A Co-Evolutionary Model for Supporting the Emergence of Authenticity

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The purpose of this study was to share our experiences using emerging technologies to create an authentic learning context where preservice teachers at a university and practicing K–12 teachers collaborate in the conduct of real-world (as opposed to "textbook") tasks. In this paper, we demonstrate and evaluate the design of professional development that involved a partnership between two universities and eight surrounding K–12 schools. This partnership provides the foundation for supporting a learning community of preservice and practicing teachers that situates in collaborative practices that are both authentic and valuable to all involved. Specifically, we studied how issues of ownership, power, authenticity, and collaboration contribute to students' successes and the success of the program through four case studies. We also explored how asynchronous conferencing tools might be used to facilitate communication across geographic and chronological boundaries, breaking down traditional barriers to distributed communities of practice and making possible the creation of a co-evolutionary model for supporting the emergence of a context that was authentic to both preservice and in-service teachers. In contrast to claims that suggest authenticity for an individual can be prescribed to a learner by the instructor, we deny the legitimacy of preauthentication. Instead, an assumption underlying this research is that authenticity is an emergent process that is actualized through individuals' participation in tasks and practices of value to themselves and to a community of practice. The co-evolutionary model for supporting the emergence of authenticity described in this study provides a means of overcoming some of the challenges associated with simulation and participation models for establishing authentic learning experiences.

SUPPORTING AUTHENTICITY THROUGH PARTICIPATORY LEARNING

☐ Although teacher education programs have been teaching students about various technological tools (describing their potential for classroom use) and assigning tasks (assignments) that require the use of these tools within the isolation of the university setting, students frequently have little opportunity to use these technologies for addressing authentic classroom problems. Upon reaching classroom placements these new teachers are ill-prepared to incorporate technology in meeting the complex demands facing beginning classroom teachers with research findings showing that students often fail to use, and dismiss as irrelevant, the techniques that they learn in teacher training courses (Richardson-Koehler, 1988). Nicaise and Barnes (1996) suggested that these findings should not be surprising, given that most teacher preparation occurs within the culturally impoverished setting of the college classroom, instead of authentic K–12 school contexts.

Whether the teaching of technology occurs through didactic lectures or through cleverly designed open-ended projects, if the learning occurs exclusively in the university context there will continue to be a gap between school learning and real-world application (Barab & Landa,

1997; Brown, Collins, & Duguid, 1989). This is because the separation of learning from authentic use creates a content-culture incongruity in which students are learning content implicitly framed in the culture of schools, but whose use and value is explicitly attributed to authentic communities of practice that are not directly in evidence (Barab & Duffy, 2000; Brown et al., 1989). Given the many challenges facing new teachers, we cannot expect that preservice teachers will gain the necessary competence once they are on the job. In fact, research on staff development in schools has indicated that K–12 teachers are generally not receiving enough time, support, access, and encouragement to become competent and comfortable with technology (Schrum & Dehoney, 1998; Siegel, 1995; Zammit, 1992). Teacher preparation programs have the responsibility to prepare these teachers to use technology in meeting the demands of the classroom (Green & Gilbert, 1995). It is how best to prepare these teachers, especially in relation to the authenticity of the learning experience, that constitutes the central focus for this research.

Although not always stated explicitly, implicit to discussions that highlight the importance of learner use and value with respect to what is learned is the notion of *authenticity*. In general, learning environments are considered authentic when there is a similarity between the structured learning activities and some meaningful context for that activity (Petraglia, 1998; Radinsky et al., 1998). However, authenticity remains a concept that is referred to by many, yet poorly defined. In designing a learning environment intended to support authenticity one has to come to terms with what is meant by authentic and to whom. For example, what is authentic to the teacher may not be authentic to the student, and what is authentic to the student may not be authentic to the teacher, and both or neither may be considered authentic in terms of real-world communities of practice (Barab & Duffy, 2000). Therefore, discussions of authenticity must consider authenticity in terms of the life-world of the student and in terms of a target professional domain (Heath & McLaughin, 1994; Lampert, 1990; Radinsky et al., 1998; Roth, 1996; Wenger, 1998).

With respect to the design of learning environments, what makes the practices being learned authentic is not that the instructional designer has mandated them as such, or that the learner wishes it to be so, or even that these practices have real use value to a community of practice. Rather, we have argued that authenticity lies in the learner-perceived relations between the practices they are carrying out and the use value of these practices. Although educators can seed learning environments using tasks that are similar to those tasks being carried out by real-world practitioners, they cannot guarantee the "buy-in" of the learner. Even when learners apprentice to experts in those environments where experts do their work, the buy-in of the learner is not ensured. We have found it necessary to deny the legitimacy of *preauthentication* and, instead, conceive authenticity as an emergent process that occurs as individuals engage in practices of value to *themselves* and to a *community of practice* (Petraglia, 1998). This perspective, grounded in ecological and self-organization models (Bertalanffy, 1952; Prigogine, 1978; Prigogine & Stengers, 1984; Swenson, 1996, 1997a,b), places authenticity not in the learner, the task, or the environment, but in the dynamic interactions among these various components. Said another way, authenticity is manifest in the flow itself, and is not an objective feature of any one component in isolation. It is the focus of this paper to examine these issues from both a theoretical and an empirical perspective.

