Three generations of technology-enhanced learning

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Abstract

The purpose of the present paper was to examine three generations of research on technology-mediated learning carried on by the present investigator’s research group. The first generation focused on examining computer-supported collaborative learning from the cognitive perspective. The main focus was to examine to what extent knowledge-seeking inquiry elicited conceptual change. Problems of transferring inquiry learning culture from one country to another pushed us to examine social practices and other participatory aspects of learning that had been invisible to cognitive researchers. The second-generation research focused on analyzing patterns of participation in computer-supported collaborative learning. The emerging third generation research aims at overcoming the dichotomy between the cognitive (knowledge acquisition) perspective and socio-cultural (participation) perspective by means of long-standing and deliberate efforts of knowledge-creation, involving what is called objects of activity. Theoretical and methodological implications of the generations are discussed.

Introduction

The purpose of the present paper is to reflect on experiences of investigating technology-mediated learning within the frame of the Centre for Research on Networked Learning and Knowledge Building (http://www.helsinki.fi/science/networkedlearning). For 12 years, the Centre has carried out studies related to cognitive technologies and practices of using computer-supported learning in schools, universities and workplaces. The focus has been on expert-like problem solving, a domain established by pioneer, cognitive researchers, such as Jerome Bruner and Ann L. Brown; a special focus has been on complex or ill-defined problems, which typically frustrate novices because of lack of established procedures leading to excessive cognitive processing load. Research into cognitive scaffolding (Wood, Bruner & Ross, 1976) and procedural facilitation (Bereiter & Scardamalia, 1987) indicated, however, that when provided with external, supporting tools and structures and real-time guidance, the
novices can be helped to succeed in cognitive processes that are otherwise impossible. Hence, the central premise of the theory being developed is the socially contextualised nature of human activity: learning activity relies on socially distributed and self-organising processes in evolving networks of human actors, and supporting tools and artefacts (related to the ‘objects’ of activity, as discussed later; Engeström, 1987). Just as the capabilities of a networked computer cannot be located inside of its processing unit, human intelligence cannot be found by looking inside the human head: human intelligent activity is distributed across a ‘wireless network of intelligence’ (Clark, 2003; Donald, 1991) based on culturally and historically evolved cognitive tools and artefacts, and heterogeneous networks of people and artefacts (Hakkarainen, Lönka & Paavola, 2004).

Investigators of the Centre took an active part in pioneering efforts of Canadian cognitive scientists Bereiter and Scardamalia (2003) to develop groupware systems (eg, computer-supported intentional learning environment [CSILE]) and its current version, Knowledge Forum (Scardamalia, 2002), for eliciting higher level inquiry and in-depth learning in education. Later in Finland, the present investigator directed the cognitive and pedagogical design of Future Learning Environment, which was developed together by Medialab, the University of Arts and Design Helsinki (see Muukkonen, Lakkala & Hakkarainen, 2005). Currently, our research community aims at elaborating and applying a new ‘trialogical’ model of cognition (Paavola & Hakkarainen, 2004), particularly in respect to novelty and innovation, especially emphasising its collaborative and social matrix. The theory has direct application to both educational and work settings, and research projects examine existing practices of creating, sharing and managing knowledge, and propose theoretically driven interventions in the processes, often involving the introduction of supporting technology.

The present investigator’s efforts to enhance learning with cognitive technology were deeply grounded in scientific inquiries into educational practices. Their investigations regarding technology-enhanced learning evolved through three generations of research and theoretical elaborations associated with three metaphors of learning (Paavola & Hakkarainen, 2005; Paavola, Lipponen & Hakkarainen, 2004): (1) knowledge acquisition (monological); (2) participation (dialogical); and (3) knowledge-creation (trialogical) metaphors. The traditional cognitive approach, elaborated prototypically in Descartes, examined learning as a process of individual knowledge acquisition taking place within the human mind (within-mind monologue). The human mind is considered as a container and learning a process of filling the container with knowledge (for criticism of the mind-as-a-container view, see Bereiter 2002). The participation or situative view, in contrast, considered learning to be a process of growing up and socialising to a social community and its norms and practices (dialogue between minds; Sfard, 1998; Anderson, Reder & Simon, 1996). The present investigator, together with his colleagues, has argued that one should additionally consider a third, distinct metaphor that addresses sustained individual and collective efforts of creating and advancing knowledge (trialogical processes mediated by shared objects of cognitive activity: Paavola & Hakkarainen, 2005).
First-generation research: the knowledge-acquisition metaphor of learning

