Computer-Supported Collaborative Learning (2007) 2:363–391
DOI 10.1007/s11412-007-9023-3

Using activity-oriented design methods to study collaborative knowledge-building in e-learning courses within higher education

Christine Greenhow · Brad Belbas

Received: 9 June 2006 / Accepted: 12 September 2007 /
Published online: 23 October 2007

Abstract Trends in higher education have contributed to the need for more coordination and collaboration among different constituencies involved in instructional design and delivery. As researchers and educational technologists working in a large public research university, our research focuses on understanding the interactions among various stakeholder groups involved in e-Learning courses. In this paper we provide an interpretation of how Activity-Oriented Design Methods (AODM) based on Activity Theory can be used to develop a more comprehensive understanding of collaborative knowledge building practices among course design teams and their students. We also discuss how these methods can inform instructional design and development within distance education programs. In the absence of universally accepted methods for applying activity theoretical perspectives, these methods provide an analytic scheme for identifying the essential elements of an activity and for examining their interrelationships or contradictions, which are essential to improving the activity overall. The procedures described here have been used in a series of e-Learning case studies at our institution. We draw from one case to illustrate our interpretation of Activity-Oriented Design Methods. The themes discussed in this paper have implications for a broad audience of educational researchers, technologists, instructional systems designers, faculty, course assistants, and administrators concerned with examining and advancing collaboration among different groups in developing e-Learning.

Keywords Activity theory · Collaboration · Course development · E-learning · Higher education · Qualitative methods

Authors contributed equally to this manuscript.

C. Greenhow (✉)
Learning Technologies, College of Education and Human Development, University of Minnesota, Rm 130A Peik Hall, 159 Pillsbury Drive, SE Minneapolis, MN, USA
e-mail: greenhow@umn.edu

B. Belbas
Social Sciences Division, Macalester College, 1600 Grand Ave, St. Paul, MN 55105, USA
e-mail: jbelbas@macalester.edu

Introduction

Anyone who has tried to use a new technology to create educational experiences would likely agree that having the opportunity to dialogue with other users facilitates improvement of instructional practices (Eraut 1994; Argyris and Schon 1974). Indeed, there is a growing consensus in the professional development and adult learning literature that educators develop their pedagogical expertise in *collaborative* resource-rich contexts where they have the opportunity to critique practices with like-minded educators and interdisciplinary experts (Darling-Hammond and Bransford 2005; Joyce and Showers 1995; Wenger 1998). Moreover, the literature acknowledges that students' involvement as participants in the design and critique of educational activities is important to the learning of course designers (e.g., instructors, teaching assistants) and to the course-related community (e.g., administrators, educational technologists, program developers) as well as to students' own learning (Bransford et al. 1999; Engeström 1991; Lee et al. 2006). Such findings suggest that close examination of course-related collaborative practices is valuable for those who seek to facilitate instructional improvement.

As researchers and educational technologists working within a large public university in the United States, we are concerned with understanding and facilitating course design and development as they unfold in technology-enhanced university contexts. Trends in higher education, including higher enrollments, the increasing diversity of students, ubiquitous access to the Internet, and an unbundling of faculty roles through employment of more non-tenure track and part-time instructional staff, have contributed to the need for more coordination among various constituencies involved in instructional design and delivery, especially with respect to *e-Learning* (Levy and Murnane 2004; Paulson 2002; Schuster and Finkelstein 2004).

We define e-learning broadly to be learning that occurs through the use of information and communications technology (Khan 2005). E-Learning can encompass both the teaching elements (e.g., posing questions, creating assignments, giving feedback) and the learning elements (e.g., responding, performing assigned activities, responding to peers) that together constitute the course event (Bernard et al. 2004). E-learning is often used synonymously with *distance education* to indicate that instructors and students are engaged in two-way communication from different locations and often at different times via computer networks (Bernard et al. 2004). E-Learning can cover a spectrum of activities from *blended* or *hybrid* learning, which combine face-to-face and online instruction, to learning that is facilitated wholly through online activities (Khan 2005).

Building on this definition, our research focuses on the interactions among various participants and learning materials in distance educational or e-Learning settings (Scanlon and Issroff 2005) with particular focus on how *collaborative knowledge building* occurs (Stahl 2006a). We examine how Activity-Oriented Design Methods (AODM) (Mwanza 2002a, b) can develop a comprehensive understanding of collaborative knowledge building practices among course design teams and their students. Our illustration and reflection on these methods can advance the work of researchers and course teams who similarly seek to model and improve such practices.

Need for comprehensive methods

In the literature on computer-supported collaborative learning, Stahl (2006a) uses the term "collaborative knowledge building" or "group cognition" in place of "collaborative learning" to refer to more than just individual learning in groups. Instead, as Stahl uses it, the term encompasses “the practices of meaning-making in the context of joint activity” (Stahl et al. 2006, p. 418). In other words, knowledge lives in groups, teams, and social networks and not simply in the minds of individual learners. With respect to university e-Learning, one is hard pressed to find accounts of effective online teaching or learning, without also encountering references to the interactions amongst various groups involved in the design and enactment of instructional practices (e.g., students, faculty, course instructors, instructional designers, graduate assistants, technical support staff, technologists, curriculum coordinators, programmers) (Ackerson et al. 2002). Guides for the development of e-Learning in higher education argue for the creation of interactive collaborative learning environments (Herring 1996; Reeves et al. 2004;) that often require the joint activity of a course design team (Boettcher and Conrad 2004).

However, research tends to focus on students’ and instructors’ collaborative processes rather than on the processes of development and design teams with respect to e-Learning (Haythornthwaite 2006; Palloff and Pratt 2005; Stahl et al. 2006; Swan 2006; Tallent-runnels et al. 2006). A contributing factor may be the lack of established methods for evaluating the interrelationships between the activities of various constituencies involved in the integration of technology, support, collaboration and learning that such courses require (e.g., how does the designer’s efforts relate to the instructor’s teaching and to the students’ experience?).

This paper begins to address these issues by examining one such method—the Activity-Oriented Design Method (AODM) (Mwanza 2002a, b)—based on Activity Theory (Engeström 1987) that offers a more comprehensive approach to capturing these relationships. This method was used to study the individual and group perspectives involved in the development and deployment of e-Learning courses at a large research university within the United States. In the sections below, we first provide an overview of Activity Theory and the rationale for its operationalization in AODM. We situate this discussion of the method within the broader methodological traditions that have characterized computer-supported collaborative learning research. Next, we present our interpretation of AODM, using examples of its application to explain our research process. Here, we also highlight selected findings about aspects of collaborative knowledge building among a course design team and their students. We illustrate the challenges and benefits of using this method in a design-based research program (e.g., Barab and Squire 2004; Design Based Research Collective 2003). Finally, we reflect on the implications of using AODM as an iterative approach to studying and refining collaborative knowledge building in distance educational contexts over time.

Theoretical perspectives

Activity theory and activity-oriented design method

Activity theory, as articulated by Engeström (1993 and 1999a) and Nardi (1996) originates from the sociocultural and sociohistorical theories of Vygotsky (1978), Leont’ev (1978) and others. Similar to notions of “situated learning” and “cognitive apprenticeship” (Collins et al. 1989) that posit learning as located in contexts and relationships rather than merely in the minds of individuals, sociocultural and historical theories argue that learning derives from participation in joint activities, is inextricably tied to social practices, and mediated by artifacts.

Recently, within education, there has been growing interest in ideas of community and the ways in which social groupings can be designed to advance individual and collective understanding, especially in the presence of powerful information and communication technologies (Hewitt 2004). Activity Theory provides a particularly powerful lens through which to study the complex social practices that arise within university distance educational contexts. This is mainly due to its focus on the *relationships* that exist among those involved in an *activity*. This is enhanced by the historical development of the activity, the issues surrounding the use of tools to support the activity, and the perspectives and actions operating where the activity is carried out (Mwanza 2002a). As Nardi (1996) states: "activity theory offers a set of perspectives on human activity and set of concepts for describing that activity...as we expand our horizons to think not only about *usable* systems but now *useful* systems" (p. 8) (emphasis in the original). Activity theorists, therefore, are not merely concerned with "disembodied action" (e.g., designing a course), but with "doing in order to transform" something in context (e.g., course designs enacted over time) (Barab et al. 2004a, p. 200).

Activity theory is rooted in the work of Lev Vygotsky (1978), who introduced the concept of *mediated action*. An underlying assumption of mediated action is that humans do not interact directly with their environment; rather, *tools* and *signs* mediate interactions. This concept is typically represented using a diagram commonly referred to as a *basic mediational model* (see Fig. 1).

Building on Vygotsky's (1978, pp. 62–63) theory of mediated action, Leont'ev (1981) developed the well-known three-level model of activity. This model articulated the developmental transformation of social activity to individually internalized cognitive structures. At the foundational level of human activity is the *object* or "motive," which he theorized as the underlying driving force of human activity.

More recent developments in activity theory (i.e., Engeström 1987; Raeithel 1992; Wells 2002), have contributed additional analytic tools for modeling activity systems. In particular, these analytic tools have helped analysts bring increased attention to the contributions of macro-level processes (i.e., community, societal) to activity systems. Engeström and others (Raeithel 1992; Wells 2002) emphasized the importance of assuming a systems, macro-level perspective for analysis as well as a subject-oriented, micro-level perspective: "[t]his dialectic between the systemic and subjective-partisan view brings the researcher into a dialogical relationship with the local activity under investigation" (Engeström and Miettinen 1999, p. 10). Engeström, in particular, emphasized the importance of analyzing breakdowns or contradictions in the interactions of elements in an activity system as a means of expanding and transforming the system and developing human practices. His theory of *expansive learning* or learning through participation in joint activities involved collaborative questioning and analyzing existing practices to generate new possibilities.

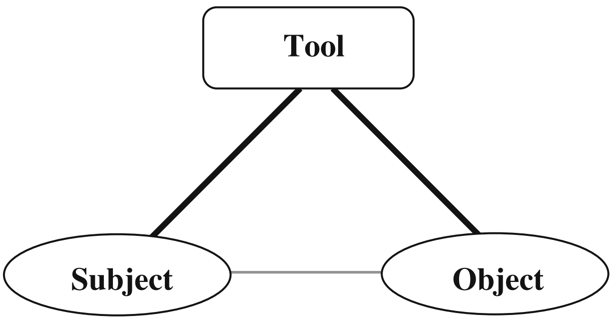


Fig. 1 Basic mediational model (Vygotsky 1978)

Engeström's (1987) expanded activity theory triangle (Fig. 2) has been at the center of much recent development. Engeström developed the expanded triangle to facilitate activity system modeling. He defined activity systems as *object-oriented, collective, and culturally mediated human activity* and designed the expanded triangle to represent an activity system's constituent elements (Engeström and Miettinen 1999, p. 9). These constituent elements include the *subject*, *object*, *community* and other mediators of human activity, namely *tools*, *rules*, and *division of labor* (Engeström 1987). The following paragraphs provide a brief description of each of these elements to orient the reader.

