

Guest Editors' Introduction: Rethinking Methodology in the Learning Sciences

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Situative (Brown, Collins, & Duguid, 1989; Greeno, 1997; Kirshner & Whitson, 1997; Lave & Wenger, 1991) and distributed (Pea, 1993; Salomon, 1993) theories of cognition increasingly are being proposed as alternatives to the traditional individualist notion offered by cognitive psychology. From this perspective, *knowledge*, perhaps more aptly termed *knowing about*, is no longer conceived of as a static structure residing in the individual's head; instead, knowing is a process distributed across the knower, the environment in which knowing occurs, and the activity in which the learner is participating. Thus, knowing and context are irreducibly co-constituted (Barab, Hay, Barnett, & Squire, in press; Greeno, 1998), and learning is (re)conceived as fundamentally constitutive of the contextual particulars in which it is nested (Cobb & Yackel, 1996; Lave, 1997). Environments developed to support such learning, what we are calling *dynamical learning environments* (DLEs), are not simply backdrops for supporting the transmission of content, but are considered dynamic arenas supporting trajectories of participation that are reciprocally constituted by and within context (Barab & Duffy, 2000; Cobb & Bowers, 1999). How one begins to account for learning and the potential of a learning context to support learning is the focus of this special issue.

FROM CAPTURING INDIVIDUAL MINDS TO BUILDING ACCOUNTS OF AGENT-IN SETTING

Initially, in the wake of the cognitive revolution, learning researchers either focused on the products of learning (ready-made knowledge) or examined the learning process as if it were a self-contained process taking place in the confines of individual minds (Atkinson & Shiffrin, 1968; Newell & Simon, 1972). Drawing primarily on the learner-as-processor metaphor and coming from an objectivist epistemology, there emerged a long history of assessment practices in which concepts and principles were treated as independent of the students who know them and the contexts in which they were learned and applied (e.g., Sax, 1989). This focus on the individual (or, more accurately, the structures in the individual's head) as unit of analysis grew in the historical context of a positivist epistemology in which controlled experiments, clinical interviews, and other techniques designed to eliminate extraneous variables or to enable the sort of intense microanalysis needed to produce information processing models and simulations were given methodological preeminence. It is within the confines of these traditions that many of us were enculturated into the practices associated with educational research. However, for researchers adopting a different set of assumptions with respect to what it means to know and learn, these classical methods are proving inadequate (Brown, 1992; Cobb & Yackel, 1996; Greeno, 1998; Kelly & Lesh, 2000; Schoenfeld, 1992; Young, Kulikowich, & Barab, 1997).

Given the individual or, more specifically, the mind of the individual as unit of analysis, the methods involving isolation of participants from their normal domains of activity were satisfactory for capturing the phenomena of interest (Brown, 1992; Schoenfeld, 1992). However, from a situative perspective, there is no separation of knowing from that which is known; rather, there is an assumption that practice, meaning, and identity constitute and are constituted within context, suggesting dialectic, as opposed to dualistic, relations among practice, meaning, identity, and context (Barab et al., 1999; Lave, 1988; Wenger, 1998). In analogy with physics and biology, "the place to look for meaningful content [is] not in the normal physical descriptors of individual particles, but instead in the variables of the *flow* [italics added] itself" (Swenson, 1999, p. 21). It is this intersection of individual, context, and activity over time (knowing in the making) that constitutes the unit of analysis (Engeström, 1993; Greeno, 1998; Lave, 1988). How much simpler it is, instead, to accept cognitive science's *factoring assumption* "that we can analyze properties of cognitive processes and structures and treat the properties of other systems as contexts in which those processes and structures function" (Greeno, 1997, p. 7).

In reframing the unit of analysis for knowing and learning, researchers have turned to a variety of alternative methodologies including those of cognitive an-

thropology, ethnomethodology, cultural–historical psychology, phenomenological psychology, critical psychology, and ecological psychology (cf. Chaiklin, 1993). Anthropological methods especially have been used in providing a comprehensive account of the communities of practice through which learning and cognizing take place within activities of daily living and working (Engeström, 1993; Glaser & Strauss, 1967; Hutchins, 1993; Knorr-Cetina, 1981, 1992; Latour & Woolgar, 1979; Lave, 1993; Lave & Wenger, 1991; Rogoff & Lave, 1984; Saxe, 1992; Scribner & Cole, 1973; Suchman, 1987). The central focus of these studies has been on understanding context as a social world constituted in relation with persons acting (Chaiklin & Lave, 1993). However, as Lave and her colleagues have so clearly articulated, understanding the dynamics of context necessitates a focus on learning. If context is viewed as a social world constituted in relation with persons acting, both context and activity seem inescapably flexible and changing. Thus characterized, changing participation and understanding in practice—the problem of learning—cannot help but become central as well (Lave, 1993).

