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COGNITIVE TOOLS AND MINDTOOLS FOR COLLABORATIVE LEARNING

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ABSTRACT

When a computer-based tool or application is used to carry out a specific task in a learning situation—that is, it is used for learning—more effectively or efficiently one speaks of learning *with* the tool or application. When, possibly, that same tool or application is used to enhance the way a learner works and thinks, and as such has effects that reach further than the learning situation in which it is used, then one speaks of learning *from* the tool or application. This article concentrates on the latter. It zooms in on the use of mindtools in education—computer programs and applications that facilitate meaningful professional thinking and working—because this is the epitome of learning *from* ICT. Mindtools and cognitive tools help users represent what they know as they transform information into knowledge and are used to engage in, and facilitate, critical thinking and higher order learning. These tools can be as simple as email and or discussion lists and as complicated as argument mapping and visualization systems. Even more specifically, it deals with one category of such tools, namely conversation tools; tools used to create and facilitate the establishment of technology-supported discourse communities—communities of practice—where collaboration can flourish.

Information and communication technology (ICT) has found its way into all levels of education and is often at the center of national educational policies worldwide. Three factors influence this trend: namely, as a means for preparing students for the future workplace by providing tools for tomorrow's practice and the learner has to learn to use these tools; as a way to make schools more efficient and/or more

productive; and as a means to reform education. There is a growing tendency to stimulate learners to learn actively, independently, in a self-directed way and/or in collaboration with others (Simons, Van der Linden, & Duffy, 2000). New technologies (e.g., Jonassen, 2000; Jonassen, Peck, & Wilson, 1999; Kanselaar, de Jong, Andriessen, & Goodyear, 2000; Lajoie, 2000) provide promising opportunities to make this *new kind of learning* possible and guide the learner in these *new ways of learning*.

Although the growth of ICT use in education is considerable, it is not without criticism. Cuban (2001) and Salomon (2000) dampen the euphoria with a profound analysis of the current situation in education with regard to the use of ICT. When looking at the benefits of the substantial government investments for developing and implementing educational ICT-policy, research reveals that new technologies are often oversold and underused (Becker, 2001; Cuban, 2001). Cuban (2001) states that the three aforementioned goals that accompany the emergence of ICT in education have not been achieved.

Although ICT use in education increases, this is often limited to generic tools (Becker, 2001; Cuban, 2001). Cuban (2001), for example, states that in a lot of situations "e-learning has turned out to be word processing and Internet searches. As important supplements as these have become to many teachers' repertoires, they are far from the project-based teaching and learning that some technopromoters have sought" (p. 178). Also, ICT is often used as a modern substitute for existing learning and teaching materials and seldom as vehicle for innovation and transformation of education (Kirschner, Hermans, & de Wolf, 1995). Salomon (2000) refers to this as the *technological paradox*: "A most powerful and innovative technology is taken and is domesticated such that it does more or less what its predecessors have done, only it does it a bit faster and a bit nicer" (np). This technological paradox "results from the consistent tendency of the educational system to preserve itself and its practices by the assimilation of new technologies into existing instructional practices." Technology becomes domesticated, which really means that it is allowed to do precisely that which fits into an educational philosophy of transmission. Learners need to learn *from* the technology, and not simply learn *with*.

Although ICT use in education gives rise to serious concerns, we must continue to invest in it. Cornu (2002) states that our current society is changing into an ICT society. Educational policies, however, should not have a technocentric focus (Salomon, 2000). Instead, technorealism[1] must be at the heart of it, as Salomon (2000) notes, "Education is far too important to society to be wiggled by a technological tail. Let technology show us what *can* be done, and let educational considerations determine what *will* be done in actuality" (p. 42).

[1] www.technorealism.org

This article emphasizes the importance of learning *from* new technologies. We zoom in on the use of mindtools in education—computer programs and applications that facilitate meaningful professional thinking and working—because this is the epitome of learning *from* ICT. Mindtools and cognitive tools help users represent what they know as they transform information into knowledge and are used to engage in, and facilitate, critical thinking and higher order learning. These tools can be as simple as e-mail and or discussion lists and as complicated as argument mapping and visualization systems (Kirschner, Buckingham Shum, & Carr, 2002). Because almost all ICT applications can be used in such a way, this special issue has chosen to highlight one category of such tools which can be categorized as conversation tools (Jonassen, Carr, & Yueh, 1998). These tools are seen as a means to create and facilitate the creation of technology-supported discourse communities—communities of practice—where collaboration can flourish (Jonassen et al., 1999).