The *object* represents the motive or problem space and provides the purpose for which individual actions and goals are constructed. The object provides the basis for distinguishing the various actions and sub-activities within the main activity system.

The *subject* element represents the individual and collective aspects of human activity. The individual aspect is represented through the use of tools to accomplish the object. The collective aspect is represented through the relationship between the subject and shared communal resources (i.e., rules, community, division of labor).

The *tools* element represents artifacts used in human activity, including physical objects (e.g., pencils, paper, computer hardware), other people, and abstract resources (e.g., language, concepts, experience). The tools element represents the principle of mediation in human activity.

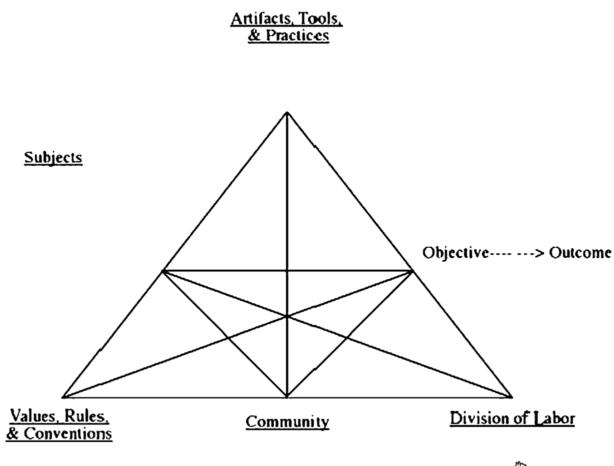
The *rules* element represents the norms, expectations, and conventions that constrain and influence the means by which an activity is carried out. Some rules are explicit while others are implicit; they depend on the norms that are in place for particular communities.

The *community* element represents the collective group and those with a shared interest in the object and outcomes of the activity; it is, also, one of three additions to the original triangle model, which contribute to the macro-level (i.e., collective) perspective.

The *division of labor* element represents the construction of roles and responsibilities, which subjects assume when carrying out an activity; it represents the allocation of tasks as well as hierarchical status and power.

Activity theory has been used to study information systems design and development (Kuutti 1999), to analyze work practices among teams in business, medicine and law (Engeström 1995, 1999b), and to inform the evolution of work-based activities in corporate settings (Collis and Margaryan 2004). In education, activity theory has been applied to analyze learning among primary and secondary school students (e.g., Hedegaard 1999;

Fig. 2 The expanded activity triangle



Lompscher 1999; Hakkarainen 1999) and among learners in higher education (Barab et al. 2004a) but less so to examine learning among course teams and its relationship to students' learning. Roth and Lee (2007) in a recent article for *Review of Educational Research* argue that the activity theoretical framework is one of the "best kept secrets of academia" for reducing the theory-praxis gap (p. 186).

However, Activity Theory can be a complex framework to utilize for analysis and design purposes (Barab et al. 2004a). Mwanza (2002a) citing Nardi (1996) and Engeström (1993) argues that Activity Theory as an analytical framework does not offer "ready-made techniques and procedures for research," and, as an "evolving framework," provides only "general guidelines" that must be operationalized and a "standard method" developed for applying it (pp. 89–90). Researchers employing Activity Theory often neglect to describe their data-gathering and analysis procedures in sequential fashion, which results in an apparently static synthesis that obscures the evolving nature and history of the research process (Barab et al. 2004a; Collis and Margaryan 2004). Where access to methodological description is denied, the reader is unable to determine whether or not the findings are credible or the methods reproducible (Anfara et al. 2002). AODM was designed to address such issues of putting Activity Theory into practice in a way that guides the researcher and reduces "cognitive complexity" while still providing an analytical tool for studying human activities in context (Mwanza 2002a, p. 97). As described in a later section of this paper, the strength of this approach for our purposes is that it lays out a series of well-structured procedures, or *stages* for applying Activity Theory to the study and improvement of the design process. We especially appreciated that AODM specifically advocates *communicating* evidence-based *design insights* to a practitioner-audience, and as such, provides a means for formative evaluation and feedback to the course design teams with whom we work. AODM is grounded in the research concerned with human–computer systems design, with its emphasis on user input and the development of useful technologies, rather than in recent research on learning and teaching. Therefore, we turned to relevant theories of instructional design with new technologies and ideas about studying collaborative knowledge-building for guiding principles to focus our analysis.

AODM within computer-supported collaborative learning research

In providing an historical perspective on computer-supported collaborative learning (CSCL) research, Stahl et al. (2006) argue that research methods are not value free; the researcher must decide what he or she will attend to based on his or her assumptions. Our experience and review of the teaching with technology literature tells us that instructional practice involves ongoing refinement of activities among course participants (Bransford et al. 1999; Jonassen 2000; Wiske et al. 2005). Therefore, we were interested in understanding and characterizing *instructional practice* as the *design*, implementation (i.e., *teaching and learning*) and *assessment* activities from the perspectives of course design teams and their students. We sought to pay close attention to identifying collaborative knowledge building where it occurred and where it broke down within each activity system. Our objective derives from Stahl (2006b) who argued that collaborative knowledge building, or shared meaning-making in CSCL research is a directly and empirically observable activity, as opposed to existing only in the mind.

However, the term "knowledge building" is used by different authors to refer to widely differing practices. Therefore, we drew on Paavola et al. (2004) useful synthesis of Engestrom's (1999b) expansive learning model and Scardamalia and Bereiter's (2004a) knowledge building model to define *collaborative knowledge building* as an iterative, social process of collectively advancing and elaborating knowledge objects in the form of "conceptual artifacts" (e.g., plans, ideas, or models) or practices (e.g., implemented instructional strategies or research methods) (pp. 560–566). In our definition, shared knowledge objects are in a constant state of flux toward actual or potential change and improvement rather than fixed truths (Paavola et al. 2004). Moreover, knowledge-building is embedded in practices (Engestrom 1999b); mediated by questioning of existing practices or understandings; and involving social interaction as intellectual resources are distributed across people and tools, and new ideas co-evolve "between" people (Paavola et al. 2004, p. 564). For example, collaborative knowledge building in a teacher community produces objects or artifacts which can be shared, developed and used to provide evidence for evaluating knowledge building. Written speech in asynchronous threaded discussions (e.g., arguments about best practices in online teaching), interview transcripts, written correspondence in response to students' work (e.g., emailed peer-to-peer reflections and critiques), or iterative versions of lesson plans or course materials developed in tandem, are all artifacts of knowledge building that one might observe. Finally, collaborative knowledge building is transformational; the goal of a knowledge-building community is not to learn something for its own sake but to solve problems, originate new ideas, *do* something with what is known, and advance communal knowledge" (Paavola et al. 2004, p. 561).

Within the CSCL literature, several methodologies have emerged for analyzing collaborative knowledge building directly or indirectly mediated by technology (Jones et al. 2006). Indeed, it is difficult to outline a "well-defined consistent, comprehensive definition of CSCL methodology" when "hybrid" approaches may be more useful (Stahl et al. 2006, p. 421). Nevertheless, three methodological traditions have emerged in the CSCL literature: experimental, descriptive, and iterative design (p. 13). We view our interpretation of AODM as a hybrid methodological approach that falls within the descriptive and iterative traditions. First, our interpretation of AODM provides descriptive analysis within the ethnomethodological tradition and, as such, the analysis is microanalytic, examining brief episodes in great detail (Stahl et al. 2006). Descriptive analyses enable only petite generalization to similar contexts but service the accumulation of evidence over time to advance theory. Our interpretation of AODM also provides an iterative analysis and fits well within the overarching design-based research paradigm that has most recently been debated in the educational technology and learning sciences literature (Dede 2004; Barab 2006). Because AODM is concerned with helping the researcher to identify contradictions within the activity system and generate design insights for further study and refinement, it provides a useful tool for the methodological toolkit of the design-based researcher concerned with developing practice and theory concomitantly (Barab 2006).

The sections above have described the theoretical perspectives that oriented our interpretation and application of the AODM. Next, we present the methods in practice, describing it in detail with examples drawn from one of our series of case studies to illustrate our interpretation of the different stages of its implementation. We begin by providing background on the research context to situate the discussion.

The AODM toolkit in context

Research setting

As educational researchers and technologists within a new media center, we are frequently called upon to improve and support the process of course development and redesign, especially with respect to e-Learning. Results of a university-wide survey of faculty, staff, and students conducted in the spring of 2003 revealed that our faculty and instructional staff wanted to better understand how online course managements systems (i.e., WebCt/Vista) were being used to facilitate teaching and learning across the university (Ernst et al. 2004). In the fall of 2004, the Pictures of Practice project funded by the Office of Information Technology began as a multi-year research project designed to address these issues. The project team included the two authors and a third researcher involved only in the first semester of the project.

As depicted in the screenshot of the WebCt/Vista course management system interface in Fig. 1, WebCt/Vista offers several tools that can foster not just information delivery but interactivity among participants involved in e-Learning courses. For instance, WebCt/Vista provides an asynchronous threaded discussions forum and its own electronic mail service which can both be used to facilitate two-way communication among course participants. As illustrated in the main page and navigation bar at the left (see Fig. 1), designers using WebCt/Vista can program interactive learning modules, which are content organizers that can be embedded with links to the discussion, chat, or whiteboard tools. The WebCt/Vista interface enables three views. The student view, shown in Fig. 3, is what students see when they enter the online environment. The builder and teacher view (not shown) provides the capability of managing, editing or adding content to the site or generating grade reports and site statistics. In builder mode, for instance, course design team members can set up ongoing assessments that are kept hidden from the students' view until a set release date. Students can then enter their responses to the assessment online. Assessments may take the form of polls, quizzes or surveys. Students' responses to assessments are then logged in an online database and linked to the WebCt/Vista gradebook, available in the teacher mode for entering grades and generating feedback to students. The online software also offers a means of publishing course documents like syllabi and assignment guidelines. Finally, WebCt/Vista offers a means of storing students' work and of managing information such as course readings, videotaped lectures, Web site links and other content.