COMING TO TERMS WITH AUTHENTICITY

The American educational system, as considered separate from hands-on apprenticeships, has in some sense maintained its identity by accentuating the distinction between those engaged in applied practices and those engaged in abstract intellectualizing (Brown et al., 1989). Within this distinction, learning that was increasingly abstract and less similar to real-world practice was considered to be more generalizable, precisely because of its lack of being tied to any specific instance. Said another way, it was believed that generalizable learning must occur "out of context" if it is to transfer to multiple situations, and that only out of context learning can lead to abstraction, generalization, transferable knowledge, and cognitive efficacy in future life situations. In response to this approach to learning, Lave (1997) stated that the "academic and educational establishments are caught in a serious dilemma concerning the role of distance from experience in strengthening and at the same time weakening learning" (Lave, 1997, p. 28). However, there was also another tradition in American education, pragmatism, championed by the late philosopher-educator, John Dewey. "And in terms of aligning American education with the value of authenticity, Dewey's influence is impossible to overstate" (Petraglia, 1998, p. 26).

Dewey's (1938/1963) thinking, and the assumption that the importance of an idea is to be located in its consequences when put to real-world use, was central to the American pragmatist movement. Petraglia stated that,

> Pragmatism provided Dewey with the philosophical grounds for rejecting the elite-idealist-vocational dichotomy, for he argues that this schism is not only psychologically unacceptable (as it supports the transmission model in which learners play the role of blank slates on which knowledge and information are accurately inscribed), but that it reflects a faulty epistemology as well. (Petraglia, 1998, p. 27)

In contrast to epistemological perspectives that view learning as a process of *acquiring* knowledge, and to ontological perspectives that equate knowledge with having symbolic mental representations (Fodor, 1980; Vera & Simon, 1993), we are seeing the rise of situativity theories that emphasize practice and participation as part of authentic communities (Cobb & Yackel, 1996; Lave & Wenger, 1991). Learning from the situativity perspective refers to a change in relationships or, more specifically, a change in the individual's position with respect to the trajectory of experience defined by the practices and goals of a community (Barab & Duffy, 2000). As such, context is not something to be stripped away so that what is learned is context-free and thus generalizable. Instead, situativity theorists have posited the inseparability of content and context, one standing in dialectic relationship with the other (Greeno, 1997, 1998; Kirshner & Whitson, 1997; Lave, 1993, 1997; Lave & Wenger, 1991; Young, Kulikowich, & Barab, 1997).

Situativity as a theoretical perspective, in part, can be said to have sprung from two separate foundations, which has implications for the design of intentional learning environments (Barab & Duffy, 2000; Kirshner & Whitson, 1998). First, there are those that have anthropological roots and which have risen from research on contexts of daily living and working (Engestrom, 1993; Hutchins, 1993; Lave, 1988; Lave, 1993; Lave & Wenger, 1991; Rogoff & Lave, 1984). Second are those theories that arose in educational circles, which are partly inspired by the work of the anthropologists but also in reaction to an increasing dissatisfaction with the practices of schools (Brown & Campione, 1990; Brown et al., 1989; Cognition and Technology Group at Vanderbilt [CTGV], 1990, 1993; Collins, Brown, & Newman, 1989; Resnick, 1987). We believe that these two historical roots have contributed to the current fascination with authenticity in terms of the design of learning environments. Specifically, they have given rise to two models of authentic learning environments, what Radinsky et al. (1998) labeled the *simulation* and the *participation* models.

The Simulation Model

The simulation model of authenticity is predicated on the assumption that classroom activity should be made to be as similar to communities of practice outside of school as possible. This includes *factual* authenticity, in which the environmental particulars of the task are made to be similar to those of the real world, *procedural* or *process* authenticity in which learner practices are similar to those that one would be engaged in outside of school, and *task* authenticity in which the tasks being addressed are similar to those being undertaken by communities of practice (CTGV, 1990). In an effort to contextualize learning that occurs within classrooms, some educators have redesigned curricula and classroom practices so that they engage students in the types of thinking and problem solving that occur outside of school (Brown & Campione, 1990; CTGV, 1990, 1993; Koschmann, 1996; Scardamalia & Bereiter, 1994; Schoenfeld, 1996).