The present investigator’s research on technology-enhanced learning started while he was pursuing doctoral studies at the University of Toronto. His doctoral dissertation was entitled ‘Epistemology of Scientific Inquiry and Computer-Supported Collaborative Learning’ (Hakkarainen, 1998). The study addressed 10–11-year-old students’ research-like process of inquiry within a computer-supported collaborative learning. The issue was to examine how these students, with scaffolds, engaged in the question- and explanation-driven inquiry characteristic of scientific research. The dissertation involved a series of studies over 3 years in which he qualitatively analysed the epistemological nature of 10–11-year-old CSILE (see Scardamalia, 2002) students’ research questions and explanations. In a resulting publication, Hakkarainen (2003a) reported that a mature, progressive-inquiry culture was taking shape in Class A; only a minority of the students produced knowledge at a high explanatory level, but gradually this practice started to dominate the class. In Class B, an inquiry culture never emerged for reasons explored.

Further qualitative analyses of the epistemology of CSILE students’ inquiry culture in Class A indicated that knowledge produced by the CSILE class in question was at a very high explanatory level both in Biology (Hakkarainen, 2003c) and Physics (Hakkarainen, 2004). Practically all research questions posed by the participants were explanation-seeking in nature. Moreover, the students pursued their research questions in-depth, following the pattern of interrogative activity (Hakkarainen & Sintonen, 2002) with initially very ‘big’ questions and tentative working theories, proceeding to search for answers to a series of subordinate questions (Hintikka, 1999), scaffolding within CSILE. The analyses indicated that many of the students made considerable conceptual progress (Hakkarainen, 2003c, 2004). The studies mentioned were carried out by qualitatively classifying the participants’ computer postings according to the epistemic nature of the research questions and knowledge produced. Because the students’ progress was assessed by examining their written productions, the evidence of conceptual progress was not, however, as comprehensive as one might have desired.

Second-generation research: the participation metaphor of learning

Back in Finland in 1994, Hakkarainen, together with several students and colleagues, started to pursue research on cognition and its support with computer technology. These studies rely on the progressive inquiry model developed in Hakkarainen’s (1998) doctoral thesis; the model guided students in advancing their conceptual ideas through computer-supported collaborative learning (Muukkonen et al., 2005). Hakkarainen’s research group, however, encountered various problems while seeking to facilitate conceptual change in Finnish science education. In some of their studies in Finnish elementary schools, they were unable to replicate the computer-supported progressive-inquiry culture prevailing in the Canadian classes despite considerable efforts involving several teachers and schools (Hakkarainen, Lipponen & Järvelä, 2002). They were not able to convey the basic concepts of inquiry to the teachers, and the computer/software focus typically led to participants becoming more interested in information and communication technology than in learning or understanding.
This finding pointed the inquirers towards participatory aspects of learning that had been invisible to many cognitive researchers. The present investigator gradually realised that learning takes place within communities of practice (Lave & Wenger, 1991), which guide and constrain the participants’ activities in multiple ways. The investigator also drew upon Vygotsky’s (1978) view that learning processes are first manifested in external (extra-individual) form. The students’ inquiry process, diffused over several collaborating individuals, took on a new character, as students scaffolded one another. This finding illustrated the crucial requirement to transform the social practices of learning that prevail in any given context. To better understand these processes, the present investigator and his colleagues teamed up with innovative teachers, started videotaping classroom practices and learned social network analysis (SNA; Hakkarainen & Palonen, 2003; Lipponen, Veermans, Lallimo & Hakkarainen, 2003). This method allowed them to examine patterns of participation and inquire into the ‘social infrastructures’ (Bielaczyc, 2006) needed to make computer-supported learning work.

Simultaneously, the present investigator was asked to investigate, on a national basis, processes of innovation in Finland: how various working communities innovated in their respective subject areas. He investigated how experts’ tacit knowledge and knowledge practices are conceptualised for communal use and, vice versa, how collective knowledge is transformed to new knowledge practices (Palonen, Hakkarainen, Talvitie & Lehtinen, 2004). Methods and practices of networked expertise prevailing in knowledge-intensive business organisations were examined with a view to helping educational and training systems to answer the new challenges of a knowledge society. Networked expertise develops interactively through blending competencies across several domains of knowledge (Hakkarainen, Palonen, Paavola & Lehtinen, 2004). SNA was used to identify key actors, structures and practices of expert communities, and their dynamically developing shared objects of activity. Cultural psychology (Cole, 1996) and activity theory (Engeström, 1987) started to emerge as approaches that provided conceptual tools that allowed us to understand, theoretically, the complex relational processes involved.