The primary objective of the research study from which this paper stems was to produce ongoing pictures or models of instructional practice that could illuminate how course design teams develop engaging e-learning courses using WebCt/Vista. Thus, we needed to investigate their design, implementation and assessment activities related to e-Learning. Specifically, we sought to acquire insights into their collective practices and to foster collaborative knowledge-building practices among course-related participants by sharing

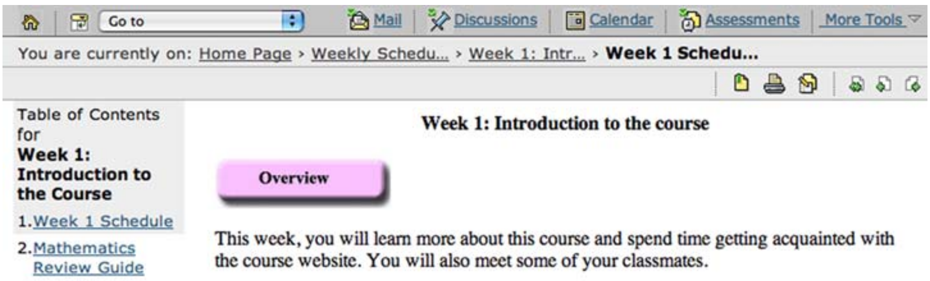


Fig. 3 Screenshot from WebCt/Vista course management interface showing the various tools in the online course environment such as mail, discussions, calendar, assessments and the learning module depicted in the main page space with accompanying navigation bar at left

the insights we gained. Participants in our study were three tenure-track faculty and three non-tenured instructional staff, their course assistants (also referred to as *instructional designers*), and students across six different disciplinary departments at the university. Three of the courses we examined were conducted entirely online and three were conducted using combined face-to-face and online instruction. WebCt/Vista course management tools were used to facilitate and support the online teaching and learning.

To identify and recruit promising candidates for the overarching study, we advertised via email or face-to-face to leaders and consultants on campus who are in regular contact with a wide range of faculty and staff. In screening interviews with instructors (not course assistants or students) prior to the start of the semester, we looked for those who espoused peer collaboration and social constructivist approaches to teaching rather than traditional didactic methods (Bransford et al. 1999). Screening for these types of participants was important because research suggests that they are most likely to demonstrate promising online teaching strategies (Becker and Ravitz 1999) that educators in similar context might emulate. Therefore, we eventually chose courses which seemed to embody such approaches as evidenced by: (1) a course organization that allowed for teacher–student and student–student interaction, (2) instructor's stated orientation toward using various methods, (3) instructor expressed a positive attitude toward students and subject matter, (4) instructor expressed interest in providing students with opportunities to tap prior knowledge, question, connect to real work practices, consider multiple perspectives, reflect, self assess, and collaborate with peers, and (5) instructor believed in his or her capacity for teaching and learning and perceived WebCT as a potentially valuable resource. We also screened for instructors who had a track record of WebCT/Vista use over several semesters; had ready access to high-speed Internet at home and in the work place; used the Internet on a weekly basis for a range of purposes; and who had a history of using WebCT or Vista course management tools for more than just delivering documents, but for innovative teaching strategies (e.g., fostering student–student interactivity or active learning projects) (Becker and Ravitz 1999; Ertmer 2005).

To gather data on participants' initial conceptions of the course design, of teaching and learning, and of assessment, we used an hour-long semi-structured interview format adapted from Mwanza (2002a) to interview instructors and their assistants at the beginning of the course. To investigate participants' interpretation of their experiences in implementing the course, we also conducted interviews after the course was over. In addition, we conducted hour-long focus groups with students mid-way through the semester, after they had a chance to experience and become proficient in using the WebCt/Vista tools to communicate. We collected records of participants' actions and interactions online, including records of discussion threads and examples of students' work that allowed us to triangulate the data and observe the course context as it evolved.

The course we are focusing on in this paper was an online introductory statistics course involving the course instructor, her teaching assistant, and 35 undergraduates. The instructor wanted her students to be able to use statistics to make reasoned decisions and better understand the world around them. Specifically, her goals were for students to be able to individually and collaboratively critique statistics used in popular media; analyze statistics used in research; and design, conduct, and represent findings from a research study in which they used statistical software and concepts discussed in the course. Students were asked to keep a statistics journal to regularly log and share their critiques (e.g., critique of a graphical display from a newspaper); to participate in regular small group assignments designed to foster collaborative reflection and problem solving; and to complete a short research project. Students were assessed in the course by their performance on quizzes, homework assignments, small group assignments, statistics journal entries, course project, and a final exam. At the end of the course, the instructor felt that students were largely successful in achieving these goals, and as discussed later in this paper, we found evidence of this in examining the course activity.

Through the application of Activity Theory and AODM in iterative cycles over several semesters, we sought to improve our methods for investigating collaborative knowledge building among course design teams and their students. We also sought to use the method to *map* practical design suggestions that could then inform the development of subsequent educational experiences and support group processes.

The four methodological tools of AODM

Designed to unify the basic concepts of Activity Theory considered relevant to analysis of work practices and tool design, AODM helped us analyze instructional practices among course design teams within contexts mediated by online tools and other artifacts (Mwanza 2002a, b). AODM introduces four methodological tools to support the processes of data-gathering, analysis, and communicating design insights. These tools are summarized here as

Tool 1 An *Eight-Step-Model* (depicted in Table 1) that operationalizes the nodes (i.e., object, subject, tools, rules, division of labor, community, outcome) on the activity triangle model defined by Engeström (1987) and contributes to the modeling of a main activity system.

Tool 2 An *Activity Notation* that facilitates decomposition of the main activity system into *sub-activity* triangles that are united through a shared *objective*. Use of the Activity Notation is proposed as a way of aiding the analysis of relationships within and between the different elements or nodes of the main activity system to identify contradictions, or system tensions and dualities.

Tool 3 A technique for *Generating Sub-Activity-Oriented Research Questions*, or areas of inquiry warranting further detailed investigation when examining the relationships within and between different activity system components. The technique is proposed as a strategy for focusing and supporting data gathering and analysis from an activity theory perspective rather than applying a purely grounded approach.

Table 1 The Eight-Step-Model tool assists the researcher in defining and describing the nodes on the activity triangle shown in Fig. 2

Identify the:		Questions to ask
Step 1	Activity of interest	What sort of activity am I interested in?
Step 2	Objective	Why is the activity taking place?
Step 3	Subjects	Who is involved in carrying out the activity?
Step 4	Tools	By what means are the subjects performing this activity?
Step 5	Rules and regulations	Are there cultural norms, rules or regulations governing the performance of the activity?
Step 6	Division of labour	Who is responsible for what and how are roles organized?
Step 7	Community	What is the environment in which this activity is carried out?
Step 8	Outcome	What is the desired Outcome from carrying out this activity?

Tool 4 A technique for *Mapping Operational Processes,* which encompasses the application of tools one, two, and three by making the links between them more explicit for the researcher as well as illustrating how the use of these tools build on one another (see Table 2 for an example).

Application of the tools

The four tools can be applied iteratively in stages, as described below.

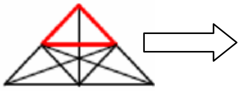
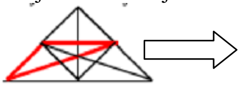
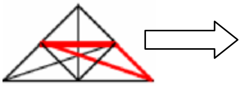
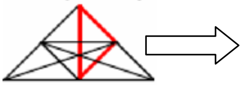
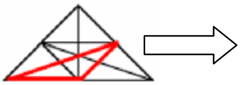
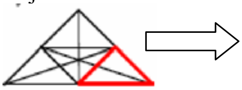
Stage 1 Interpret the situation being examined in terms of Activity Theory
Stage 2 Model the situation being examined
Stage 3 Decompose the situation
Stage 4 Generate research questions
Stage 5 Conduct a detailed investigation
Stage 6 Interpret and communicate findings

To this we added a *Stage 0* or *preparatory stage* which acknowledges the preliminary analysis we felt was needed in order to organize the data so that it could be more easily retrieved throughout the stages. In describing our interpretation of each stage, we discuss the benefits to applying these tools as well as strategies we developed and challenges we faced. Our description also mentions selected findings from our case to illustrate the research process.

Preparing the data for AODM analysis

One of the challenges we faced at the beginning of the study was in deciding how to organize the mass of data we were to collect in a way that would facilitate ease of retrieval while preserving accuracy and context. Because we were interested in understanding instructional practices as they occurred in situ, we needed to collect information from a variety of sources in multiple media. Our data sources included audio recordings and transcripts of interviews, texts of threaded discussions, assignment submissions, screenshots of the WebCT/Vista interface, and course documents. The digital audio recordings and electronic transcripts of the interviews were imported into Transana, a qualitative research software for analyzing digital audio and video (Fassnacht and Woods 2006). Transana allowed us to select text in the transcript, assign keywords to it, create a link between the selection and its location in the audio file, and group related selections into collections (i.e., a process in Transana referred to as creating clips). Figure 4 illustrates the clip properties box that appears on the Transana interface when text and audio clips are created. The selected text can be seen with its assigned keywords shown at the right. We derived the first nine of the ten keywords listed in Fig. 4 from the activity theory categories Mwanza (2002a) identified (i.e., background, activities, actions, operations, etc.). We found ourselves adding descriptive labels to clips within a keyword category such as “guiding principles_history of reasons for doing quizzes” to describe the dimensions of the categories we identified. Organizing the interview data into activity-oriented categories in this way was an essential preliminary step to being able to meaningfully interpret it in stage one. Furthermore, it allowed us to critically examine whether keywords derived from activity theory concepts were comprehensive enough to adequately represent the situation participants’ described. We added a tenth key word, “contradictions” to make explicit transcript selections that suggested tensions or challenges in the system.

Table 2 A format used for operational mapping to represent and communicate findings

Sub-Activity Triangle focused on	Questions generated from case study		Identified area of contradiction
Subject-Tool-Object 	How do the guidelines for small-group threaded discussions (Tool) affect a student's (Subject) development of practical and conceptual knowledge of statistical research methods (Object)?		Some discussion questions and tasks lead to a single correct answer.
Subject-Rules-Object 	How does the rule that "students are required to interact frequently" in threaded discussions" (Rule) affect a student's (Subject) development of practical and conceptual knowledge of statistical research methods (Object)?		Perceptions that distance learning is independent
Subject-Div. Labor-Object 	How does the distributed responsibility for assignments (Div of Labor) affect student's (Subject) development of practical and conceptual knowledge of statistical research methods (Object)?		Some group members don't actively participate
Community-Tool-Object 	How does the instructor's synthesis of each group's threaded discussions (Tool) contribute to students' (Community) development of practical and conceptual knowledge of statistical research methods (Object)?		Unclear if students read or learn from instructor comments
Community-Rules-Object 	How does the requirement that class members participate in collaborative projects (Rule) support students' (Community) development of practical and conceptual knowledge of statistical research methods (Object)?		Student concerns regarding value of peer knowledge versus instructor knowledge
Community-Div. Labor-Object 	How does the use of a group leader (Div of Labor) affect students' (Community) development of practical and conceptual knowledge of statistical research methods (Object)?		Dealing with low participation by some group members

Additional data sources collected from within the WebCt/Vista course environment included threaded discussion messages, assignment submissions, screenshots of the WebCT/Vista interface, and other digital course documents. These were imported into a FileMaker Pro database primarily as text files. The ten keywords used in the transcript analyses were assigned to each item, making it possible to retrieve specific items using the software's search function. As an example, Fig. 5 illustrates the data entry interface for the course documents database which allowed us to input and organize baseline information for each record (i.e., a course document or screenshot) within a single screen. Although for ease of sorting we tried to code items with only one keyword which we felt was most relevant, we often found that two or more codes were needed to accurately categorize an object. For instance, not shown in Fig. 5 is how the keywords "rules" and "tools" were attached to the object (i.e., homework guidelines) in this example. Additional interfaces were used to facilitate keyword coding and other functions.

