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INTRODUCTION: COGNITIVE TOOLS FOR COLLABORATIVE COMMUNITIES

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The notion of computers as cognitive tools is not new—but increasingly, they are powerful tools for creating communities and supporting collaborative learning. As a number of researchers point out, cognitive tools can be designed to extend classroom experiences beyond the physical classroom to enable learning in virtual spaces (Lajoie & Derry, 1993, Jonassen & Reeves, 1996, Lajoie, Garcia, Berdugo, & Ramirez, 2005). Such tools, often designed based on strong theoretical commitments, can change the nature of teaching and learning as they enable new forms of activity. "Cognitive tools refer to technologies, tangible or intangible, that enhance the power of human beings during thinking, problem solving, and learning" (Jonassen & Reeves, 1996, p. 693). This is similar to Salomon's (1993) notion of effects *with* technology, that is, those tools that allow the learner to accomplish different kinds of cognitive activities while using technology. In this conception, computers serve as intellectual partners that enable higher-order thinking and learning as lower-level activities are offloaded to the technology. But Salomon also noted the importance of the effects *of* technology—the cognitive effects that last beyond the use of technology. For both kinds of effects to occur, computers need to be integrated into meaningful activities that afford constructive processing. Cognitive tools actively engage learners in constructing new understanding and making their own conceptualizations visible. Jonassen & Reeves (1996) argue that cognitive tools are best used to represent knowledge and solve problems within the contexts of personally meaningful problems and investigations. They enable mindful, challenging learning and can be used to support deep reflection. Some examples of cognitive tools include programming

languages, databases, hypermedia construction kits, computer microworlds, concept mapping, and various collaboration environments.

Early work on cognitive tools focused largely on tools that advanced individual learning but more recent thinking and advances in technology permit considering how computers can serve as cognitive tools to enable new forms of social knowledge construction (Lajoie, 2000). This is consistent with a change in learning theories that move from individualistic accounts of learning to more socially situated accounts (e.g., Greeno, Collins, & Resnick, 1996). Cognitive tools for collaborative communities go beyond earlier individualistic formulations (Derry & Lajoie, 1993; Jonassen & Reeves, 1996). Such tools can provide shared contexts; opportunities for learners to compare different perspectives as they participate in different communities; use, create, and share information; and provide a communications medium (Goldman-Segall & Maxwell, 2003). They need to support both individual and group cognition.

Group cognition emerges from group discourse through an intertwining of personal and group perspectives. As Stahl (2006) notes "[g]roups are where the meaning-making action is" (p. 437) and meaning making is a group achievement. This perspective argues for the importance of considering the group as the unit of analysis. Related to this and implicit in considering cognitive tools for collaborative communities is the notion of collaborative knowledge building—continual improvement of the group's collective knowledge in addition to individual understanding (Bereiter, 2002; Lee, Chan, & Van Aalst, 2006). Cognitive tools to support collaborative knowledge building need to provide support for (Bereiter & Scardamalia, 2006):

- Social organization,
- Creation and revision of conceptual artifacts,
- Citing and referencing each other's work,
- Working with the same ideas in multiple contexts,
- Providing feedback to support monitoring of ongoing processes.

Understanding how cognitive tools provide affordances for collaborative knowledge building necessarily requires understanding group cognition.

This special issue of *Journal of Educational Computing Research* explores how computer technology can serve as a cognitive tool that enables new forms of activity. The articles consider factors that are involved in using technology as cognitive tools that actually support productive collaborations and learning, and where those technologies might fall short. The five articles in this special issue represent a range of research methodologies and issues related to using cognitive tools for collaborative communities. They examine both effects *with* technology and effects *of* technology as the articles consider both group and individual level phenomena.

Stahl presents an in-depth study of how a particular design feature, the ability to point to an item on a shared whiteboard, allows students to create common points of reference for their discourse as they engage in open-ended mathematical problem solving. This tool overcomes what could otherwise be considered a barrier to collaboration, as the article presents a case study of how a graphical referencing tool supports group cognition in a synchronous chat environment. In particular, Stahl examines how this tool supports coordination of the group's joint attention. The tool allows the group to co-construct a shared reference through their online social interactions. The research identifies a number of (sometime unanticipated) strategies that the students use to make sense of references to graphical objects and other posts in the chat. This study demonstrates how this tool provided affordances that overcame some of the constraints of an online chat environment and allowed the learners to construct a shared understanding.