Under this model, "learning goals are often framed in terms of the extent to which student activity shares behaviors, goals, tools, or conceptual constructs with a set of practices of a profession, or a scholarly or artistic practice" (Radinsky et al., 1998, p. 3). Problem-based learning is an example of an approach to establishing authenticity through the creation of simulation models (Evenson & Hmelo, in press; Koschmann, Kelson, Feltovich, & Barrows, 1996; Savery & Duffy, 1996). Cognitive apprenticeship presents still another approach to conceptualizing and designing simulation models (Collins et al., 1989).

The classroom, from the simulation perspective, can be viewed as a "practice field" (Senge, 1994). Practice fields are separate from the "real" field, but they are contexts in which learners, as opposed to individuals who Lave and Wenger (1991) referred to as *legitimate participants*, can practice the kinds of activities that they will encounter outside of schools. The goal in designing a practice field is to situate these authentic activities within environmental circumstances and surroundings that are present while engaged in these activities outside of schools. The design of practice fields and discussions of the central learning principles have received extensive attention over the last decade (Barab & Landa, 1997; CTGV, 1990, 1993; Duffy & Jonassen, 1992; Duffy, Lowyck, & Jonassen, 1992; Edwards, 1995; Hannafin, Hall, Land, & Hill, 1994; Hmelo & Emerson, in press; Kommers, Grabinger, & Dunlap, 1996; Koschmann, 1996; Roth, 1996, 1998; Roth & Bowen, 1995; Savery & Duffy, 1996; Wilson, 1996).

Within practice fields, while the problems may be "authentic" in the complexity they bring to the learner, they are frequently not authentic in the sense that they are an integral part of the ongoing activity of the surrounding community. The point here is that simulation models are practice fields and, as such, are by design distinct from the real world in which students will later be expected to apply what they learned. This is not to imply that teachers do not make efforts to build connections between classroom work and real-world applications, only that these environments are frequently limited in terms of their meaningful connections to some target professional domain (Heath & McLaughin, 1994; Lampert, 1990). As such, activities are not necessarily viewed by learners as meaningful in their own right; rather, they are frequently viewed as preparation for some later situation, having exchange value (frequently for grades) as opposed to use value. In fact, it is through a reference to "something" and "someplace" else that parents, teachers, and even students ascribe use value to that which is being taught. We, like Dewey before us, believe that "education . . . is a process *of* living and not a preparation *for* [italics added] living" (Dewey, 1897, p. 78).

Participation Model

The participation model for establishing authenticity is predicated on the assumption that the authenticity of an activity is dependent upon the extent to which learners engage in the authentic practices as part of a community (Lave, 1993; Lave & Wenger, 1991; Wenger, 1998). In addition to factual, process, and task authenticity, participation models have *ecological* authenticity, referring to the learners' tasks being embedded in ongoing activity within the ecological niche in which the real-world practitioner functions. This shift in the unit of analysis, from the classroom environment to out-of-school communities, leads to a shift in focus from acquiring skills and knowledge to one in which "developing an identity as a member of a community and becoming knowledgeably skillful are part of the same process, with the former motivating, shaping, and giving meaning to the latter, which it subsumes" (Lave, 1993, p. 65). It is not that a sense of self as a member of the referenced community does not or cannot develop in practice fields. However, there is something more to membership in a community; something beyond the temporary collaborative environment of a practice field.

In the case of teacher education, this means initiating teacher education students into authentic communities of practice throughout their development as teachers (Case, Norlander, & Reagan, 1993; Petrie, 1995). Case et al. (1993) described clinic placements at professional development centers (participating schools) as an essential aspect of their teacher development program. It is in these placements that students begin to analyze and reflect on classroom behavior and school community situations. These experiences allow students to experience the effects of becoming knowledgeably skillful in terms of their participation as part of the community of teachers. Relegating participation in classroom cultures to the occasional fieldtrip or a singular student teaching experience with most learning occurring in the university context is inadequate from the situated perspective; sustained meaningful opportunities for participation *within* communities of practice are essential. While few educators would argue with the value of engaging learners in authentic communities of practice, many obstacles prevent preservice teachers from participating in precollege classroom communities. Isolated in college classrooms, most students lack the transportation, time, and resources necessary to becoming involved in classroom communities. Likewise, mentoring a cadre of students adds extra work to already burdened teachers. At the very least, coordinating the schedules of these busy populations for the planning, training, and evaluation needed in good teacher development can be daunting.