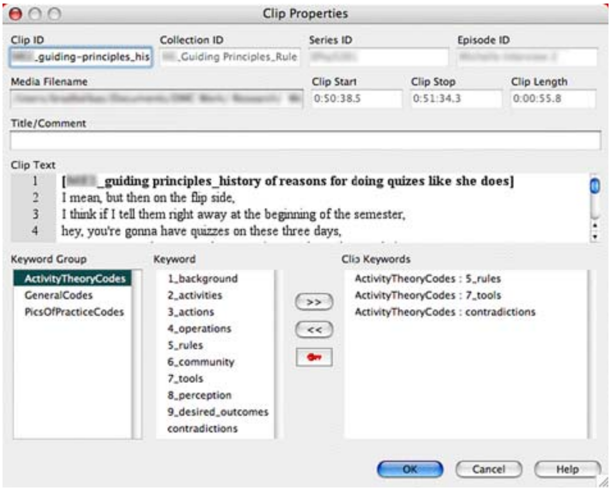


Fig. 4 Transana clip properties dialog box

Once we were in a position to perform keyword and text searches across these various data sources, we were able to begin to interpret the data more holistically using stages one and two of AODM.

Stages 1 and 2: Interpreting and modeling the course design activity

In applying stages one and two of AODM, the analyst interprets and then models the situation in terms of activity theory. In *Stage 1*, the eight-step model (see Table 1) is used to facilitate the process of interpreting the data in terms of the eight activity theory concepts (see Table 1, middle column). Questions corresponding to each concept (e.g., "Why is the activity taking place?") help to scaffold the researcher's interpretive process. For example, to complete the first step in the table, identifying the activity of interest, we translated our research agenda into activity theoretical terms (i.e.,"we are interested in course design

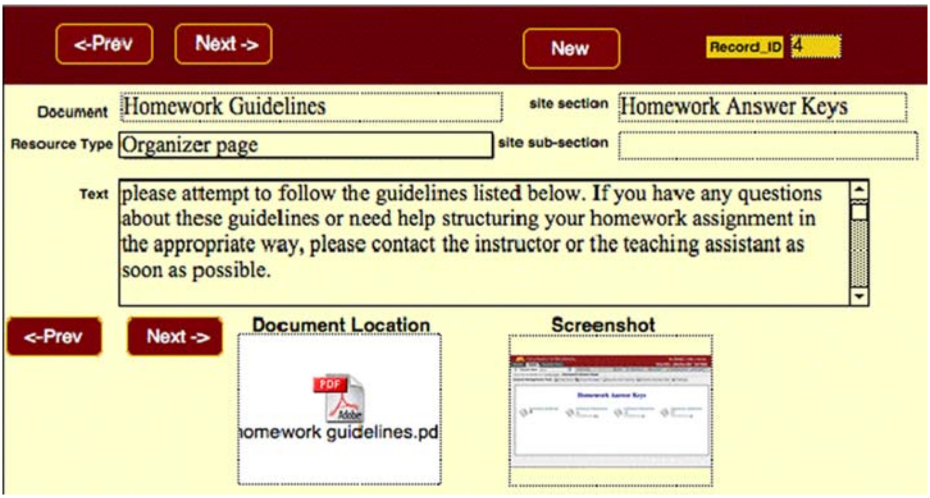


Fig. 5 Screenshot of database created in FileMaker Pro

activity, teaching and learning activity, and learning assessment activity"). Although these steps may seem obvious, we felt they were especially helpful for novice activity theorists trying to conceptualize and characterize the data as well as for experienced researchers trying to make explicit a process that has become intuitive.

Information produced from working through the questions in Stage 1 can then be used in *Stage 2* to create an initial model of the main activity system, which must be refined over several iterations. As shown in Fig. 6, each concept listed in the first column of Table 1 corresponds to a node on the expanded activity triangle. Effectively developing the main activity system model is critical because it provides a basis for identifying and analyzing the constituent sub-systems as well as representing the overall system or context.

It is worth emphasizing here that each stage of analysis produced insights that required us to revise the interpretations and models generated in earlier stages. Rather than progressing through a linear, unidirectional sequence, our progress was cyclic and cumulative. AODM procedures are most clearly understood by defining the stages as *indicators of progress* in a dynamic process through which observations and insights are refined. We felt that this back-and-forth progression between the first and second stages was both useful and necessary to ensure the accuracy and consistency of our interpretations.

For example, cycling through stages one and two helped us consider concurrently the collective and individual orientations of the course team, providing us with a more complete perspective. Our investigation into collaborative knowledge building began with an analysis of the *course design activity system*. Interviews with the instructor and instructional designer indicated that they were the two principle collaborators responsible for the course design (i.e., subjects), and as such, we defined them as the *course design team.* The eight-step-process (Stage 1) and modeling (Stage 2) were conducted for each of the two subjects separately. Creating a separate activity triangle model for the primary instructor and instructional designer, who worked in a different department and discipline, allowed us to compare the perspectives that each brought to the course design process, including similarities and differences (i.e., contradictions) between their points of view. This was an important step in our method. As other researchers have pointed out (Barab et al. 2004a; Wells 2002), using a single activity triangle to represent the diverse perspectives of the subjects can obscure their differences and prevent design insights.

Interestingly, a comparison of the two activity triangle models from the point of view of each subject showed considerable overlap between the instructor's and instructional designer's perspectives. In particular, both considered peer collaboration among students as important for carrying out the course objective (i.e., developing practical and conceptual knowledge of statistics). In activity theoretical terms, each considered peer collaboration an important design principle, or *rule* and instructional *tool* for carrying out the *object* of the course. This was interesting to us given that we had not interviewed the course assistant prior to her participation in the study and several studies have documented tensions between the different mindsets or rules of different subjects in an activity system, which can lead to system dysfunction (e.g., a review in Barab et al. 2004b, p. 206, 208).

Next, working through these two stages again, we looked for evidence of collaborative knowledge building in the *teaching and learning activity system.* That is, we wanted to understand if and how the course design team's pedagogic beliefs and expectations for peer collaboration were represented in the documents and other artifacts they produced for the course and that students experienced. Data sources included course documents and large group communications (i.e., group email messages, threaded discussion postings, assignment descriptions, syllabus). We analyzed the content and design of these materials

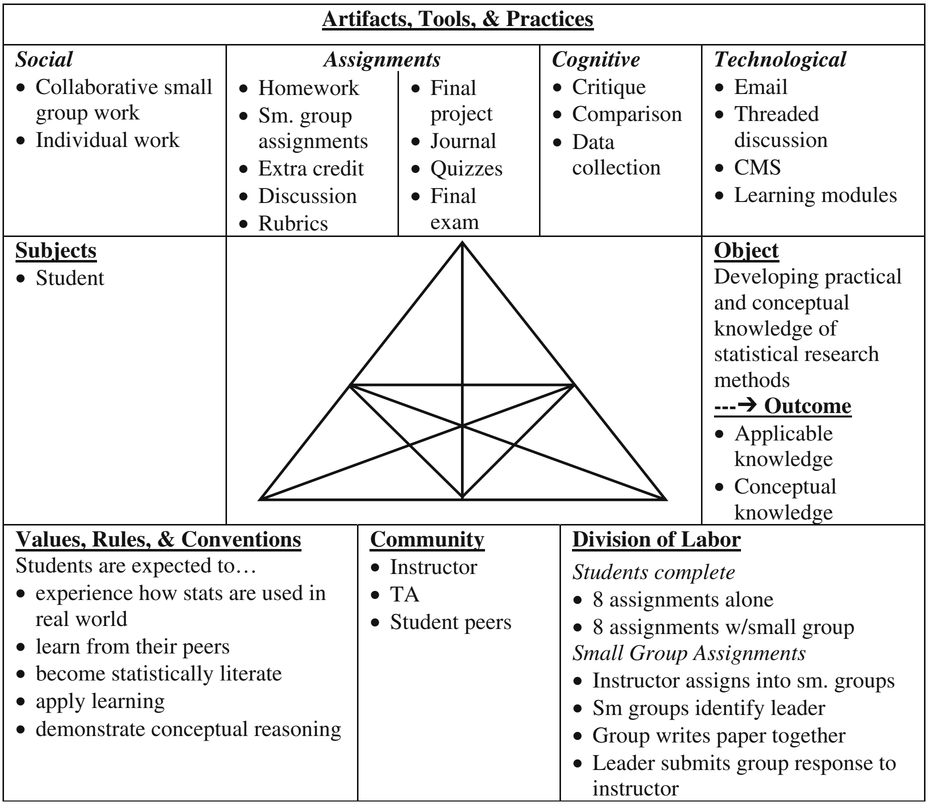


Fig. 6 Stage two generated a model of the teaching and learning activity system

on the WebCT/Vista site to understand what was communicated to students about peer collaboration. Specifically, we looked to see if expectations for participating in student-to-student interactions were explicit and the extent to which peer collaboration was used to facilitate learning in the course.

The teaching and learning activity system model (Fig. 6) that eventually resulted from this process represents the course from a *student's* perspective (i.e., with the student in the subject node as seen in Fig. 6, left column, center row).

One insight this analysis of the teaching and learning activity system provided was that the course design team used frequent small group assignments as a strategy to implement peer collaboration (e.g., see the *artifacts, tools and practices* node at the top of the model in Fig. 6). As illustrated in Fig. 6, information pertaining to small-group work was evident in all of the mediator nodes (i.e., tools, rules, community, division of labor). For example, the syllabus indicated that students should consider peers as important resources for learning and outlined eight small-group assignments (i.e. tools) which students worked through in thinking about statistics. In other documents, the course designers indicated that students should learn from and help each other to succeed in the course. We noted "learning from peers" as an overarching *value* embodied in the system students experienced. As indicated by the *division of labor* (Fig. 4), the assignment tasks were equally distributed between individuals and groups. That is, half of all the assignments were designed to be performed in collaboration. The hierarchical structure to the small group assignments, where the instructor and small group leader had clearly delineated roles was another indicator that the course embodied strategies to facilitate the small-group process.