Lai and Law investigate how learners use the scaffolding provided by the *Knowledge Forum* (Bereiter & Scardamalia, 2006), an online discussion tool, to create a knowledge-building community. Creating a knowledge-building community requires all group members to take responsibility for advancing the collective understanding of the group (Bereiter, 2002). This study is particularly interesting because there is a combination of software-based scaffolding (Guzdial, 1994, Hmelo-Silver, 2006) and peer scaffolding (Palincsar, 1998). In particular, they examine how Hong Kong students worked with the *Knowledge Forum* before and after collaborating with other students (from Canada) who were experts in using *Knowledge Forum*. Their results suggest that the more experienced Canadian students helped scaffold the Hong Kong students' engagement in knowledge building, and that this engagement continued even after the Canadian students were no longer participating. They conclude that the online discussion platform was not sufficient to promote knowledge building but that there was a synergistic effect of peer scaffolding.

Derry, Hmelo-Silver, Nagarajan, Chernobilsky, & Beitzel focus on how the new media available in computer-based learning environments can promote transfer. To accomplish this, they describe STELLAR, their theoretically-guided integrated suite of cognitive tools for computer-supported collaborative learning that uses videocases, hypermedia, and online collaboration tools to promote transfer. The video cases and hypermedia provide shared contexts for learning where students can mesh the conceptual ideas of the learning sciences with the problems of practice represented in the video cases. The STELLAR environment includes tools to scaffold the learning process as well as human facilitators. This article presents several studies that are part of a program of research. In a quasi-experimental study, they show that students who use the STELLAR environment outperform students in comparison courses. In addition, Derry et al.

provide process data that demonstrate how their tools were used as well as studies of alternative instructional designs that can be created with the STELLAR system.

Lajoie, Garcia, Berdugo, Márquez, Espindola, and Nakamura examine how technology can be used to support international collaboration in higher education between a university in Canada and another in Mexico. They use a course management system, WebCT, which includes a discussion tool, to support online discourse. Theoretical frameworks drawn from communities of learners and cognitive apprenticeship models guide this research. The course instructors at the two sites scaffolded the discourse. Their discourse analysis indicates that there are differences in the role of the teacher and the interaction patterns between the two universities. The results demonstrated that Lajoie et al. were successful in creating a community of learners but cultural and language difference posed barriers to discussion across the two sites. In the technology used for this study, the course instructors and peers provide the scaffolding. The technology provides a space for discussion but no scaffolding for particular models of instruction.

Not all articles important for understanding technology involve studies of technology itself. Often studying the practices that learners engage in can help identify the kinds of tools that are needed. O'Neill and Weiler examine the need for particular kinds of tools as they studied how metahistorical practices were enacted in school. Their analysis suggests that students have difficulty with many of the practices of history partly because of prior conceptions of how similar practices are used in other disciplines. This study demonstrates that particular kinds of artifacts form boundary objects that help students bridge between their idea about familiar practices and how historians use those practices. They suggest that tools such as digital libraries of practice that show the kinds of notes historians take and how ideas flow from original sources to final written form will connect students better to the community of historians and the practices they engage in.

Kirschner and Erkens conclude with a commentary on the articles. They contrast productivity tools as providing effects *with* technology and mindtools as leading to effects *of* technology. The commentary focuses on mindtools for supporting and promoting collaboration. They consider the how the tools discussed in the articles support collaboration in terms of three levels of coordination: task-level, social group level, and communicative level.

This set of articles represents researchers working with different populations in different subject domains. They consider a variety of important issues: the kinds of cognitive tools needed to support collaboration, the nature of interactions, and designs to promote effective collaborative learning. The technologies that the authors describe include those that provide shared contexts and resources, opportunities for sharing perspectives across different communities and communication spaces. Interestingly, all the articles raise as many (or more) issues than they resolve. As Stahl notes, cognitive tools for collaborative communities are different

than cognitive tools for individuals as they make specific forms of group interaction possible, often as part of complex distributed technological and social infrastructures. Studying such tools is complex and may require a variety of methodologies to understand both the effects *with* and effects *of* learning with these tools (Hmelo-Silver, 2003; Salomon, 1993). This set of articles contributes to an ongoing dialogue needed to develop theories about cognitive tools for collaborative communities, how they support collaborative knowledge building as well as individual learning, and how these technologies might be designed.

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