Further, relegating the learning of preservice teachers to on-the-job apprenticeships with in-service teachers has additional problems—especially when the learning in question is related to the increasingly changing realm of technology use. First, the practices and meanings that we would like preservice teachers to learn are not necessarily "residing in" the K–12 or university classrooms. One cannot expect that classroom teachers, responsible for five classes per day with one preparation period and frequently more than 100 students, can possibly keep current and skilled on the latest technology developments (Schrum & Dehoney, 1998; Siegel, 1995; Zammit, 1992). In fact, with respect to technology, many preservice teachers are more competent than those teachers working in the classroom. Second, it has been argued that in many domains there is no single, privileged or correct view. Instead, there is a number of different competing and arguable sets of justifiable beliefs (Knorr-Cetina, 1981; Latour, 1987; Petraglia, 1998b). Third, even if we could find examples "out there," one cannot *preauthenticate* practices and meanings for students. Educators need to find means of stimulating ownership.

From the perspective of an instructional designer, the simulation and participation models of authenticity are at odds. On one hand, the simulation model suggests designing classroom contexts so they stimulate the central practices and questions representative of the target domains; on the other hand, the participation model suggests finding means to immerse students into the actual communities as peripheral participants. With respect to supporting preservice teachers' learning about technology, the former model runs the risk of facilitating the development of inert and impractical knowledge (Whitehead, 1929) as students engage in practices and discourse about technology use in K–12 schools within the confines of the university classroom. The latter model also has limitations both in terms of physical space and time constraints and in the fact that these in-service teachers may not be engaging in the types of practice or using the technologies that we want students to learn (Barab & Hay, in press). Therefore, in the next section we will argue for another model of authenticity: a model based on shared authenticity, expertise, and ownership among university students and classroom practitioners.

CO-EVOLUTIONARY MODEL

Implicit and explicit to both the above models of authenticity is that a learning environment develops authenticity because of its similarity to real-world environments—in fact, the participation model suggests that learning should actually occur in these environments. We have argued that authenticity lies in the learner-perceived relations between the practices they are carrying out and the use value of these practices. Educators need to find means of aiding students in owning these practices and meanings, but in ecologically valid contexts. To address these two problems we have grounded the development

of our course in an ecological or self-organization model where university students and classroom teachers reciprocally construct tasks and, in the process, what is taken-as-authentic (Bertalanffy, 1952; Gibson, 1986; Prigogine & Stengers, 1984;).

Epistemologically, the model builds on the assumption that practices and meanings are emergent within environments that have the appropriate boundary conditions (Barab et al., 1999; Swenson, 1996, 1997a). That is, given the appropriate environmental conditions (including individuals having adopted specific intentions) certain practices and meanings are likely to emerge. This emergence of particular practices and meanings is not magical, but consistent with work in self-organization theory and dynamical systems, in which certain structures emerge in relation to the function that they serve, and to the physical properties in which they are grounded (Bertalanffy, 1952; Kelso, 1995; Prigogine & Stengers, 1984; Swenson, 1997a,b). The central notion underlying self-organization theories is that "order" does not have to be credited to any one component of the system, but emerges through the dynamics of a system. Barab et al. (1999) discuss instructional implications of this approach.

> From an ecological perspective, instruction involves mediating key elements of a larger context so as to facilitate the merging of learner and environment into a single system. As learners work toward functional goals, the "facilitator" guides their practice to support the emergence of meaningful relations. Learner ownership of functional practices and meanings need not, and we would argue, cannot, be externally arranged by the "teacher" for the student; rather it flows as part of the self-organizing dynamics that are uniquely emergent when the individual becomes a member-participant in an ecosystem or context for a task. (pp. 353–354)

It is this ecological grounding that leads us toward a co-evolution model of supporting the emergence authenticity. In this model, meaningful task constraints evolve as part of the self-organizing dynamics that are uniquely emergent when the individual becomes a member-participant in an ecosystem (as part of a community) for a task. Said another way, *authenticity emerges through meaningful relations* among individual, community, and task. This approach is consistent with designs advocated by Radinsky et al. (1998), for example, when they proposed the "mutual benefit partnership" model. In this model, students and teachers are brought together in a partnership with a professional community so that they may complete a shared task. The terms of the partnership are discussed among all existing parties in relation to a particular task, problem, or product, with the resolution potentially having value to all parties. For example, in one project undergraduate students and course instructors worked with a campus organization interested in increasing faculty technology use in the curriculum. The campus organization worked with course instructors and the students to define the problem, the scope of research, and the expected deliverables. Over the course project, students did background research, designed a marketing plan, wrote a proposal, and presented their work to relevant audiences. In this project, the collaboration offered an ideal context for students to develop competencies in organizational research and design, while they contributed to the organization's knowledge base. In this sense, the organization and the students engaged in collaborative work for the benefit of both parties.