DYNAMICAL LEARNING ENVIRONMENTS

What anthropology contributes to situative investigation is a comprehensive account of the community of practice as a location for cognitive activity and development. Within this tradition, the community of practice is characterized as a relatively stable, historically constituted repository of practices to which newcomers become acculturated as they gradually progress from peripheral to full participation. However, as we advance to examining situated cognition in DLEs, we are drawn to a more dynamic sense of the evolving community and, consequently, to a variety of new methodological challenges. Our sense of the dynamic possibilities for learning within DLEs is informed by the critical distinction that Scardamalia and Bereiter (1993) observed between knowledge and learning in *incidental* versus *intentional* learning environments. In incidental learning environments (including both traditional school classrooms and everyday living environments), knowledge is relatively stable: “One becomes an old-timer comfortably integrated into a relatively stable system of routines” (Lave & Wenger, 1991, p. 267). Intentional learning environments are characterized by a dynamic volatility: “What one person does in adapting changes the environment so that others must readapt” (p. 267). Intentional learning environments, which are characterized by the learners’ collective intention to create knowledge products, thus, are one instance of DLEs in which learning is conceived as iteratively adaptive.

Consistent with theories of self-organization and dynamic systems (Clark, 1997; Kelso, 1995; Maturana & Varela, 1992; Prigogine & Stengers, 1984), we

see DLEs as continually evolving as the system components (students, teachers, class assignments, resources) that constitute DLEs reciprocally interact in ways that both stabilize and destabilize the system, and allow for continual evolution of the system as a whole. This is not to imply that the phenomena of study for anthropologists and for educators are different, with the former being static and the latter being dynamic. Rather, the focus of the anthropologist is on identifying stable communal structures or individual dynamics in relation to these stable structures, whereas the focus of DLE researchers is on providing an account of changing individuals, changing environments, and the dynamic flow through which knowing occurs.

Although Scardamalia and Bereiter (1993) located the possibilities for stable versus dynamical processes within the environments themselves, our preference is to regard such possibilities as residing in the perspective of the researcher. Thus, we regard certain classroom environments as DLEs only because we (together with the other contributors to this volume) choose to regard them as such. We could, instead, set out to characterize asymmetrical relations among classroom participants in which the teacher's shrewd classroom assignments result in his or her transmission of the desired knowledge products. Conversely, the focus of analysis in apprenticeship or other everyday settings could be shifted to the dynamic generativity of knowing and learning therein (cf. Mead's, 1934, notion of emergence).

What motivates our interest in dynamical complexity is the explosive possibilities for learning it engenders. This is evident in all of the core articles that constitute the main body of this special issue. Each grapples with learning as emergent and dynamic, delving into the nuance of students' situated engagement relative to the evolving knowledge products of the evolving community. For instance, Barab, Hay, and Yamagata-Lynch (2001, this issue) examine how students construct virtual worlds that involve the actualization and understanding of, for example, the 23°-tilt of the Earth, logarithms as tools for representing planetary dynamics, and complex astronomical concepts such as the line of nodes. Roth (2001, this issue) explores the moment by moment focus of two students on the graphical display of a computer console, coordinating their utterances and gestures with the objects of study and allowing them to make sense and develop rich explorations for the objects they are studying. Kulikowich and Young (2001, this issue) capture the problem-solver's perception-action cycle, visualizing how actions at one point in time can only be understood with respect to their relative position in the entire solution space. Cobb, Stephan, McClain, and Gravemeijer (2001, this issue) discussed how an elementary student participated in the construction of methods that allowed her to reason in ways that were compatible with explanations treated as legitimate in public classroom discourse, suggesting reflexive relations in which her learning was supported by participation in the emergence of the very practice to which she contributed by learning.

Our educational stake in these endeavors is to find and articulate new ways of seeing and understanding learning in DLEs. In doing so, we can imbue educational discourse with new possibilities for learning that others may strive to see (and hence to create) within their own classrooms. However, establishing a coherent and viable discourse about learning in DLEs requires a coordination of research methods and assumptions across research studies. This is the principal project of this special issue, to which we now turn.

THE METHODOLOGICAL CHALLENGE OF DYNAMICALLY INTERACTING SYSTEMS

What unites the four reflective articles that form the core of this special issue is a commitment to agent-in-setting as unit of analysis, and to the contention that cognition occurs and is given meaning through the dynamic relations among the knower, the known, and the evolving context through which knowing occurs. Each article is focused around the analysis of particular data collected within the authors' broader investigation of learning in a DLE. With respect to these data, each author was asked to address (a) the central epistemological assumptions, (b) the unit of analysis for the research, (c) the context of the research (sufficient to ground the interpretations and conclusions), (d) the methodological approach or approaches employed in their research, and (e) the scope and limitations of the methodology (touching on issues of trustworthiness, credibility, transferability, and confirmability).