COGNITIVE TOOLS AND MINDTOOLS

Computer owners frequently make use of applications such as databases (e.g., File Maker® Pro, Access®), spreadsheets (e.g., Excel®), intentional information search engines (e.g., Google®), visualization tools (e.g., PowerPoint®, Inspiration®, Micrografx Flow Charter®), multimedia publishing tools (e.g., Front Page®, Macromedia Flash®), live conversation environments (e.g., MSN Messenger®, ICQ®), and computer conferences (e.g., FirstClass®, NetMeeting®). Most of these applications have been developed as aids in the execution of work, to make the users more productive. We call them, therefore, *productivity* tools. But apart from being a productivity tool, these same tools can also be used as an intellectual partner that enhances the cognitive powers of human beings during thinking, problem solving, and learning (Jonassen & Reeves, 1996). In other words, as mindtools.

When used as a mindtool, databases help learners integrate and interrelate discrete bits of content, making them more meaningful and more memorable. In using a spreadsheet, learners design, use, and fill in values and formulas requiring them to use existing rules, generate new rules to describe relationships, and organize information, thus engaging critical thinking in them and forcing learners to think more deeply (Blignaut, 1999; Jonassen & Carr, 2000). In this situation, ICT applications are referred to as *cognitive technologies* (Pea, 1985), *technologies of the mind* (Salomon, Perkins, & Globerson, 1991), *cognitive tools* (Jonassen & Reeves, 1996; Lajoie, 2000) or *mindtools* (Jonassen, 1996, 2000). In this article, we will use the latter term for those ICT tools that play the role of intellectual partner.

According to Jonassen (2000), mindtools are "computer-based tools and learning environments that have been adapted or developed to function as intellectual partners with the learner in order to engage and facilitate critical thinking and

higher order learning" (p. 9). We broaden the scope and include the facilitation of work (by knowledge workers) in this definition. Since critical thinking and higher order learning also can play a prominent role during professional work, mindtools are also intellectual partners with the worker, especially in knowledge intensive situations where working and learning are intertwined. Nowadays, professional workers must continuously develop themselves and teachers are (or at least should be) just this type of professional. As such, they continually have to learn, and in this learning process, mindtools can play an important role. Aspiring teachers must therefore learn how to use mindtools both as a means to encourage constructive learning in the classroom and as a tool for their own professional growth.

Jonassen (2000) distinguishes five characteristics of mindtools. First, they are *cognitive amplification* and *reorganization* tools, which exceed the limitations of the human mind by doing things more accurately and at a higher speed, and extend the use of other (mechanical) tools. Second, mindtools are *generalizable* tools, which can be used from setting to setting and domain to domain for engaging and facilitating cognitive processing. They are not specific to any one purpose nor do they reduce information processing. They make better use of the user's mental efforts in a multitude of domains and situations. They do not make processing easier, but afford it/allow it to occur. This also means that users have to think harder since to think more deeply costs more effort.

Mindtools are also *critical thinking devices* which help learners think for themselves, make connections between concepts, and create new knowledge. This is similar to what Crombag et al. (1979) call operations on knowledge. They are also *intellectual partners*. As a partner in the learning and working process, each are responsible for what they can perform best. Computers should calculate and store and retrieve information, while the user of the tool should be responsible for recognizing and judging patterns of information and its organization. Finally, a mindtool is a *concept*. It is a way of thinking about and using ICT, other technology, the learning environment, or intentional and incidental learning activity/opportunity (constructivist in nature) so that the users of these tools can represent, manipulate, and reflect on what they know instead of reproducing what others tell them.

The distinction between productivity tools and mindtools is analogous to Salomon's (1995) distinction between the two effects of technology. We generalize this idea to the effects obtained *with* something and effects *of* (i.e., learning *from*) that something. Effects *with* technology are those changes that take place in learners while they are engaged in working with ICT and/or while they are busy with the technology-tools available. An example of effects *with* technology can be seen as the changed quality of problem analysis and solution as a result of either working in a group decision room with others or when a specific project being delivered on time because of the use of project planning software.

Effects *of* or *from* technology are those *longer lasting changes* in learners that are a result of working with technology or are the result of having made use of the

tools available. An example of the effect of technology could be the skill of asking more exact and explicit questions because of the experiences within the group decision room or the ability to formulate more precisely oneself. An effect *of* the tools used could be that the person is able to plan and carry out a project more effectively and efficiently (at a later date) due to earlier use of specific project planning software or the ability to carry out more effective and efficient information search procedures due to having used broad, general search engines. Salomon argues that educational emphasis should be on the attainment of effects *of* and not just on the attainment of effects *with*.

Used as productivity tools, we speak of the effects obtained *with* a program or application. Used as a mindtool, we speak of the effects *of* or gained *from* the program or application.