Consistent with the mutual benefits project discussed above and predicated on an emergent model of authenticity, we designed our course to bring together the shared competence, resources, and goals of preservice and in-service teachers with support from university professors. In particular, it was our goal that preservice teachers would develop and expand their competencies (including practices and meanings) with respect to technology use in the classroom within the expertise of experienced classroom teachers. In other words, neither the university professors, the textbooks, the preservice teachers, nor the in-service teachers housed the "right" practices and meanings; instead, these were to emerge through shared discourses and practices all within the constraints imposed by the tasks at hand in relation to their function to all parties. It is in this sense that we have moved away from and taken advantage of both the simulation and participation models for establishing authentic learning environments. Instead, central to the co-evolution model is the emergence of a learning context that is neither, and is both the classroom and the community of practice. Our goal is that the shared task will conditionally constrain the university classroom–K-12 community system, setting up boundary conditions that would make certain practices and meanings more likely to emerge. Further, it would do so in a context that allows university students and classroom teachers and their students to appreciate and directly experience the real-world function of what is being learned (Barab et al., 1999).

A co-evolutionary model for supporting the emergence of authenticity is one that allows for collaboration among the learner participant(s) and the real-world practitioner participant(s) so that all parties mutually define and co-evolve the parameters for defining and addressing the task at hand. Central to this model is that the task at hand has meaning and significance to all parties, and that it addresses a real-world need that has significance independent of school-created expectations. In other words, completing the assignment has applications that go beyond the university classroom context.

THIS STUDY

For this study, both naturalistic and quantitative data were used to gain a holistic vision of the semester-long course (Guba & Lincoln, 1983; Scriven, 1983). Two researchers who were not involved with the development or implementation of the class attended and took field notes a minimum of 90 min for each of the twelve 2-hour classes. In this study, we will refer to the preservice teachers taking this course as *students*, refer to K–12 students as *K–12 students*, the classroom teacher as *teacher*, and the university professor as *professor*. Student-teacher and student-student discussions over a conferencing system were also examined. In addition, students were interviewed using open-ended questions (e.g., To what extent and in what ways were you able to become members of the classroom community?) intended to illuminate the four research issues discussed below, and to confirm and probe observations made in class. These 10-min interviews were conducted with each of the groups discussed in the case studies on at least two occasions, with an additional interview occurring directly after visiting the K–12 classrooms if that occurred. Multiple interviews were also carried out with the professors and K–12 teachers. It was stated in the consent form that any information shared with the researchers would not be discussed with the course instructor until after grades were submitted.

Field notes, learner interviews, and teacher observations were discussed in meetings among the researchers so as to generate assertions used to direct data collection efforts the following week. In particular, these meetings illuminated pertinent issues with respect to the successes and challenges of the course. The issues most prominent at the end of the study (and that structure the case studies) were: (a) What types of interactions emerged within groups? (b) Did students believe the projects were authentic? To whom? And how did this differ among groups? (c) What was the nature of students' participation in the K–12 classroom and, conversely, the nature of the teachers' participation in the projects? and (d) How did issues of power and control contribute to emergent authenticity? The issues were continually refined during fieldwork, group meetings among the researchers, and increasingly focused data collection and analyses. The constant-comparative method (Glaser & Strauss, 1967), in which the data and emergent interpretations interacted in a dialectic fashion, allowed us to be attentive to the issues that emerged from the data and not to simply impose our a priori expectations top-down, from theory to practice.

Lincoln and Guba (1985) recommended triangulation as one means of increasing the credibility of interpretations derived from naturalistic interpretations. Interpretations were triangulated using multiple data sources; including observations, interviews, document analysis, learner debriefing, and analyses of referential materials. Last, member checks were used with the students, the teachers, and the professors to further substantiate that the issues and interpretations were indeed consistent with the course

experience. From these data, four case studies were written with each one focusing on the emergent issues discussed above.

THE CONTEXT

Participants

Thirty-four junior undergraduate students worked in groups of 3 or 4 (frequently, with 2 students at each campus) and with a classroom teacher to complete three group projects, in addition to two individual assignments. Students differed in terms of their computer proficiency, but all students had chosen to obtain a special computer endorsement of which this was one of the last classes in the five-class sequence. Within these courses, students learned to use the Microsoft Office™ suite, developed Hyperstudio™ lessons, and developed Webquests™ using hypertext markup language (HTML) code. It was common practice that computer endorsement courses would be hands-on, designed to support students in using computers. Of the students, 22 were located on a residential campus, while the other 12 were located on a commuter campus in a city approximately 65 miles away.

The teachers who participated in the projects taught K–12 students with diverse ethnic and socio-economic backgrounds, including inner-city K–12 students who constitute at-risk populations. The ten teachers selected were chosen using a convenience sample, taken from a list of people who had previous collaborations with the university. All teachers had at least one computer with an Internet connection in their classroom. None of the cooperating K–12 teachers discussed in the case studies had ever developed their own Web sites, or had used a Web site in a class lesson. In fact, only one teacher had participated in professional development activities related to using computers, and he was also the only teacher who used the computer for more than word processing and occasional e-mail. The professor working at the inner-city university had taught this course six times previously, while this was the first time for the other professor. Both professors had extensive computer experience, running workshops for K–12 teachers, teaching K–12 and university courses on using technology, and writing their own code in various languages.