**Third-generation research: the knowledge-creation metaphor of learning**

Something was, however, still missing, and the dynamics of learning were only partially grasped. My group was studying social networks and practices, but are losing a relation to epistemic processes essential for in-depth understanding as well as advancement of knowledge. Many versions of participatory and situational approaches on cognition appeared to reduce learning and intelligence to shared practices and social structures (Hakkarainen, 2003b). The present investigator found that these approaches did not provide a sufficient basis for understanding the actual epistemic processes of the turbulent, emerging knowledge society. At present, learning is neither a mere assimilation of existing knowledge nor growing up through apprenticeship in a stable community. Persons are called upon to meet novel challenges and to engage in systematic creative reinvention of their inquiry practices so as to elicit knowledge processes characterised by novelty and conceptual innovation (Knorr-Cetina, 1999, 2001).
The present investigator and his colleagues found such successful settings in certain research establishments and designated them as innovative knowledge communities (IKCs) rather than traditional communities of practice (Hakkarainen, Paavola & Lipponen, 2004). So the present investigator’s group began to compare the most promising models of IKCs, ie, Carl Bereiter’s (2002) version of the knowledge-building approach, Nonaka and Takeuchi’s (1995) knowledge-creation model for companies, and Engeström’s (1987, 1999) expansive-learning approach (Paavola et al, 2004). Within these communities, I observed social practices and knowledge practices tailored to promoting continuous innovation and change (Knorr-Cetina, 1999, 2001). Similarly with individual experts (Bereiter & Scardamalia, 1993), IKCs pursue challenging projects by relying on limited resources of fluid intelligence; they develop new practices and procedures that transform novel activities into routines (crystallised intelligence), thereby releasing new resources for attaining even more challenging project goals. These investigations indicated the need to articulate a more general theory of knowledge creation, as well as to anchor the progressive-inquiry model more closely in social practices.

Currently, the present investigator and his colleagues are struggling to understand learning as a form of trialogical activity focused on collaboratively advancing a shared object of inquiry, whether it is a research problem, theory, plan, product, practice (to be transformed) or project. The concept of ‘object’ has philosophic roots in Hegel’s and Marx’s as well as Peirce’s and Popper’s studies, and psychological roots in activity theory as developed by Vygotsky (1978) and elaborated by Engeström (1987) and Engeström and Blackler (2005). The object arises, within Engeström’s perspective on human activity, as essentially sign- and tool-mediated (see also Skagestad, 1993). Semiotic interpretation of Popper’s (1972) notion of objective knowledge comes very close to the present approach. The present investigator draws from Popper’s philosophic vision of three worlds: ‘one day we will have to revolutionize psychology by looking at the human mind as an organ for interacting with the objects of the third world [World 3]; for understanding them, contributing to them, participating in them; and for bringing them to bear on the first world [World 1]’ (p. 156). Popper examined human cognitive evolution in terms of such objects: ‘Human evolution proceeds, largely, by developing new organs outside of our bodies or persons, “exosomatically”, as biologists call it, or “extrapersonally”. These new organs are tools, weapons, machines, or houses’ Popper (1972, p. 238). Investigators examining scientific knowledge creation are concerned about ‘epistemic objects’ existing at the edge of their epistemic horizon and incorporating what the investigators do not yet know (Rheinberger, 1997; see also Miettinen & Virkkunen, 2005). The challenge is to develop methods of empirical, psychological inquiry into these ‘objects’ (an early example, Bereiter, 2002).

Our model of learning holds the promise of more general applicability in the investigation of the mediated nature of human activity. The ‘trialogical’ account of inquiry, from which I draw, helps us to understand sign- and tool-mediated activities (Engeström, 1987; Skagestad, 1993; Vygotsky, 1978). Moreover, the trialogical approach being developed appears to provide a unified framework for research related to flow (merged
intellectual and socio-emotional efforts; Csikszentmihalyi, 1996), personal projects
(individual or interpersonal endeavours that structure human activity; Little, 1993; Salmela-Aro & Nurmi, 1997) and scientific creativity (pursuit of a supportive and
dynamically developing network of enterprises; Gruber, 1981). All of these are object-
oriented processes integrating the epistemic, socio-emotional and social aspects of
learning. Here, dialogue with various cultural–psychological approaches, such as
knowledge building, activity theory, distributed cognition, actor-network theory or
situated cognition, will provide valuable guidance. Knowledge-creating learning can be
seen as a self-organising system (Resnick, 1994) that involves coevolution of agents,
artefacts, and dynamically evolving social communities and networks (Engeström,