In summary, we saw from our initial interpretation and modeling of the course design system using Stages 1 and 2 and the eight-step process of AODM, that the course team considered peer collaboration among students as essential to enacting the course objective (i.e., developing a practical and conceptual knowledge of statistics). Modeling the teaching and learning activity system helped us identify the prevalence of peer collaboration in the course and the features of the system that seemed designed to help bring this about. However, a limitation of our model was that it presented what we felt was only an *overview of* peer collaboration without actually describing it in detail or critically examining *how* it was enacted. As Mwanza (2002a) points out, "it is difficult to conduct a critical analysis of human practices represented in the activity system generated at this stage because the information gathered is too general" (p. 191). A more fine-grained analysis was needed to produce insights about peer collaboration *in practice,* especially how students interpreted and participated in small group assignments. In particular, we wanted to know whether students' participation was consistent with the course designers' expectations. Stages three, four and five of AODM provided us with methodological tools and systematic procedures for conducting such inquiry.

Stages 3 and 4: Examining sub-activities for evidence of collaborative knowledge building

We applied stages three, four, and five of AODM to derive detailed insights about peer collaboration practices in the course as an indicator of the course design team's success in facilitating collaborative knowledge building among students. If the course team espoused peer collaboration and designed the course to support it, we needed to determine if their expectations were embodied in what students actually did. To this end, we *decomposed* the teaching and learning activity system we were considering into sub-activities (*Stage 3*) and *generated* research *questions* (*Stage 4*) to guide more *detailed investigation* (*Stage 5*) (Mwanza 2002a, b). Decomposing the activity system is critical to examining the relationship between its subsets of components (i.e., nodes) and the *object* that structures collective activity within the system as a whole. It is important to clarify here that each of the six sub-activities (see left column in Table 3 for a diagram) that together constitute the system are oriented toward the same object; therefore, the researcher must establish the object clearly in completing the analysis. At this stage, AODM provides a helpful tool—*activity notation* guidelines—which are designed to assist the analyst in systematically decomposing the system into sub-activities. For instance, the activity notation guidelines specify three necessary components of a sub-activity, which are: the identified object of the activity system, a particular actor or doer (e.g., subject, community), and a mediator (e.g., tools, rules, division of labor).

In our research, we used the activity notation guidelines to help us identify these three components for each of the six sub-activities in our teaching and learning system; however, a complete discussion of this process and our insights is outside the scope of this paper. Therefore, we include an illustration of our process of analyzing only one sub-activity using Stages 3–5 and the AODM tools mentioned previously. For instance, we wanted to understand the possible influence of the course team's guidelines for small group discussion on students' collaborative interactions. These guidelines were evident in a document provided to orient students to the small group assignment process. We conducted an analysis of one sub-activity to investigate the influence of these guidelines. Using activity notation, we identified the sub-activity as comprised of three components: discussion

Table 3 Summary of the SLANT analytic framework (Mercer 1996)

Three levels of analysis	Linguistic	Psychological	Cultural
		Analytic questions	
	What kinds of speech acts are observable?	How are ground rules used to act out communicative relationships?	How do participants judge the educational value of speech?
Disputational talk	Assertion followed by counter assertion	Competitive relationship Defensive orientation	Individualized decision-making is valued
		Information is flaunted Different opinions are opposed	Knowledge isn't publicly accountable
Cumulative talk	Repetitions	Implicit concern with solidarity and trust	Speakers build positively, but uncritically on each other's comments.
	Confirmations Elaborations	Constant repetition and confirmation of partners' ideas and opinions	Common knowledge is constructed by accumulation.
Exploratory talk	Challenges and requests for clarification followed by explanation and justification	Foregrounds reasoning Views of all participants are sought and considered Proposals are explicitly stated and evaluated; visibility of reasoning	Talk embodies principles of Accountability Constructive criticism
		Explicit agreement precedes decisions and actions	Receptiveness to well-argued proposals Statements and suggestions are offered for joint consideration Knowledge results from engaging critically, but constructively with each other's ideas.

guidelines for small group processes (i.e., tools), students (i.e., subjects), and the development of a practical and conceptual knowledge of statistical research methods (i.e., object).

Next, we generated *sub-activity-oriented research questions* (Stage 4) that allowed us to further examine the relationship among these three elements. As shown in the first row of Table 3, our questions were: How do the guidelines for small-group threaded discussions affect a student's development of practical and conceptual knowledge of statistical research methods? With these questions in mind, we were then able to target particular episodes of data for more *detailed investigation* (Stage 5). To do this, we needed to draw on additional methods as described and justified below.

Stage 5: Integrating discourse analysis to investigate peer collaboration practices

In interpreting AODM, we found that no specific method is recommended in stage five for gathering and analyzing data in the detailed analysis. Barab et al. (2004a) state that researchers and designers adopting an Activity Theory perspective are "often committed" to the use of strategies and tactics from other methodologies. They cite case study and design experiment as two examples (p. 208). Our purpose was to focus on "identifying possible contradictions in relationships *within* and *between* the various sub-activities that existed within the main activity system" (Mwanza 2002a, p. 192). Understanding contradictions is necessary to obtaining "a comprehensive understanding of the means by which these contradictions develop from a social, cultural and historical perspective" (Mwanza 2002a, p. 192). Therefore, to begin to conduct the detailed investigation that was needed to determine these tensions we incorporated discourse analysis into our methods to examine conversation in small groups.

For instance, we were interested in learning how the guidelines for conducting threaded discussions (tool) among groups of four to five students influenced a student's (subject) development of statistics knowledge (object). Therefore, we first needed to examine instances of peer collaboration as they happened in the course. Studies of talk during collaborative projects with peers (Edwards 1990; Light et al. 1994; Mercer 2000, 1996) suggest that cognitively important kinds of talk occur when interlocutors use reasoned arguments to work through *intellectual disagreements*.

To identify instances of collaborative knowledge building in students' discourse, we drew upon the analytic framework developed by Mercer and colleagues in the Spoken Language and New Technology (SLANT) study (Fisher 1997; Mercer 1996; Mercer and Fisher 1997; Wegerif and Mercer 1997; Wegerif and Scrimshaw 1997). The SLANT study examined the quality of students' face-to-face talk during computer-intensive small group projects. The analytic framework (shown in Table 3) concentrates on three aspects of social interaction (i.e., linguistic, psychological, cultural) that taken together offer a holistic picture of the sociocultural context in which thinking as a social activity takes place. The framework identifies three types of talk (i.e., disputational, cumulative, exploratory), which represent three distinct social modes of thinking (Table 3, left column).

We used these three types of talk as conceptual tools to analyze students' peer-to-peer interactions and to gather evidence regarding the presence or absence of collaborative knowledge. Of these three, exploratory talk was particularly interesting to us because it provided a model for the kind of talk we expected to see during instances of collaborative knowledge building. For instance, *disputational talk* refers to discourse that is defensively orientated. Little effort is made in disputational talk to acknowledge other participants' thinking, accept or offer constructive criticism, or consider alternative proposals; assertions are met by counter-assertions. In contrast, *cumulative talk* is positive and builds on other participants' thinking. It focuses on building solidarity and agreement; participants' assertions are confirmed, elaborated on, and repeated, but are not critically examined or challenged. *Exploratory talk* is characterized by verbal exchanges in which participants "engage critically but constructively with each other's ideas" (Mercer 1996, p. 369). Participants are receptive to constructive criticism; they challenge each other's statements and proposals, but provide explicit justifications, explanations, and alternative suggestions. Reaching agreement prior to making decisions or taking action is characteristic of exploratory talk, but in contrast to disputational and cumulative talk, participants reach agreement through critically evaluating the strength of the underlying reasoning of an assertion.

Applying this framework to our analysis meant interrogating the discussion messages with each of the three analytic questions (Table 3, row 4). In practice, this involved reading through the discussion threads while paying particular attention to instances of disagreement and how group members resolved them, if at all. Next, we analyzed the disagreements with regard to their linguistic, psychological, and cultural characteristics (Table 3, columns 2–4). This analytic process organized the data in preparation for identifying contradictions in Stage 5, including a contrastive analysis to identify the conditions under which exploratory talk did and did not occur.

Data sources for our investigation of students' discourse were a series of twenty messages posted by three members of a small group during one small group assignment. These messages were part of a larger archive of online threaded discussions that corresponded to additional small group activities and assignments. In analyzing the students' discourse, we found that two group members expressed disagreement with ideas presented by the other group member, but in each case the disagreement was resolved by *critically* and *constructively* engaging with each other's ideas. The insights from the discourse analysis, which are mentioned only briefly here, were supported in other episodes of students' online conversations that we analyzed.

The following example of students' discourse is composed of portions of messages that present a disagreement and how three small group members resolved it. The exchanges occurred in a threaded discussion during a small group assignment. In the assignment, students were expected to critique an article about a research experiment involving Therapeutic Touch, a technique that uses the human energy field to treat illness. The guidelines stipulated that the group must share their critiques and "come up with a new experimental design that will attempt to control for the confounding variables/sources of bias your group has identified."

As shown in the excerpt from the students' discussion (see Table 4), Student 1 contributed the first design ideas to the group; however, Students 2 and 3 expressed, in turn, their disagreement with this idea, but resolved it constructively through a combination of *politeness* strategies (Brown and Levinson 1987) and reasoned arguments. For instance, in an effort to constructively disagree, Student 2 first complimented Student 1's idea for the experiment (line 4) and then softened the introduction of the negative assessment of the idea with "I wonder" (line 5). The compliment and softening are examples of *redressive actions*, which are politeness strategies that speakers use to offer negative assessments, but minimize them as a *threat to face* (Brown and Levinson 1987). In this case, the politeness strategy is interpreted as an indication of the student's willingness to engage constructively in resolving the disagreement. This interpretation is further reinforced by Student 2's choice to use a reasoned argument (lines 5–8), which established a constructive tone and the content of the disagreement. The use of reasoned argument was an indicator of exploratory talk. Student 3 intensified the disagreement by concurring with Student 2's concern (line 9), but indicated a desire to work it through constructively by softening the potential threat to face by being just "a bit" concerned. Student 3 also used a reasoned argument as the basis for resolving the disagreement (lines 10–13), another indicator of exploratory talk. In the final turn, Student 1 responded to her group members' critiques with an explanation, clarifying her rationale for proposing to select a sample from individuals with the same illness (lines 14–15). Next, she withdrew the disputed idea, which preserved group solidarity: "but I am ok with whatever we decide together" (line 16).

In this example, despite the predominance of exploratory talk (lines 1–15), the speaker who proposed the disputed idea resolved the disagreement by deferring to the group's will (i.e., cumulative talk). When multiple types of talk occur during an episode of interaction the task of characterizing the interaction increases in complexity. Mercer (1996) stipulates that disputational, cumulative, and exploratory talk "are not meant to be descriptive categories into which all observed speech can be neatly and separately coded" (p. 369); rather they are more accurately conceived as analytic categories that typify how participants in their research project *thought with each other* during collaborative educational activities. Engeström (1987) argues that one requirement for an activity theoretical study is to follow the development of the activity system over time. Therefore, we resolved to analyze the group's threaded discussion for the duration of the course and to base characterizations of talk on how it developed over time, rather than at one specific moment.