Our purpose in bringing together these methodological reflections is twofold. First, the burgeoning interest in DLEs suggests that a compilation of methodological reflections would provide a useful resource for educational researchers wishing to conduct situative inquiry in such domains. Second, the four research programs highlighted, although not representative of all work in this area, are strong and innovative instances. Comparing and contrasting their commitments, assumptions, and methods may reveal something of the broader parameters within which the research genre is evolving.

What is most striking about each of the methodological approaches presented in the core articles is an almost frantic oscillation of perspectives. It seems that the need to account for the dynamic unfolding of knowledge in DLEs pushes the researcher to continually sift among, and reflexively relate, multiple time scales (minutes and months), perspectives (individual and social), phenomena (human and nonhuman), and sources of evidence (experience and theory). To illustrate, consider just the dimension of time scale. Roth (2001, this issue), following Hutchins (1993), coordinates a moment-by-moment analysis of eye and hand movements (about 1.5 sec increments) with changes in individual perceptual fields (what is salient for the individual as learning progresses with classroom practices evolving over a semester).

Barab et al. (2001, this issue) move from individual classroom episodes (1–2 min) to patterns of knowledge diffusion occurring over days or weeks. Kulikowich and Young (2001, this issue) identify four time scales corresponding to the situational moment, the diurnal level (hunger and rest), the sociocultural level (good student, brother), and the species level (procreation, curiosity). Cobb et al. (2001, this issue) seek to reflexively relate the moment being analyzed with the sociomathematical norms that best characterize the trajectory of the classroom. In his commentary for this special issue, Lemke offers a fascinating theorization of multiscale complex systems, considering classroom dynamics in terms of individual activities, identities, and trajectories, all as they relate to the broader school and community contexts in which they occur. One of the delights of this collection of articles is to chart the intriguing ways in which diverse perspectives are brought together to construct powerful and defensible analyses of learning.

Technology

To a considerable extent, the ability of these researchers to conduct multifocal time-scale analyses accrues to a heavy reliance on technological tools. As Cole and Engeström (1993) put it,

Audio and video tape recording, films, and computers have all, in their own way, enabled us to interact with the phenomena of mind in a more sophisticated way. We can now not only talk about the mutual constitution of human activities, but display it in scientifically produced artifacts. (p. 43)

Although mindful of Hall's (2001, this issue) observation that "the interesting stuff usually gets up and moves out of the frame" (p. 207), we cannot but help but note the exquisite and often overwhelming capacity for observation, juxtaposition, and coordination enabled by computational tracking and recording devices used in these studies. For example, Roth (2001, this issue) uses a computer interface to create a database that organizes and makes immediately available texts, photographs, his own notes, and copies of written artifacts that the students produced, establishing for himself a multidimensional environment with multiple sense-making resources. Barab et al. (2001, this issue) use a computer database to record nodes of activity, and then take advantage of graphing capabilities to dynamically represent the network of activity that captures knowing and learning. Kulikowich and Young (2001, this issue) developed a computerized interface that generates time-stamped records (log files) representing the student's perception–action cycle with respect to problem solving. It remains a challenge of the metadiscourse to evaluate the extent to which technological capabilities underlie the resurgence of the pragmatists' earlier interest in knowledge as recursive and emergent currently being explored in situative accounts of DLEs.

EFFECTIVITY OF THE RESEARCHER WITHIN THE CLASSROOM SETTING

We have illustrated some of the ways in which the epistemological commitments of situative learning in DLEs spawn new methodological practices for researchers. In this section, we make the further argument that methodological principles are influenced as well.

Ethnographic research shares with quantitative research ontological assumptions about the independent existence of the research subject. For instance, in participant observer studies the principle of unobtrusiveness serves the ideal of gaining insight into the ordinary cultural experiences of participants absent the researcher's influence (Hanks, 1990). Even in Garfinkel's ethnomethodological work in which a standard technique is to disrupt the smooth flow of routine events, the objective is still to uncover "background understanding that are taken for granted in commonplace conversations and incidents" (Meltzer, Petras, & Reynolds, 1975, p. 77).

In contrast, the research methods described here tend to place the researcher as an integral participant in the learning culture, helping to intentionally shape the learning environment through their participation. The goal of these researchers, educators, and designers moves beyond offering explanations *of*, and onto designing interventions *for*. In fact, and consistent with pragmatists such as Dewey, Pierce, and James, to some degree it is the latter functional constraint that constitutes what is a useful explanation *of*. This is particularly evident in the work of Cobb et al. (2001, this issue), who are explicit about the complementarity of their roles as analysts and educational supporters within the learning environment.