MINDTOOLS FOR COLLABORATIVE LEARNING

In the rest of this article we will highlight the different contributions to this special issue in terms of their value as mindtools for stimulating, scaffolding, and maintaining collaboration processes. In our discussion, we will focus on the collective instead of the individual effects of tools in collaborative settings. Mindtools in collaborative learning are meant to facilitate and scaffold shared processes of cognition in order to achieve a common goal or product in a group or community of learners. Gerry Stahl offers in this issue nine convincing arguments why cognitive tools for collaborative groups or communities are different from cognitive tools for individuals. He emphasizes that collaborative groups or communities are complex multi-interactive systems wherein tools are (re)interpreted for meaning by their members and become part of their social practices of collaborative work. The cognition the tools foster is shared and thereby inseparable from the collaboration that they support. Stahl labels this collective cognition "group cognition."

Furthermore, we think that tools for collaborative learning can support collective activities on three levels of coordination (Erkens, Prangsma, & Jaspers, 2006). First, on a task-related level students have to coordinate and agree on their activities and task strategies in order to solve the learning task at hand. On the task level, executive activities (i.e. writing, problem solving) as well as meta cognitive activities (i.e. planning, monitoring and reflection) can be supported by specified tools. At the executive task level, the sharing of products and mutual access of common resources is in many cases facilitated by tools. Tools that script problem-solving phases (Weinberger, Ertl, Fischer, & Mandl, 2005) are examples of mind tools at a metacognitive task level.

On a second social group level, students have to coordinate group dynamics and the social processes of collaboration. They have to create and maintain a positive collaborative climate in which they feel safe to contribute and can take responsibility for shared task activities. Mutual support, acknowledgment of contributions

of the other, humor, open communication about irritations, and absence of flaming are activities that are intended to maintain a positive collaborative climate. Meta social and/or meta cognitive activities are called for, for example, when group processes tend to become negative. Explicit discussion of social aspects of collaboration and irritations can help to avoid these situations and solve problems that arise. Important for coordination at this social group level seems to be awareness of group dynamic aspects. Tools that are meant to support this social awareness are tools that visualize social presence or participation of members in the collaborative group or community (Janssen, Erkens, Kanselaar, & Jaspers, 2007; Kreijns, Kirschner, & Jochems, 2003). Participation in a community of co-learners, and on a broader scale participation in a community of practitioners, can be characterized as socialization: learning to adhere the social and cultural rules and conventions that are common in the community.

On a third, communicative level students have to coordinate and maintain the communication and interaction between themselves and the other participants in the collaborative group or community. Students have to tune their communication to each other and have to make sure by clarifying and asking for clarification that mutual understanding is ascertained (Beers, Boshuizen, Kirschner, & Gijselaers, 2005; Clark & Brennan, 1991). Tuning and grounding are activities that students can use to maintain their communication. Explicit planning of communication and discussion of prevention of misunderstandings are meta communicative activities that students may employ. Of course, tools that support communication between students are most common in CSCL environments. However, forms with different affordances are being used: synchronously (chat, video-conferencing) and or asynchronously (e-mail, discussions forums). Furthermore, task or social-related tools, especially when there are shared, also often seem to have a communicative function. In the discussion of the contributions in this special issue, we will comment the tools that are studied from this perspective of three levels of execution and coordination: task related, social and communicative.

O'Neill and Weiler state in this issue (2006) that undertaking authentic historical analysis may be the most meaningful way for students to learn about history as a science and about the historical inquiry process. Good history teachers give their students realistic experiences of historical research: collecting data, searching documents, interpreting primary historical resources and writing reports in genres that are common in the community of historians. As online archives of historical resources are becoming more accessible, tools to support the historical inquiry process become more needed. However, as the authors show in their study of a history inquiry project, simply offering task-related tools will not be enough and will lead to idiosyncratic interpretations of activities if they are not supplemented by social and communicative tools that connect to the wider community of historical practitioners. The authors propose a "library of practice" along side a traditional historical archive of source materials. In the library of practice, students will not only be shown—through the use of task oriented

video-clips—how historical practitioners go about doing inquiry, they will also get access to discussion forums that enable dialogue between students and practitioners about historical research. These forums do not serve only task-related or communicative purposes, but are seen also to support a socializing goal: "the thoughtful membership in the community of historical interpretation."

The study in this issue written by Lajoie, Garcia, Berdugo, Márquez, Espíndola and Nakamura (2006) describes the experiences in creating national and international communities of learners. In the project, students from Canada and Mexico entered the same seminar on cognition and instruction that was supported by WebCT © as virtual learning environment. The tools the students were offered in this environment were mainly communicative in nature. The students had to discuss and pose questions in a discussion forum. The creation of an international collaborating community proved to be much more complicated than the establishment of the local classroom CMC communities. Not only linguistic barriers, but also barriers of differences in experience with the use of CSCL learning environments and barriers of socio-cultural differences in classroom rules and conventions were encountered. Remarkable in both local communities was that both showed a high level of critical thinking in the discussions by the students. However, relevant differences were found in the way the teachers modeled and supervised the inquiry that the students had to fulfill. The study shows that the socio-cultural way that students interact (amongst themselves and with the teacher) influences the activities within the community to a large extent, perhaps more than the inquiry task that was posed to the students. Furthermore, the study emphasizes the role that earlier experience with computer mediated communication and virtual collaboration plays in scaffolding the collaborative processes between students .