Course

With the goal of situating the learning experience and strengthening university and K–12 partnerships, the current course on using technology in the classroom discussed in this study was totally revamped. Instead of learning through lectures and individual assignments, the revised course involved a collaboration between students at two universities and eight different K–12 teachers at public schools. It was designed to benefit both preservice teachers working toward their computer endorsement and the K–12 teachers in the cooperating schools. It was the instructors' intention that university students would learn about using computers in the classroom and writing grants through collaborating with K–12 teachers in developing Web sites, evaluating software, and writing grants.

Because the university courses occurred simultaneously, the distributed teams (one or two students at each campus, and a K–12 teacher) used synchronous video-conferencing equipment and an asynchronous collaboration tool (ACT) as their vehicles for collaboration (Sloffer, Dueber, & Duffy, 1999). More specifically, they were expected to go online and post at least two messages a week related to course assignments. The three projects that all teams completed were: (a) the constructing and testing of a World Wide Web (WWW) site designed to meet the teacher's specified curricular needs; (b) the evaluation of software to be used in conjunction with specific topics in the Web-site project; and (c) the development and submission of a technology grant proposal to meet the teacher's technology needs.

All of the projects involved authentic problems in the use of technology in a school. In all cases the students were in close collaboration with the teacher: they responded to the teacher's needs; teacher and students explored options collaboratively; and the "product" was tested in the school. Further, the students were intimately involved in the use of technology (ACT and video conferencing) to collaborate with the teacher and among themselves. The professors located at the two universities were expected to provide constructive feedback to stimulate critical thinking. Telephone communication between the professors and the teachers was used to teach the teachers to use ACT.

Uses of Technology: Course Content

In terms of classroom uses of technology, the instructors promoted the uses advanced by Barab, Hay, and Duffy (1998): information resource, communication tool, content contextualization, construction tool, and visualization-manipulation tool. These five uses were not discussed as features that are inherent to the technology as if technology were an independent entity; rather, they refer to uses or roles that technology can afford within various contexts; that is, they emphasized their contextualized nature. Barab et al. (1998) described these as situated potentials, which are actualized (and given shape) within the larger context of learner inquiry—a process that requires the guidance of an effective teacher. Research related to the first four uses (both in terms of the actual tools being used and the theoretical framework) provided the empirical base out of which the activities in this course were developed.

Briefly, we will overview these four uses. The use of technology as an information resource for learners is, arguably, growing to become the dominant use of technology in education and business; examples include the WWW and interactive CD-ROMs. The rise of theories of learning that emphasize context as co-determining the meaning of content (e.g., theories of situated cognition) have stimulated the use of technology as a means of situating the material to be learned within a rich learning context; examples include anchored instruction and experiential simulations. The third use of technology that was relevant to this course was as a communication tool, facilitating collaborative and distributed learning across time and space; examples include ACT and teleapprenticeships (Levin, Riel, Miyake, & Cohen, 1987). The final use of technology relevant to our work is that of a construction kit in which technology provides a concrete tool for building various phenomena (e.g., interactive lessons, multimedia presentations, or even 3-D worlds); examples include LOGO, HTML, and virtual reality modeling language editors, and HyperStudio). The question of how to best support teachers in developing competence with respect to these various uses was the prime focus of this study.

CASE STUDIES

Case 1: Native American Group

This group consisted of four women distributed between two campuses working with one teacher, Little Tree. All four female university students had completed three computer and education courses, but had not yet taught in a classroom. Little Tree teaches Grade 2 at an elementary school located in the same city as two of the students. She has two computers in her classroom, both of which have an Internet connection. She uses the computers for e-mail and for word processing. However, she had yet to incorporate the Internet into any lessons. In fact, the district just developed its Internet-use policy so students could use the Internet. We refer to this group as the Native American group because the Web site it developed was about Native Americans.

Framing the project. In the first project, Little Tree's group developed a Web site on Native Americans to be used in her class. Much of the group's initial efforts in building the Web site focused on determining the size and scope of the project. Negotiation of goals and tasks occurred throughout the semester. Little Tree, as well as one of the university students, expressed an interest in including K–12 student work on the pages. Little Tree also wanted to be able to create and edit the pages developed by the university students. After some discussion, they decided that Little Tree lacked the authoring tools necessary to create a Web page, but these pages would be accessible to her so that she and the

students could update them in the future. Little Tree initiated the dialogue on the ACT:

Little Tree As I have been thinking more about the Web site and its layout, I have been wondering about student participation. I have asked about a place for student dialogue (chatting) (if this is possible) and also a place for student work to be displayed. I would like students to be part of this process. I checked out our larger IBM lab at school and we do have Netscape Navigator™. Are any of you willing or available to come and teach some of the children (and me) how to work on a Web site?