Thus, the issues discussed are not only academic, but also relate to the challenge of
European education to devise ways of preparing learners to engage in intensive work
focused on deliberate knowledge advancement (Hakkarainen et al, 2004) through
evolving forms of collaborative teamwork and sustained knowledge sharing and cre-
ative advance. The Centre is coordinating the Knowledge Practices Laboratory project
(KP-Lab; see http://www.kp-lab.org); this integrated European Community project is
focused on developing ‘trialogical technologies’ aimed at facilitating innovative prac-
tices of working with knowledge (‘knowledge practices’) in schools and workplaces
(Hakkarainen et al, 2006). The intention is to refine the cognitive–theoretical principles
underlying what the present investigator and his colleagues call trialogical technolo-
gies, ie, semantic-web-based tools which support long-standing and extended work in
advancing and developing shared knowledge objects. The project aims at eliciting such
creative practices of working with knowledge that characterise the work of experts
in rapidly changing knowledge-intensive organisations and networks. The project
involves extensive longitudinal investigation of transforming knowledge practices in
universities, polytechnics and professional organisations. Students of higher education
(universities and polytechnics) solve complex problems for real customers (enterprises,
public organisations and research communities) and engage, early on, in field studies
aimed at gaining experience of the professional knowledge practices in their own field;
simultaneously, professional communities encounter new ideas and practices from the
students, so as to bring about cross-fertilising knowledge practices between educational
and professional communities. The project includes extensive research training and the
participation of tens of professors and hundreds of months of graduate and doctoral
students’ work representing 22 organizations from 14 European countries.

Concluding remarks
The present investigator’s research community examines various individual and col-
lective problem solving and knowledge advancement processes taking place in educa-
tional and professional domains. The ‘trialogical’ research approach being developed
does not address social and cultural processes in general; its special focus is on epistemic
processes given form by the matrix of social processes and structures. It is focused on
examining reciprocal individual, social and cognitive–technological transformations
taking place in such processes. It appears essential to examine human cognition devel-
opmentally and longitudinally in order to reveal self-organising and ‘transactive processes’ (Samerroff & Mackenzie, 2003) of cognitive growth based on reciprocally interacting individual and social processes and their objects, within a given cultural environment. Such processes imply that the objects created and practices enacted change the environment of participants’ activity in a way that makes pursuit of more demanding objects accessible for subsequent activity. These investigations aim at creating a comprehensive view of human cognition, addressing sustained individual and collective processes of deliberate knowledge advancement, considering the conceptual, physically embodied, and practice-related aspects of such processes.

Along with theoretical and conceptual development, one needs corresponding improvements of research method in order to expand investigations to knowledge practices involved in trialogical processes. The problem of accessing and characterising the ‘object’ necessitated that the present investigator use multiple methods of cognitive research, such as participant observations, structured interviews, thinking-aloud protocols and validated self-report instruments. The computer environment is designed to provide affordances for objects; the ‘portfolios’ or folders offered by the software have allowed us to examine, at all stages of their elaboration, sketches, photos and plans posted to the common database. For the recorded verbal productions, the present investigator has employed various methods of frequency analysis, multivariate statistics and social network analysis. Several investigations were design experiments (Collins, Joseph & Bielaczyc, 2004) involving cycles of (1) developing technology-enhanced learning environments; (2) implementing these technologies in educational practices; and (3) collecting empirical data that guided further theoretical and technological development.

Trialogical learning processes, at best, take place across long periods of time and involve profound cognitive transformations that reshape the human mind and brain. Because some of such temporally extended cognitive processes cannot be easily experimentally studied, the present investigators are engaged in developing rigorous methods of collecting longitudinal data of complex interactive processes of learning and cognition. Within the frames of KP-Lab project, research instruments have been developed based on 3G mobile devices for doing contextual activity sampling (Muukkonen, Hakkarainen, Inkinen, Lonka & Salmela-Aro, 2008), based on ecological momentary assessment (Reis & Gable, 2000) and experience sampling method (Csikszentmihalyi, 1996). Thus, we are collecting time-series data regarding transformations of trialogical objects worked upon as well as longitudinal changes in knowledge practices of students of universities and polytechnics.

References