The scaffolding role of experience in CSCL is also the central issue in the study in this special issue written by Lai and Law (2006). They, as well, studied an international collaboration between two classes of students. However, in their study, the students were primary school students in classes from Hong Kong and Canada. The students used the Knowledge Forum© (KF; Bereiter & Scardamalia, 2003) to support collaborative knowledge building . In our categorization, KF is primarily a learning environment with task and communication related tools in which students can share resources and ideas to support collaborative construction of knowledge. It proved to be the negotiation of meaning and the interrelatedness of the contributions to the collective knowledge building that was learned by novice students from experienced students that were familiar with the KF learning environment. In essence, the more experienced students served as true scaffolds for the novice students with respect to different aspects of knowledge building. The collaboration between the two groups of students resulted in another community of practice with the novice students, with other rules and conventions pertaining to how to go about reacting to and constructing knowledge in a collaborative learning environment. The

communicative interaction and collaborative task strategy of knowledge building was changed in the novice class, even after the collaboration with the experienced class ended. The results show that a community of learning does not come into being by itself just by offering a learning environment, but should be stimulated, developed, scaffolded, or modeled.

Experience with the tools used in the collaborative learning environment was also found to play a major role in the study presented in this issue by Derry, Hmelo-Silver, Nagarajan, Chernobilsky and Beitzel (2006). The results with several eSTEP courses for teacher training in two campuses are described. The courses are made in the STELLAR environment offering several tools for collaborative learning such as a personal notebook, a video case database and a hypertext book of relevant concepts as shared resources, a threaded discussion forum, and a collaborative whiteboard as a tool to scaffold the design of lessons. The courses were set up both as problem-based learning to scaffold, step-by-step, the authentic lesson design task (this is comparable to using process worksheets) and as a learning environment to study videocases and understand the relevant concepts by means of an indexed hypertext book. After gaining experience in the environment, both task related tools were used in a more in depth manner and in relation to each other. Furthermore, the facilitator in the environment proved to be very supportive as a model for task-related inquiry and in this way, for involvement in collaborative learning. In fact, the researchers could pinpoint a change in interaction patterns and collaborative performance in the protocols after the facilitator's modeling interventions. It was found that, in comparison with more traditionally taught courses on the same subject over 3 years, the online courses were more effective.

Stahl in this special issue (2006) reports on the findings of a 5-year research project: Virtual Math Teams at the Math Forum. In this project, small groups of students get access to a chat tool for communication and to a whiteboard in which they can share, draw, and annotate their ideas on the math problems posed. The history of the whiteboard can be scrolled. Stahl focuses primarily on the social and communicative levels of coordination in collaborative learning. From an ethnomethodological perspective, collaborative interaction patterns are interpreted as methods by which students socialize and establish interpersonal relations on the one hand and establish common ground and shared meaning, in other words "group cognition," on the other. Demonstrating his method of chat analysis, Stahl shows how students construct collaborative meaning and experience by uptaking [*sic*] each others' contributions, relating to each other, defining themselves as a group, diverging and reorganizing their interaction, and negotiating their topics of discussion. Groups constitute themselves and adopt the tools offered to them to establish this in their own ways. In this respect, tools are never fully used as they were designed but are incorporated in the group's culture and practice.

CONCLUSION

The goal of education is not, or at least should not be, to give a new generation of learners subject matter knowledge and task-specific skills. The primary goal of education should be, at the least, the transmission of those competencies which allow learners to become practitioners who are reflective of the decisions that they make and who are able to interact with their ever changing environments in a meaningful and responsive way. This means that they need to become competent life long learners within their field(s) of expertise. They have and need to keep current their knowledge and skills within their area of expertise. They must keep abreast of the newest, or recurring, perspectives and techniques with respect to their fields. They must also move with society with respect to the tools of their trades. It is not possible for them to do this in traditional teaching and training situations. Things are moving and changing too quickly, and life is becoming so much more complex, that the courses cannot be made quick enough and in enough numbers to meet the need and the teachers do not have the time or possibility to follow all of these courses.

Educational institutions are just beginning to make use of ICT as mindtools in collaborative learning. There are examples of good practice, but they are sparse and in the early stages of development and use. Education is still busy transferring instrumental skills and teaching students how to make use of productivity tools. The solution is not continuing education at universities and colleges, but rather continuous (and ubiquitous) learning in communities of practice, communities of interest, and communities of expertise in schools, at training institutions, and in society in general. Mindtools for collaborative learning as proposed in the contributions in this issue can support these developments.

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