The only ideas I have to include in the Web site so far would be link-ups for children and teachers. It would also be good to include children's work, or even a place for children to dialogue—is this possible?

Student 1 Those ideas were very similar to some other parts of the page that I was thinking of. I thought maybe a section where students could dialogue with one another. A place to post questions about each other, in which they can try to respond and answer to. Also, what kind of work are you doing in your class that we could post on the Web?

Student 2 We were thinking of creating 4–5 pages, stemming from a homepage originally created. An overall introduction of the class project and your goal. We thought of a links page for teachers and students both. What types of other pages would you like to be linked? Do you want a page on various Native American cultures, traditions? What type of student work do you want posted?

Your idea of conferencing between the schools is a good idea, but will be very difficult. The schools can e-mail back and forth about the pages, but conferencing will be very difficult.

This excerpt illustrates the process in which the Web site and requisite tasks emerged through collaboration among the university students and the classroom teacher. Neither the teacher, the student, nor the professor dictated what content should be on the site; rather the process by which the framework for the Web site was established was one of shared negotiation. The team proceeded to develop the content for the site in a similar manner, settling on a page for each of the five tribes of Native Americans being studied by Little Tree's class. Once the framework for the site was established, issues of interactivity and Little Tree's access to the site were revisited.

Little Tree I am so impressed with the opening page of the Web site. It looks great. Did you read my questions about possibly having a place for dialogue? and a place where the students can add items themselves?

Student 1 I agree that it would be an excellent choice to put the children's work onto our Web site. At this time I don't think we can have students adding to the site. But, it is a possibility that the school could create a site which students could work with. Creating a page is not always as easy as it looks and seems. It might be that the teacher would have to direct the editing and posting of pages for the students. Student participation would be through their creative work: designs, writing, etc. I think the students will be very proud when they find their work is on the Web for anyone to see. The work which would be posted could be updated or deleted at any time. As Anita and Margarita have expressed, conferencing or dialogue between schools is not possible at this time. We feel that the best way to talk back and forth right now is through an e-mail for the school or particular classroom and monitored by the teacher.

In this passage, Little Tree asked the students if providing a forum for her K–12 students to dialogue and space to showcase their work were technically feasible, deferring to the university students' expertise as technical experts. The students seized this role, noting the technical difficulties in providing online discussions and managing a shared online space. The students also capitalized on their university training, acknowledging the theoretical rationale for publishing students' work on the Web. The teacher responded by exerting her own expertise in managing a classroom and working with students:

Little Tree I appreciate your response in regard to the dialogue and posting of children's work. I realize that the teacher would have to be overseeing the entire process of adding and deleting from a Web site. I also think that the creating a Web site is not as easy as it might seem (to me it does not seem easy at all). I am curious though why you think that it is not advantageous or appropriate to have a place for children to submit their work on this particular Web site at this particular time?

The students quickly acknowledged the teacher's experience, adopting an apologetic tone and offering to help the teacher do whatever it takes to meet her classroom needs:

Student 2 It is definitely appropriate for students to submit their work. At the current time, your students do not have access to the server where this site is located. Members of our group will be glad to post any materials you would like to submit to us . . . Sorry about the confusion. I want you to know that I am willing to do whatever you feel is needed to make this site useful for you, your students, and the school.

The teacher was more than willing to reveal what she did not know, and defer to students in their areas of expertise:

Little Tree Thank you for getting back to me about the students' work. Question: If I do not have access to the server off of which you are working can the students post their work on our server and have a link-up? (I am not sure if this is even possible.) If we could do this, would that mean that we would have to have our own Web site on which these projects, etc. were posted? I don't know what would be easier at this point.

Throughout the dialogue, open negotiation occurred, with authentic concerns, technical constraints, existing teacher skills, and acceptable Internet use entering the discussion. Indicative of this negotiation process was the manner in which students offered suggestions to Little Tree. In all of the previous examples, students took a relatively deferential role in acknowledging Little Tree's expertise within her classroom, and a more assertive role in offering suggestions about technical issues. Similarly, Little Tree deferred to the students in deciding what was technologically feasible, but asserted herself in knowing what use of the Web would be best for her students. At the end of this exchange, the students acknowledged Little Tree's experience in writing, stating we are "willing to do whatever you feel is needed to make this site useful for you, your students and the school." In response, Little Tree opened herself to new possibilities, sharing uncertainty over what was possible in this medium. Social construction occurred throughout the course in a similar manner, as the students collaborated with their cooperating teacher, ultimately creating a shared vision and shared project.