Analyzing the group's threaded discussions over the duration of the course, we found that group members were increasingly engaging critically and constructively with each other's ideas. Focusing on Student 1 as an example, we found that during the first two group project discussions she demonstrated a pattern of deferring to her group rather than challenging or contributing to her group members' proposals or suggestions; however, this pattern shifted in project discussions over the next several weeks. She commented several times that she lacked confidence in her comprehension of the course material. Her team members posted messages expressing similar insecurities and encouraged her to express her

Table 4 Transcript excerpt analyzed for evidence of peer collaboration in a sub-activity

Line	Speaker	Discourse
01	Student 1:	I would create a randomized experiment.
02		I would randomly select two groups of people with some ailments (arthritis,
03		migraines etc).
04	Student 2:	I like your suggestion about how to design the experiment.
05		I wonder if it is important in the design to make sure that the illness is the same
06		in each group?
07		I just wonder how we would measure the "change" and decide if someone
08		is improved or not.
09	Student 3:	I too am a bit concerned about choosing individuals with illness.
10		I think that the point of the study is to see if "healers" can detect energy fields.
11		
12		If so, we need to design an experience that does that.
13		If so, the variables need to be restricted as much as possible.
14	Student 1:	I think sickness does matter if you are trying to help someone with TT, but I am ok
15		with whatever we decide together.
16		

ideas. Messages offering Student 1 encouragement and praise for her ideas continued into the third and fourth group projects. Threaded discussions around the fifth group project revealed that Student 1's deferential comments had decreased as had her expressions of diminished self-efficacy. By the courses' end, her participation appeared less inhibited as indicated by her increased willingness to critically engage other group members. Mediating elements in the online environment (i.e., other group members, division of labor, the practice of encouragement, the threaded discussion tool) seemed to support her increasing engagement with course ideas.

This brief example from our larger study illustrates how the incorporation of an additional tool (i.e., SLANT framework) proved useful for conducting a detailed investigation of one sub-activity. Combining the SLANT and activity theoretical frameworks, especially the requisite practice of observing the activity system's development over time, we observed increased instances of exploratory talk in students' threaded discussions that suggested students were indeed building knowledge of course concepts collaboratively.

However, this analysis does not demonstrate that the course design, and the guidelines for small group interaction specifically, helped to bring this about. To do this, we needed to examine the sub-activity's *relationship* to the overarching system that structured the sociocultural and technological environment in which the discourse occurred. The next section presents the additional analysis in Stage 5 that was conducted to provide this context.

Stage 5, part 2: Contextualizing the peer collaboration sub-activity

To integrate findings from the students' discourse, the small group discussion guidelines and other components of the sub-activity and interpret these within the overall system, we needed additional analysis. Examining the group's discussion messages again revealed that excerpts from the guidelines actually appeared in what students were posting. The discussion leaders, in particular, had copied and pasted passages from the electronic document into their own messages. This was especially evident in messages posted during the early stages of the course when the students were figuring out how to work together on small group assignments. We interpreted this as evidence that the students internalized the discussion guidelines as a tool, which facilitated their collaborative behaviors. The group leaders relied on and invoked the course team's expectations or rules for participation as a means for facilitating their own and other group members' interactions. The role of group leader (i.e., in the division of labor) facilitated the adoption of practices outlined by the course design team. A follow-up interview with students regarding this particular finding would be helpful for producing more substantive insights.

Furthermore, closer examination of the assignments (tasks) that students were discussing in their small groups revealed that these contributed to the students' development of practical statistical research knowledge (i.e., the object in the main activity system). For instance, the assignment tasks resembled the work practices of actual researchers who review and critique other studies and design experiments using statistical methods. Within their small group's discussion, the students were asked to critique a study design they had read about in an article and focus on confounding variables and sources of bias, two important but difficult concepts from the course. Next, they needed to create an experimental design that improved on the one they had critiqued. Using scaled down versions of actual work practices as assignment tasks, the course design team facilitated students *doing research* and assisted them in collaboratively developing practical and conceptual knowledge of statistical research methods.

Using AODM to decompose the activity system, generate research questions, and conduct a more detailed investigation of sub-activities we sought to understand, ultimately enabled us to construct a more refined and comprehensive model of peer collaboration in practice (see Fig. 7) and understand this more clearly in relation to the course team's design.

Stage 6: Interpreting and communicating the findings to inform subsequent designs

The sixth and final stage of AODM involves interpreting and communicating results to stakeholders, which in our case were the instructor and instructional designer that constituted the course team. To assist this, AODM provides an *Operational-mapping Tool* that can be used to summarize the results of activity-oriented investigations. Up to this point, we have talked about how we used AODM to identify the presence and nature of collaborative knowledge building practices in an e-Learning course. The operational-mapping tool assisted us in also identifying *contradictions* and mapping them to the various sub-activities they influence. Activity theorists assert that contradictions are "sources of development" for innovation and change in activity systems and therefore, are important to locate (Engeström et al. 1999, 1993; Kuutti 1996). We provide an example of our use of the tool in Table 2, introduced earlier. The operational mapping tool summarizes the results of the last four stages of our analysis (Stages 3–6) and creates a map between each research question and the one or more contradictions we identified. For example, the information in the first row indicates the sub-activity components, research question, and contradictions we formulated in looking at the influence of discussion guidelines on the small group's development of knowledge related to statistics. In three instances we identified more than one contradiction, and some contradictions or tensions were more prominent in the activity

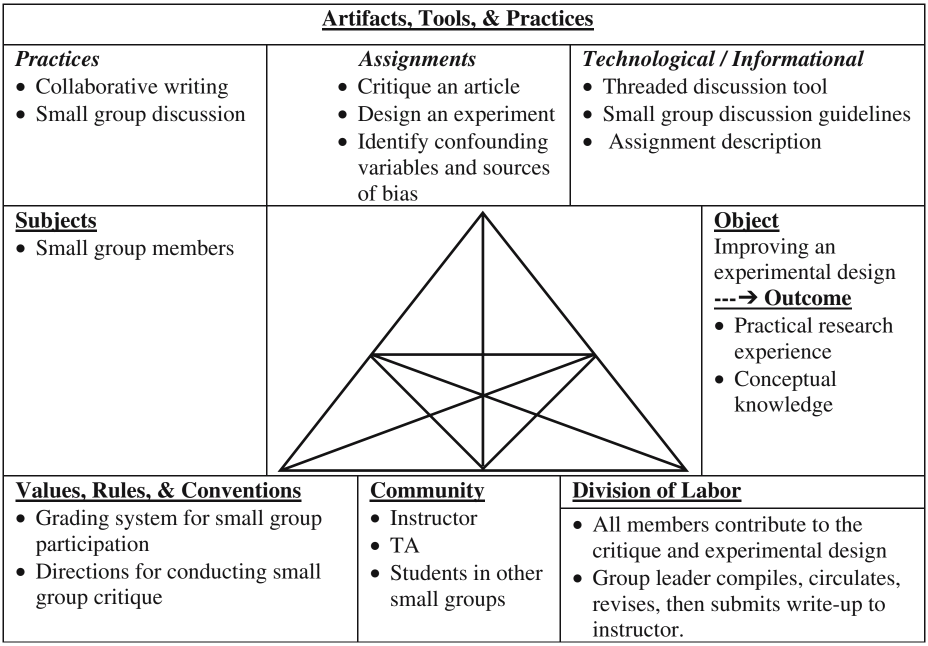


Fig. 7 Model of the small group sub-activity system

system than others (e.g., students' perceptions that learning online is independent and self-paced contradicted the values shared by the course designers).

We gained important insights from analyzing contradictions within and between the sub-activities that illuminated whether and how the course team's design was enacted. For instance, we learned that some small group assignments did not result in substantive collaborative knowledge building as indicated in small group discussions where the students seemed to agree immediately with little commentary or critique. Examining the discussion threads for instances of argumentation and instances where the conversation stalled and comparing the two, we learned that some assignment tasks seemed to generate single answers which inhibited dialogue. In a follow-up interview, the instructor corroborated our observation. She commented that students felt discussions where there was "one right answer and everyone happened upon it right at once" lead to the disintegration of the group's dialogue and "they felt like there was really nothing to discuss." We realized that the work-practice quality of the assignment tasks, the guidelines specifying expectations for participation in small group discussion, and the role of the group leader were not enough to support collaborative knowledge building; it was also important to provide students with the opportunity to explore challenging terrain and the freedom to arrive at a variety of conclusions.

Several studies have indicated the importance of *improvable objects* for facilitating active knowledge building among peers (Wells 2004, 2002; Scardamalia et al. 2004b). An improvable object can be conceived generally as something that is constructed or improved upon and can take many forms (Wells 2002). An improvable object might be a "functioning model" learners are constructing or an "explanation of some phenomenon they are observing" (Wells 2004, p. 298). We interpreted the task of designing an experiment as having qualities of an improvable object. For instance, the purpose of the experimental design task was for students to design an experiment that improved upon the deficits they identified in their critique. Through the process of analyzing contradictions between course design and enactment, we were able to refine our model of the small group activity. We established the object of the small group activity as *improving an experimental design* (see Fig. 7) and determined that this was in *alignment* with the aspects of practical and conceptual knowledge specified as the object in the main course activity.

To conclude this discussion of our use of AODM to study e-Learning we emphasize that the operational-mapping tool was extremely useful in helping us synthesize and outline our research process in a way that other researchers might emulate. We also found that it forced us to systematically interrogate our data. This helped us generate and summarize the insights we gained so others might understand and learn from our work. It is important to point out here that the goal of using AODM, and the operational-mapping tool in particular, is to facilitate *design insights*, but not to "find or predict solutions" (p. 192). Because we work with course design teams across several disciplines and departments, each with its own ways of thinking about teaching and learning, we found the operational-mapping tool helpful in representing the influence of contradictions and in stimulating discussions with course team members about tensions we identified.

Conclusion

Currently, there is no universally accepted method for implementing Activity Theory (Barab et al. 2004a). We feel that AODM is a promising tool for operationalizing the theory and making it more accessible to a wider variety of researchers, especially those committed to supporting the transformation of CSCL practices. In this paper, we interpreted the stages of the research process, and tools used at each stage, to further define AODM in terms with which other educational researchers and educational technologists might identify. In this paper, we have demonstrated how AODM was used to create a more comprehensive picture of a course design team's instructional practices within an e-Learning course. We discussed how using the method improved our understanding of collaborative knowledge building in small groups. From analyzing the course design activity system, we gained insights about the values shared by the course design team. The analysis of the teaching and learning system identified the instructional strategies used to implement these values and key artifacts used to facilitate them. Although much has been written about the importance of fostering students' interaction, collaboration and social presence to improve active learning and retention in online courses few studies have actually examined the intentions of course teams as they are manifested in course designs and as they relate to students' demonstration of peer collaboration. Using AODM helped us define the characteristics of assignments that facilitated collaborative knowledge building. The operational-mapping tool helped us track our progress through the stages and ultimately, communicate contradictions we identified between design and practice back to the course team.

