Scaffolding collaborative knowledge integration of students and teachers through visualizations

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Abstract: What scaffolds can support students and teachers to collaboratively integrate their knowledge in technology-enhanced environments, particularly in science education? This guiding question connects both my doctoral and postdoctoral work. A particular focus of my research is on how different forms of visualizations can scaffold collaborative knowledge integration activities. For my doctoral research, I developed and investigated a technology-enhanced online learning unit on human evolution with a novel form of concept map to support collaborative knowledge integration processes. My post-doctoral research focuses on how groups of teachers collaboratively design and revise learning units in a technology-enhanced environment.

My doctoral research focused on scaffolding students while my post-doctoral research focuses on supports for teachers. In my doctoral dissertation research (Schwendimann, 2011), I investigated how different forms of concept mapping embedded in a collaborative technology-enhanced learning environment can support students' integration of biology concepts using case studies of human evolution. I used Knowledge Integration (KI) (Linn & Hsi, 2000) as the operational framework to explore concept maps as knowledge integration tools to elicit, add, critically distinguish, group, connect, and sort out alternative evolution ideas. Concept maps are a form of node-link diagram for organizing and representing connections between ideas as a semantic network (Novak & Gowin, 1984). I developed a novel biology-specific form of concept map, called Knowledge Integration Map (KIM) using a design-based research approach (Brown, 1992; Cobb, Confrey, diSessa, Lehrer, & Schauble, 2003). Three iterative studies were implemented in ethnically and economically diverse public high schools classrooms using the web-based inquiry science environment (WISE) (Linn, Clark, & Slotta, 2003). The studies systematically explored generating or critiquing Knowledge Integration Maps as collaborative learning tools for biology education. The online learning environment and KIM activities were developed in collaboration with science teachers, scientists, computer scientists, and education researchers. I identified effective design patterns to implement KIMs in an inquiry-based learning environment and distinguished the learning effects from either generating or critiquing KIMs as embedded learning tools. Findings suggest that critiquing KIMs can be more efficient than generating KIMs. Using KIMs that include common alternative ideas for critique activities can create genuine opportunities for students to critically reflect on new and existing ideas. Critiquing KIMs can encourage knowledge integration by fostering self-monitoring of students' learning progress, identifying knowledge gaps, and distinguishing alternative evolution ideas. My doctoral research demonstrated that science instruction of complex topics, such as human evolution, can succeed through a combination of scaffolded inquiry activities using dynamic visualizations, explanation activities, and collaborative KIM activities. This research contributed to educational research and practice by describing ways to make KIMs effective and efficient learning tools for evolution education. Supporting students' building of a more coherent understanding of core ideas of biology can foster their life-long interest and learning of science.

In my post-doctoral research, I shifted my focus to scaffolding collaborative curriculum design activities of K-12 and higher education teachers (both pre-service and in-service). The process of collaborative technology-enhanced educational design conducted by inter-disciplinary teams is not well understood. Together with my team, we set up a new facility, the educational research studio (EDRS), to study technology-enhanced collaborative design activities of groups of teachers (Schwendimann, 2013). Design studios are well established as settings for collaborative work in creative disciplines, such as architecture, art, and product design. Design studios provide users with spaces for experimentation, frequent formal and informal critique, and physical and digital tools to work collaboratively on complex design problems. However, empirical studies of educational design are rare, and studies in studio settings even rarer. I am collecting data using the newly built EDRS which (i) is equipped to support small teams of people (between two and ten) engaged in existing or newly created educational design problems, using their own or design methods and resources that we make available, while (ii) allowing us to make clear audio-visual recordings of all members of the design teams, sufficient to transcribe and/or annotate key passages in the design process, and to playback such passages for stimulated recall debriefings with the designers. We are capturing the design discourse, gestures, expressions and other important elements of non-verbal communication within the design team, and the evolving state of their design artefacts.

The goal is to develop a deep understanding of collaborative practices of design-for-learning and improve design-for-learning by providing better tools and methods that are consistent with current scientific understanding of how people learn. I am collecting data from design teams working on design-for-learning projects. My research uses constructs from activity theory and is influenced by anthropological studies of traditional work practices and participation in communities of practice, naturally occurring and artificially created knowledge-building communities, and networks. Data collection includes discourse, gestures, artefacts construction, tool usage, and space usage. These rich datasets allow triangulating the complex interactions during collaborative educational design work. Research in the EDRS focuses on two types of studies: self-directed studies and experimental studies. In the self-directed studies, groups of designers are working on their own projects using their own tools, scripts, and representations. The research goal for this condition is to gain a deeper understanding of existing collaborative design-for-learning practice. Findings from studying self-directed design will inform the development of methods and tools for the experimental studies. In the experimental studies, participants receive tools and methods provided by the researchers. These are informed by the previous set of studies but may include tools to support the design process such as instructional design tools or different design processes such as the Stanford d.school design method (Stanford d.school Design Method, 2013). The research goal for the experimental studies is to iteratively develop a framework to effectively and efficiently support collaborative groups with a focus on design-for-learning. Data analysis focuses on five different areas: Usage of tools, stages in the design process, roles in the design process, forms and usage of representations, and usage of digital and physical space. Findings from my studies will be valuable for improving design-for-learning for inter-disciplinary instructional design teams. Better tools and methods for collaborative design-for-learning contribute to improving the quality of instructional design, make the instructional design process more efficient, and raise learning outcomes. My iterative research studies will implement methods and tools that support design for learning consistent with current scientific understanding of how people learn.

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