Guest Editorial - Knowledge Visualization for Learning and Knowledge Management

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Knowledge visualization is an emerging area, in which visual imagery is used to construct and convey complex insights for improving understanding and communication. Knowledge visualization has been widely used in various learning environments to augment cognition, facilitate thinking and scientific inquiries, and assist meta-cognition. By representing cognitive structures or mental models using various techniques, knowledge visualization has the potential to facilitate the construction of understandings at a deeper level as well as with multiple perspectives such as interpretation and abstraction. Interpretation employs a familiar representation to support or revise misconceptions of the understanding of less familiar or more abstract knowledge. Examples include conveying an abstract idea by relating it to a concrete phenomenon, relating new insights to already understood concepts, and simulating complex objects or processes. Abstraction, on the other hand, refers to “throwing details” by synthesis and generalization. Abstraction exposes the underlying structure of a concept, or abstraction can involve the creation and organization of high level concepts, actions, and procedures in the form of concept maps (Novak, 1998), knowledge structures, conceptual frameworks, and so on. Knowledge conveyed by abstraction is usually schematic and analytic, with a format that is typically highly structured and systemic due to the reduction of conceptual complexity and the articulation of relationships (Ainsworth, 2006). In addition to deep understanding and high level thinking, knowledge visualization can support meta-cognition by helping learners develop an awareness of their mental representations, which may help foster conceptual change and knowledge transfer (Jacobson, 2004).

In the current global knowledge economy, the importance of learning is seen not just in traditional educational contexts but also in informal and practical work settings as well as in self-directed and lifelong learning. Accordingly, knowledge management (Nonaka & Takeuchi, 1995) is increasingly being recognized by individuals and organizations as an important competitive strategy. In addition to learning or consuming knowledge, people are increasingly becoming engaged in knowledge management processes, such as contributions of new knowledge from practice, applications and verifications of existing knowledge, and development of intellectual assets for improving individual, group, and organizational performance. In these contexts, knowledge visualization offers great potential for the creation of new knowledge from individual or group activities using heuristic sketches or rich graphic metaphors. Innovation or knowledge creation can be fostered by making preliminary ideas or unstable knowledge explicit and debatable. Moreover, visualization improves knowledge application or problem solving by providing rich representations to express “know-how” knowledge exercised in the accomplishment of tasks (Wang, Ran, Liao & Yang, 2010), which is usually tacit and associated with hands-on experience and practice at solving problems. Visualizations may externalize or reify tacit know-how knowledge into explicit formats such as competency models, workflow charts, business process diagrams, decision-making models, reasoning patterns, and argument processes.

Another area closely related to knowledge visualization is information visualization (Tufte, 1990), which is the visual representation of datasets. Information processing and knowledge construction are closely intertwined in the learning process as learners need to access information to acquire knowledge and formulate understandings. While knowledge visualization is primarily intended to facilitate subject understanding and interpretation, information visualization supports the perception of patterns and structural relations in data via data manipulation, data analysis, data representation, and data mining techniques. In addition, information visualization is becoming more socially constructed, especially in web-based environments, which in turn has generated work on social visualizations for finding trends and patterns of people and their behavior in social communities (Gilbert & Karahalios, 2009). Representations like network diagrams, tag clouds, tag clusters, and scatterplots for social visualizations help foster an awareness and accountability of a community’s behavior and structure, thus serving as a medium for reflection, motivation, and community contributions.

Various methods or techniques from paper-pencil to computer-based tools have been used to create images, diagrams, or animations to communicate both abstract and concrete ideas. In particular, computers are used as electronic tools for reflecting human cognitive processes through visual representations on the screen. Computer-
based visual representations may amplify, extend, or enhance human cognitive functions, thus engaging users as they represent, manipulate, and reflect on what they know (Jonassen, 2000). Moreover, techniques for dynamic and interactive visualization are being explored and utilized (Lowe, 2004). While there is no doubt that technologies enable and promote knowledge visualization in various ways, the educational benefits of knowledge visualization do not occur automatically. To foster effective learning and knowledge construction, pedagogical functions should be integrated with visual representations, and cognitive tasks must be undertaken and scaffolded in many learning processes aimed at understanding complex phenomena (Spector, 2006).

Knowledge visualization, viewed broadly to include both information and social visualization, has potential advantages for encouraging deeper understanding, hypothesis building, reasoning, and problem solving, and these advantages have been well recognized in learning and knowledge management research and practice. However, as an emerging area, there have been relatively few studies that address the multifaceted nature of knowledge visualization and its role in representing and organizing knowledge as well as in supporting learning. The articles in this special issue address some of the broad issues discussed above.

In the first paper “Visualizing Topic Flow in Students’ Essays” by Stephen T. O'Rourke, Rafael A. Calvo, and Danielle S. McNamara presents a document visualization technique and a measure of document quality based on the semantic distance between the parts of a document. The visualization in this study focuses on the structure and the flow of topics of a document. The results provide evidence that the degree of topic flow between consecutive sentences and paragraphs is consistent with the essay quality and helps assessing and improving the quality of essay writing.

Concept mapping as an important tool for knowledge visualization has been widely used to help learners construct, communicate, and assess their understanding. Jorge Villalon and Rafael A. Calvo proposed to extend the use of concept maps from reading to writing by proposing a concept miner tool to automatically generate concept maps embedded in student writings. Their paper “Concept Maps as Cognitive Visualizations of Writing Assignments” presents the design and implementation of the tool and its integration with a writing support environment that provides automatic feedback to students in their writing activities.

While concept mapping is effective in fostering in-depth thinking and understanding, self-constructed maps pose high cognitive demands on learners’ ability to integrate multiple forms of thinking for knowledge analysis and externalization. The paper “Knowledge Visualization for Self-Regulated Learning” by Minhong Wang, Jun Peng, Bo Cheng, and etc. proposes the use of knowledge maps created by experts to guide and scaffold the self-directed learning process of novices who suffer from “lost-in-hyperspace.” The focus of their study is on visualizing the domain knowledge structure and integrating it with the curriculum, learning resources, intellectual process, learning assessment, and social learning process.

To support learning in different ways, knowledge can be visualized with multiple representations. Wing-Kwong, Wong, Sheng-Kai Yin, Hsi-Hsun Yang, and etc. explored the use of computer-assisted multiple representations in learning geometry proofs. Their paper “Using Computer-Assisted Multiple Representations in Learning Geometry Proofs” investigates the design of multiple representations to support the learning of theorem proving. Their visual representations cover problem description, static and dynamic geometry figures, formal proof, and proof tree, which are designed for different pedagogical functions and integrated with a computer-assisted learning environment.

In the last paper of the special issue, Demosthenes Akoumianakis looked into the visualization of collaborative practices with electronic traces in virtual settings. His paper “Learning as ‘Knowing’: Towards Retaining and Visualizing Use in Virtual Settings” investigates the role of and challenges for visualization in mediating collaborative activities and leading to recurrent co-engagement in practice. Two case studies were presented where visualizations are employed as sharable and accountable practice vocabularies capable of capturing collective intelligence, thereby unfolding a variety of informal learning patterns.

We conclude by noting that the papers in this special issue are intended to be representative of ongoing research in the area of knowledge visualization for learning and knowledge management. The international scope of this research is distinctive, and the breadth of applications for knowledge visualization discussed in these papers is important. Overall, we hope this special issue and the individual research projects that are featured will foster further interest in what we believe will become an area of increasing importance as new visualization techniques are
developed and their efficacy explored to support individual and collective learning and understanding in schools and organizations.

References