Reflecting on our experiences in using AODM, we offer the following parting insights on the relative merits and challenges to applying it.

A tool for analyzing social practices

To relative newcomers conducting research based on Activity Theory, AODM provides a valuable source of guidance and structure. AODM tools helped to structure the complexity of interpreting observations in activity theoretical terms and ensure accuracy and consistency throughout the research process. In particular, the process of decomposing and analyzing sub-activities made readily apparent the need to be very clear about the object and provided the guidance to do so over multiple iterations. AODM tools assist the researcher with organizing and attending to details, and looking closely at the shifts that occur in an activity system as it develops over time. Moreover, AODM provided a useful heuristic for stimulating further investigation of the tensions we were seeing and enabled the incorporation of additional methods for targeted analysis while preserving a sense of the overall activity system. Although studying human activity in naturalistic settings is challenging, AODM helps the researcher find clarity and focus in observing complex social behaviors and in interpreting the mediating elements that influence those behaviors.

However, AODM is itself complex and requires vigilance in maintaining perspective on the relationship between the part and the whole. For instance, decomposing an activity system into six sub-activities produces a fine-grained analysis on a particular aspect of an activity. The focus one chooses can lead to a very narrow path. Therefore, it is important to continuously weigh the significance of choices made relative to other options to avoid being inadvertently directed away from realizing which events are significant and which, insignificant in a particular context.

In addition, Activity Theory posits that insights can come from examining observed contradictions, and indeed, AODM helped us discover a lack of alignment in certain areas. This was useful in helping us think about how to improve this course and future courses over time; however, we needed to regularly step back and evaluate whether the contradictions we identified were the most important. Otherwise, a minor contradiction could inadvertently assume undue prominence. The challenge of maintaining perspective between part and whole is, of course, not unique to AODM; however, the amount of information the researcher has to manage to maintain this perspective can be overwhelming at times. We are not aware whether other methods might have found these gaps, or others, more easily. We encourage readers to test out and improve these methods and wrestle with what remain for us, open questions.

Need for dynamic modeling tools

The clarity that AODM contributed to our understanding of the data and the research process also revealed a myriad of details we needed to manage as our findings accumulated. As we refined our knowledge at each successive stage we were struck by the complexity of determining the implications of this new understanding for the accuracy of the models we had developed earlier in the research process. In other words, tweaking one aspect of the system (e.g., one element of the values that underlie the activity) had ripple effects throughout the whole system. We found the logistical challenge of tracking these ripples demanding. This was as an information management challenge that left us with a deeper understanding of the dynamic nature of the analytic process. We found ourselves wishing for a technological tool to help us manage the dynamic flow of information more efficiently and lessen the cognitive demands that this type of research imposes. In these ways, our use of AODM produced design insights into the very methods we sought to exemplify. We are reminded of the insights of Arne Raeithel (1992) in his *Activity Theory as a Foundation for Design:* "object-oriented activity creates a world full of new objects...[a] heritage that the next generation has to cope with, and by which the activities of elders and children alike are transformed...we may expect that all new computerized workplaces will produce noticeable effects on the activity structure, and that means the personality, of workers" (p. 397–398).

Consequently, we have begun prototyping software solutions to help streamline the analytic process for use in the next phase of the research. Specifically, we are creating a software application to support the management and *dynamic* modeling of data during the six stages of AODM analysis. We expect this software will also be useful for communicating findings to course teams and sparking course design insights.

Tool for integrating perspectives and communicating with constituencies

Furthermore, we felt the AODM toolkit offered advantages over purely grounded approaches to studying instructional practices. For our work as researchers and consultants, it is important to have well-specified procedures and tools for integrating perspectives and representing and communicating results to various constituencies. AODM assisted us in representing the perspectives of multiple participants in course activity systems. This capacity allowed us to understand e-Learning course design, development, and implementation as collective practices, which we think is an important perspective to represent to the course teams with whom we work. As universities and the students they serve continue to demand more interactive, online or hybrid courses which require cross-university collaborations, AODM constitutes a means of integrating the values, tools, and division of labor of constituencies who enter the course design system to produce new educational experiences.

However, when the researcher has generated conclusions and it is time to present selected findings to stakeholders, it is important to keep in mind that if working with activity theoretical concepts required the researcher's cognitive investment, stakeholders, too, will need some introduction and guidance. Sociocultural approaches to educational research in general, where phenomena are examined over time, in context, with an eye toward progressive refinement, are themselves unfamiliar to many of the stakeholders with whom we consult. The conceptual and visual complexity of the expanded activity triangle and operational mapping tool used to represent and communicate findings can potentially confuse and overwhelm those with no background in the theory. Anticipating possible cognitive overload and preparing to communicate results in as accessible a format as possible can determine whether or not stakeholders comprehend and value the insights revealed.

Fortunately, the operational mapping tool offers a format and structure for summarizing results for stakeholders; however, this tool by itself is insufficient. In our experience, AODM representations are most useful if used in the context of dialogue; the activity system can be introduced and their interrelationships suggested and discussed as stimulus for feedback and further dialogue. We find an additional benefit to using AODM tools to communicate with different constituencies is that the tools honor the real complexities of designing for change and reinforce the idea of teaching and learning as a team endeavor. When instructors, teaching assistants, instructional technologists, technical support staff, researchers and others view themselves not as lone operators but as members of a community, new and more powerful forms of collaboration become possible.

A tool for designing e-learning practices

Overall, AODM holds promise as a tool for assisting the design of e-learning practices.

For instance, AODM tools and procedures help make tacit values explicit and can assist designers in understanding whether and how sub-activities reinforce a common objective. Participating in AODM enables designers to draw comparisons between design vision and enactment, which is important to justifying change.

However, a contradiction we encountered in our own research process was that it proved difficult for us to use the insights we gained to inform actual change in the courses we studied. One reason for this may be that our studies occurred when a course was already in progress and had been taught for several years. A second reason may be that we were not perceived as insiders, or formal members of the course team, but as outsiders analyzing the course from the periphery. Mwanza (2002a) indicates that AODM was intended for use in the early stages of the design process. While we feel that AODM tools can offer insights to educational researchers and technologists at any stage in the development or revision process, the method seems likely to have greatest impact if the researcher is accepted and participates as a collaborator in the project and the findings inform initial phases of development in the first year of implementation when design teams may be most receptive to suggestions.

In conclusion, developing a flexible understanding of AODM required a considerable investment of our time and energy to work out the analytic process and interpret how to use the methods; it required us to frequently reference the activity theory literature and individuals that conducted the research. This proved difficult at first as we could find few empirical studies where methods for using activity theory to study higher education had been applied and made explicit. Despite these difficulties, and commensurate with the complexity we sought to capture, we feel AODM offers much to researchers who are interested in understanding and characterizing the messiness of real world practice in a way that is valuable to others "with context being a core part of the story" (Barab et al. 2004b, p. 3). We suggest that further research is needed that contributes to the development of activity-oriented methods and our understanding of their application in higher education settings. This discussion of AODM is intended to provide a step in this direction. We encourage others to continue to test out, improve upon and contribute to ideas discussed here.

References

Ackerson, V., Medina, V., & Wang, N. (2002). A collaborative effort to improve university engineering instruction. *School Science and Mathematics, 102*(8), 405–419.

Anfara, V. A., Brown, K. A., & Mangione, T. L. (2002). Qualitative analysis on stage: Making the research process more public. *Educational Researcher, 31*(7), 28–38.

Argyris, C., & Schon, D. A. (1974). *Theory in practice: Increasing professional effectiveness*. San Fransisco: Jossey-Bass.

Barab, S. A. (2006). Design-based research: A methodological toolkit for the learning scientist. In R. K. Sawyer (Ed.), *The Cambridge handbook of the learning sciences* (pp. 153–169). Cambridge: Cambridge University Press.

Barab, S., Barnett, M., Ymgala-Lynch, L., Squire, K., & Keating, T. (2004a). Using activity theory to understand the systemic tensions characterized in a technology rich introductory astronomy course. *Mind, Culture and Activity, 9*(2), 76–107.

Barab, S. A., Evans, M. A., & Baek, E. (2004b). Activity theory as a lens for characterizing the participatory unit. In D. H. Jonassen (Ed.), *Handbook of research for educational communications and technology* (pp. 199–214). Bloomington, IN: Association for Educational Communications and Technology (AECT). Retrieved May 1, 2006, from http://www.aect.org/Intranet/Publications/index.asp#hb.

Barab, S., & Squire, K. (2004). Design-based research: Putting a stake in the ground. *The Journal of Learning Sciences, 13*(1), 1–14.

Becker, H. J., & Ravitz, J. (1999). The influence of computer and internet use on teachers' pedagogical practices and perception. *Journal of Research on Computing in Education, 31*(4), 356–384.

Bernard, R. M., Abrami, P. C., Lou, Y., Borokhovski, E., Wade, A., Wozney, L., et al. (2004). How does distance education compare with classroom instruction? A meta-analysis of the empirical literature. *Review of Educational Research, 74*(3), 379–439.

Boettcher, J. V., & Conrad, R. (2004). *Faculty guide for moving teaching and learning to the Web*, 2nd edition. Phoenix, AZ: League for Innovation in the College.

Bransford, J. D., Brown, A. L., & Cocking, R. R. (1999). *How people learn: Brain, mind, experience and school.* Washington, D.C: Committee on Developments in the Science of Learning.

Brown, P., & Levinson, S. C. (1987). *Politeness: Some universals in language usage*. Cambridge, United Kingdom: Cambridge University Press.

Collins, A., Brown, J. S., & Newman, S. E. (1989). Cognitive apprenticeship: Teaching the crafts of reading, writing, and mathematics. In L. B. Resnick (Ed.), *Knowing, learning and instruction: Essays in honor of Robert Glaser* (pp. 453–494). Hillsdale, NJ: Lawrence Erlbaum.

Collis, B., & Margaryan, A. (2004). Applying activity theory to computer-supported collaborative learning and work-based activities in corporate settings. *Educational Technology Research and Development, 52* (4), 38–52.

Darling-Hammond, L., & Bransford, J. (2005). *Preparing teachers for a changing world: What teachers should learn and be able to do*. San Francisco: Jossey-Bass.

Dede, C. (2004). If design-based research is the answer, what is the question? A commentary on Collins, Joseph, Bielaczyc; diSessa and Cobb; and Fishman, Marx, Blumenthal, Krajcik, and Soloway. *The Journal of Learning Sciences, 13*(1), 105–114.

Edwards, D. (1990). Classroom discourse and classroom knowledge. In C. Rogers & P. Kutnick (Eds.), *Readings in the social psychology of the primary classroom* (pp. 20–35). London: Routledge.

Engeström, Y. (1987) *Learning by expanding: An activity-theoretical approach to developmental research*. Helsinki, Finland: Orienta-Konsultit Oy.