[A]cademic discourse about education often reflects the assumption that instructional approaches should be derived from theory in a top-down manner. [Our approach] involves an alternative view of the relation between theory and instructional practice in which neither is taken as primary. Instead, the basic relation is one of reflexivity in which the development of theoretical ideas is driven by and remains rooted in instructional practice that is itself guided by current theoretical ideas. . . . From this point of view, the relevant criterion when assessing the value of a theoretical construct is whether it enables us to be more effective in supporting students' mathematical learning. (p. 118)

Roth (2001, this issue) also positions himself as instructor and researcher, stating that,

As a teacher-researcher, I am afforded the unique opportunity of being on the "inside," working with students as they build their scientific explanations and I construct interpretations of what is salient (figure) to them (these are different rather than privileged interpretations). This positioning, my role as teacher, allows me to test my inter-

pretations through continual rearrangements of the learning context in ways that allow me to refine my interpretations. (p. 34)

Similarly, others of the research approaches described in this special issue seek to enhance the educational learning environment, even as they try to characterize the processes of learning within it. Thus, the basic methodological concern for the independence of the learning environment from the researcher seems not to be operative in the evolving situative DLE research. This tendency in these articles is consistent with the current trend toward “design experiments” (Brown, 1992) in which the researcher designs entire classrooms, researches how the design impacts the learning process, and then cycles the results from the research back into the next iteration of the design. This design goal, in which the researcher is helping to intentionally shape the focus of study, is clearly distinct from the goal of the anthropologist, who intends to understand the culture in its own right (Clifford & Marcus, 1986; Geertz, 1983). Furthermore, as Hall (2001, this issue) indicates, this special issue makes salient the challenges of creating sustainable products from design experiments, for if the process of adoption itself is situated (i.e., involves further design, fitting, and adaptation to local circumstances) then realistic goals may not be to “scale up” but to employ research methodologies that allow us to describe local challenges and develop local instructional theories in a manner that supports others in adapting lessons learned in one context to their local contingencies.

In one interpretation, this departure from traditional methodological strictures may be attributed to a sociological shift: Educational researchers are becoming as interested in education as in research (cf. Wagner, 1997). The aforementioned quote from Cobb et al. (2001, this issue) indicates that this interpretation may have some explanatory power within the current collection. However, as hinted at in the Roth (2001, this issue) quote, there is a more basic epistemological interpretation possible that concerns the self-organizing character of knowledge in DLEs. To a greater or lesser extent, each of the approaches described in the core articles is concerned with the emergence of knowledge in individual’s perception cycles as modulated through a coevolving social environment. This emergence hypothesis is a defining characteristic of DLEs as we apprehend them. Thus, even apart from the social positioning of researchers as supporters of educational improvement, the epistemological assumptions tend to deconstruct the presumed integrity of an ongoing community of practice that can be protected from, or else contaminated by, the external influence of the researcher (cf. Kirshner & Whitson, 1998). As Kulikowich and Young (2001, this issue) point out, in situative research the environment is just as problematic (and unstable) as the agent. There simply is not any point in worrying about the framing characteristics of an environment in which the boundaries and structures of participation are being continuously created. We get a glimpse through these articles of a paradigm shift in which the researcher is swallowed up into the dynamically evolving learning environment under study.

We are fortunate to have two strong commentaries to help synthesize and propel the central concerns of this special issue. Lemke's (2001, this issue) article, following this introduction, critiques each of the core studies according to the degree to which it embraces the radical project of multiple time-scale analysis as a central principle. He relates this concern to his own (carefully articulated) theoretical interests, but we can read into the variations he identifies across the studies methodologically significant differences in degree of dynamism of DLEs. This is of crucial importance to demarcating the methodological departures currently evolving with the burgeoning interest in DLEs in that it is this dynamism that creates the new methodological challenges. Hall's (2001, this issue) concluding article performs the vital work of bringing us back to the researcher's workbench to examine the practical implications of these methodological departures, thereby positioning this special issue to contribute directly to the training of researchers and the design of new research initiatives. He painstakingly reviews the program of research activity within each study, noting practical difficulties as well as theoretical obscurities. In his synthesis, he raises key operational questions about the work schedules of researchers and teachers, the amount of infrastructure needed to support this work, and the sheer interpretative difficulty of coordinating multiscale analyses. The fact that these authors have succeeded in raising so many provocative questions speaks to the need for continuing dialogue and deliberation on the evolving enterprise of research in the new learning sciences.

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