Mapping technology is one technology among a variety of others that provides facilities for individual users for externalizing knowledge in emergent knowledge repositories. For keeping knowledge up-to-date the externalized knowledge may be maintained by arbitrarily resurveying, reorganizing, annotating, and authoring according to the users interests.

Perspectives for application and research

Computer-based mapping tools meet the demands of coping effectively with managing conceptual, content and resource knowledge in one coherent visual representation modern computer-based tools have a high potential to support learners in self-regulated learning and knowledge management. However, representing, making accessible and localizing knowledge elements with the help of computer-based maps is not enough to make a learner-centered conception of knowledge management become true. It is important to develop conceptions of how to use strategies and tools for knowledge management for the purposes of coping with knowledge-rich task situations more effectively. It is the task of educational information technology to develop systems and tools for individual knowledge management and to integrate them into platforms for web-based e-learning. The task of instruction is to develop learner-centered instructional scenarios and integrate the use of knowledge management systems and tools. In addition, research on the effective use of mapping tools for supporting the management of conceptual, content and resource knowledge in e-learning scenarios has to be initiated. The research has to focus on the individual and situational conditions of effective use of mapping tools for knowledge managing and how managing-processes may be fostered by technical features and instructional measures.

A research program on studying the conditions of effective individual managing of knowledge with computerized mapping tools has been initiated. The conceptual rationale of the program as well as results of experimental and quasi-experimental studies will be presented at a symposium at the 10th biennial conference of the European Association for Research on Learning and Instruction (EARLI) in Padova (Italy) in August 26 - 30, 2003. Further an international workshop titled "Visual Artifacts for the Organization of Information and Knowledge. Searching for Synergies for Enhancing Learning" will take place at the Knowledge Media Research Center (Tübingen, Germany - http://www.iwm-kmrc.de) on May 13 - 14, 2004. At this workshop international experts working in the domains of information visualization and knowledge visualization will discuss progress in the use of visual artifacts for the organization of information and knowledge and search for synergies in research and development for enhancing learning.

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