Engeström, Y. (1991). Non scolae sed vitae discimus: Toward overcoming the encapsulation of learning. In H. Daniels (Ed.), *An introduction to Vygotsky* (pp. 151–170). New York, NY: Routledge.

Engeström, Y. (1993). Developmental studies of work as a testbench of activity theory: The case of primary care medical practice. In S. Chaiklin & J. Lave (Eds.), *Understanding practice* (pp. 64–103). Cambridge: Cambridge University Press.

Engeström, Y. (1995). Innovative organizational learning in medical and legal settings. In L. M. W. Martin, K. Nelson & E. Tobach (Eds.), *Sociocultural psychology: Theory and practice of doing and knowing*. Cambridge: Cambridge University Press.

Engeström, Y. (1999a). Activity theory and individual and social transformation. In Y. Engeström, R. Miettinen & R. Punamaki (Eds.), *Perspectives on activity theory* (pp. 19–38). Cambridge: Cambridge University Press.

Engeström, Y. (1999b). Innovative learning in work teams: Analyzing cycles of knowledge creation in practice. In Y. Engeström, R. Miettinen & R. Punamaki (Eds.), *Perspectives on activity theory* (pp. 377–404). Cambridge: Cambridge University Press.

Engestrom, Y., & Miettinen, R. (1999). Introduction. In Y. Engeström, R. Miettinen & R. Punamaki (Eds.), *Perspectives on activity theory* (pp. 377–404). Cambridge: Cambridge University Press.

Engeström, Y., Miettinen, R., & Punamäki, R.-L. (Eds.). (1999). *Perspectives on activity theory.* Cambridge: Cambridge University Press.

Eraut, M. (1994). *Developing professional knowledge and competence*. London: Rutledge Falmer.

Ernst, D., Jorn, L., Wagner, M., McGlynn, N., Molgaard, L., Sonnack, J., Oliver, J., et al. (2004). *Faculty technology survey.* (Tech Report), Digital Media Center, Office of Informational Technology, University of Minnesota, MN, USA.

Ertmer, P. A. (2005). Teachers pedagogical beliefs: The final frontier in our quest for technology integration? *Educational Technology Research and Development, 53*(4), 25–39.

Fassnacht, C., & Woods, D. (2006). Transana (Version 2.10) [Computer software]. Madison, WI: The Board of Regents of the University of Wisconsin System. Retrieved May 10, 2006, from http://www.transana.org.

Fisher, E. (1997). Developments in exploratory talk and academic argument. In R. Wegerif & P. Scrimshaw (Eds.), *Computers and talk in the primary classroom* (pp. 38–48). Philadelphia: Multilingual Matters.

Hakkarainen, P. (1999). Play and motivation. In Y. Engeström, R. Miettinen & R. Punamaki (Eds.), *Perspectives on activity theory* (pp. 231–249). Cambridge: Cambridge University Press.

Haythornthwaite, C. (2006). Facilitating collaboration in online learning. *Journal of Asynchronous Learning Networks, 10*(1), 7–24.

Hedegaard, M. (1999). Activity theory and history teaching. In Y. Engeström, R. Miettinen, & R. Punamaki (Eds.), *Perspectives on activity theory* (pp. 282–297). Cambridge: Cambridge University Press.

Herring, S. (1996). *Computer-mediated communication: Linguistic, social and cross-cultural perspectives*. Amsterdam, PA: J. Benjamins.

Hewitt, J. (2004). An exploration of community in a knowledge forum classroom: An activity system analysis. In S. A. Barab, R. Kling, & J. H. Gray (Eds.), *Designing for virtual communities in the service of learning* (pp. 210–238). Cambridge, United Kingdom: Cambridge University Press.

Jonassen, D. H. (2000). *Computers in the classroom: Mindtools for critical thinking*. Englewood Cliffs, NJ: Prentice-Hall.

Jones, C., Dirckinck-Holmfeld, L., & Lindstrom, B. (2006). A relational, indirect, meso-level approach to CSCL design in the next decade. *International Journal of Computer Supported Collaborative Learning, 1*(1), 35–56.

Joyce, B., & Showers, B. (1995). *Student achievement through staff development: Fundamentals of school renewal*, 2nd edition. White Plains, NY: Longman.

Khan, B. H. (2005). *Managing e-learning: Design, delivery, implementation and evaluation*. Hershey, PA: Information Science.

Kuutti, K. (1996). Activity theory as a potential framework for human–computer interaction research. In B. A. Nardi (Ed.), *Context and consciousness: Activity theory and human–computer interaction* (pp. 17–44). Cambridge, MA: MIT Press.

Kuutti, K. (1999). Activity theory, transformation of work, and information systems design. In Y. Engeström, R. Miettinen, & R. Punamaki (Eds.), *Perspectives on activity theory* (pp. 360–376). Cambridge: Cambridge University Press.

Lee, E. Y. C., Chan, C. K. K., & Aalst, J. V. (2006). Student assessing their own collaborative knowledge building. *International Journal of Computer-supported Collaborative Learning, 1*(1), 57–87.

Leont'ev, A. N. (1978). *Activity, consciousness, and personality.* Englewood Cliffs, NJ: Prentice Hall.

Leont'ev, A. N. (1981). Problems of the development of the mind. Moscow: Progress Publisher

Levy, F., & Murnane, R. J. (2004). *The new division of labor: How computers are creating the next job market*. Princeton, NJ: Princeton University Press.

Light, P., Littleton, K., Messer, D., & Joiner, R. (1994). Social and communicative processes in computer-based problem solving. *European Journal of Psychology in Education,* 9(1), 93–109.

Lompscher, J. (1999). Activity formation as an alternative strategy of instruction. In Y. Engeström, R. Miettinen, & R. Punamaki (Eds.), *Perspectives on activity theory* (pp. 264–281). Cambridge: Cambridge University Press.

Mercer, N. (1996). The quality of talk in children's collaborative activity in the classroom. *Learning and instruction, 6*(4), 359–377.

Mercer, N. (2000). *Words and minds: How we use language to think together*. London: Routledge.

Mercer, N., & Fisher, E. (1997). The importance of talk. In R. Wegerif & P. Scrimshaw (Eds.), *Computers and talk in the primary classroom* (pp. 13–21). Philadelphia: Multilingual Matters.

Mwanza, D. (2002a). *Towards an activity-oriented design method for HCI research and practice.* Unpublished doctoral dissertation, The Open University, Milton Keynes, United Kingdom. Retrieved April 15, 2006, from http://iet.open.ac.uk/pp/d.mwanza/Phd.htm.

Mwanza, D. (2002b). Conceptualising work activity for CAL systems design. *Journal of Computer Assisted Learning, 18*(1), 84–92.

Nardi, B. A. (1996). *Context and consciousness: Activity theory and human–computer interaction*. Cambridge, MA: MIT Press.

Paavola, S., Lipponen, L., & Hakkarainen, K. (2004). Models of innovative knowledge communities and three metaphors of learning. *Review of Educational Research, 74*(4), 557–576.

Palloff, R. M., & Pratt, K. (2005). *Collaborating online: Learning together in community.* San Francisco: Jossey-Bass.

Paulson, K. (2002). Reconfiguring faculty roles for virtual settings. *Journal of Higher Education, 73*(1), 123–140.

Raeithel, A. (1992). Activity theory as a foundation for design. In C. Floyd, H. Zullighoven, R. Budde, and R. Keil-Slawick (Eds.), *Software development and reality construction* (pp. 391–415). Berlin: Springer-Verlag.

Reeves, T. C., Herrington, J., & Oliver, R. (2004). A development research agenda for online collaborative learning. *Educational Technology Research and Development, 52*(4), 53–65.

Roth, W. M., & Lee, Y. J. (2007). Vygotsky's neglected legacy: Cultural–historical activity theory. *Review of Educational Research, 77*(2), 186–232.

Scardamalia, M., & Bereiter, C. (2004a). Computer support for knowledge-building communities. *Journal of the Learning Sciences, 3*(3), 265–283.

Scardamalia, M., Bereiter, C., & Lamon, M. (2004b). The CSILE project: Trying to bring the classroom into World 3. In K. McGilley (Ed.), *Classroom lessons: Integrating cognitive theory and classroom practice* (pp. 201–228). Cambridge, MA: MIT Press.

Scanlon, E., & Issroff, K. (2005). Activity theory and higher education: Evaluating learning technologies. *Journal of Computer Assisted Learning, 21*(6), 230–239.

Schuster, J. H., & Finkelstein, M. (2004). *The American faculty: Restructuring academic work and careers*. Baltimore: Johns Hopkins University Press.

Stahl, G. (2006a). *Computer support for building collaborative knowledge*. Cambridge, MA: MIT Press.

Stahl, G. (2006b). Analyzing and designing the group cognitive experience. *International Journal of Cooperative Information Systems (IJCIS)*. Retrieved April 24, 2006, from http://www.cis.drexel.edu/faculty/gerry/pub/ijcis.pdf.

Stahl, G., Koschmann, T., & Suthers, D. (2006). Computer-supported collaborative learning: An historical perspective. In R. K. Sawyer (Ed.), *The Cambridge handbook of the learning sciences* (pp. 409–425). Cambridge: Cambridge University Press.

Swan, K. (2006). Assessment and collaboration in online learning. *Journal of Asynchronous Learning Networks, 10*(1), 45–62.

Tallent-Runnels, M. K., Thomas, J. A., Lan, W. Y., Cooper, S., Ahern, T. C., Shaw, S. M., et al. (2006). Teaching courses online: A review of the research. *Review of Educational Research, 76*(1), 93–135.

The Design-based Research Collective (2003). Design-based research: An emerging paradigm for educational inquiry. *Educational Researcher, 32*(1), 5–8.

Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes.* Cambridge: Harvard University Press.

Wegerif, R., & Mercer, P. (1997). A dialogical framework for researching peer talk. In R.Wegerif & P. Scrimshaw (Eds.), *Computers and talk in the primary classroom* (pp. 48–64). Philadelphia: Multilingual Matters.

Wegerif, R., & Scrimshaw, P. (Eds.). (1997). *Computers and talk in the primary classroom*. Philadelphia: Multilingual Matters.

Wells, G. (2002). The role of dialogue in activity theory. *Mind, Culture and Activity, 9*(1), 43–66.

Wells, G. (2004). Creating and improving a 'virtual object' through web-mediated discourse. In R. Ottewill, L. Borredon, L. Falque, B. Macfarlane & A. Wall (Eds.), *Educational innovation in economics and business VIII: Pedagogy, technology and innovation*. Dordrecht, NL: Kluwer.

Wenger, E. (1998). *Communities of practice: Learning, meaning, and identity.* London: Cambridge University Press.

Wiske, M. S., Franz, K. R., & Breit, L. (2005). *Teaching for understanding with technology.* San Francisco: Jossey-Bass.