More social construction. In the grant project, the team discussed tasks, roles, and responsibilities in a manner very similar to that of the first project. Little Tree and the university students went through cycles of construction, determining what goals the teacher wanted to accomplish, what technology was currently available in the school, and what kinds of grants were currently available. In writing a grant for an actual classroom, students were quickly forced to wrestle with authentic classroom constraints.

The university students initiated the discussion, asking Little Tree what software was currently available. Little Tree replied, "We have a lab of 10 Mac computers close to our 2nd grade classrooms that we use. The kids have used them to do HyperStudio projects and browse the Internet for information." A student, trying to determine how much technology was currently available throughout the school, responded,

Student 1 I remember that you had said earlier that there were both MAC and PC's in the school. The site license that you would receive for the school for the network would work for all computers within one building. But, you need to get different software for MAC and Windows.

Little Tree We have a lab with 18 IBM computers and a small lab of 10 MAC computers. I am also going to write another grant to go along with both of yours for 3 MAC computers in each of our three classrooms. We are planning a lot of computer work for next year and we will need the extra computers. I think it would be good to have software for both.

Student 2 Thanks for getting back to us (or me) about all of my questions. I have one more question. Do all of the IBM's and Mac computers have a CD-ROM in them? If so, then there is a CD-ROM of the software available that would be much cheaper than buying software for each platform separately.

Little Tree Yes, every computer has a CD-ROM, both the IBMs and MACs.

In this series of exchanges, again, we see the construction process by which the group arrived at most decisions. In outlining potential purchasing decisions for the school, students were forced to wrestle with very real concerns about

the types of equipment available in the school, licensing agreements, and hardware requirements. The constraints facing the students were not teacher-developed and artificially imposed. Rather, they stemmed from actual constraints.

Summary and discussion: During the semester, students in this group expressed some frustration over not being able to interact more with Little Tree's students. In class, one student was observed as saying, "I'm uncomfortable doing this—I feel like I don't know the students." Another student remarked, "I need to build a better relationship with the teacher and students—it would make the project better." In interviews, all four students offered "no interaction with the kids" as a source of frustration. However, later in the semester, some students did visit Little Tree's class. In closing interviews, they revealed that much of their frustration had been alleviated by actually going to the class.

At the end of the course, Little Tree offered the following feedback,

> Little Tree The site is incredibly good. I had the two other second grade teachers take a look at it today and they were in awe. You have done a wonderful job presenting the information in a readable, understandable way for second graders. It will be a valuable tool for us in the future and hopefully for others. There is not much on the Internet (informationally appropriate) for this age group. Thank you for your effort, time, and hours of frustration. This will benefit many children and teachers.
>
> I wrote on another message what a terrific job I thought you did on your lesson plan. It is very well thought out and has clear objectives. I think it would take 2nd graders longer than 1 hour to complete the entire plan. They are just at the beginning stages of learning how to navigate their way through the Internet. This lesson would provide them with very specific directions and locations. Their note-taking is not very well developed at this point and so we would use this lesson to utilize the writing process. I think I might triple the time allotted and integrate skills.
>
> Another great aspect of your lesson is that it can be adapted at any elementary grade level. The individual teacher could then add in suitable language arts skills.

These excerpts illustrate how the teacher's comments provided students their criteria for success and the source of feedback and evaluation for this project. Unlike traditional classes, where university professors establish the criteria for success and evaluate students' work, in this environment, students learned from practicing teachers; project constraints, criteria, and evaluation all emerged from participation in a K–12 classroom. By interacting with practicing teachers and learning through engagement in K–12 classrooms, students were situated within a K–12 community of practice, instead of only the university communities of practice.

In this case, we see how authenticity was not something that could be prescribed, or decided prior to the learning experience (preauthentication); rather, authentication arose from meaningful social interactions and situated constructions of practices. Students were immersed in a rich learning environment where they had access to authentic resources and opportunities to engage in authentic practices. In this way, they were afforded opportunities for legitimate peripheral participation in the K–12 education community. By constructing roles and tasks with their cooperating teacher, these students were able to find a legitimate place in the classroom as they learned and participated in authentic practice; that is, practice with a real-world need.

Case 2: Wetland Group

This group consisted of three female students, all located at a rural campus. In contrast to the competencies of the other group members, one student had taken only one previous course on using computers in education. Further, where the other two students had developed their own elaborate home pages, the inexperienced student had almost no experience developing Web sites. They collaborated with an elementary teacher, Mrs. Dundee, who worked at a rural school located 25 min from the university. Mrs. Dundee was the least experienced teacher in terms of using technology. She had three computers with Internet connection, which she had used for e-mail only. She expressed initial reservations about the project, stating she had very few computer skills. We refer to this group as the Wetland group because of its Web-site focus on wetlands.

Dundee's group evolved very similarly to Little Tree's group. The first weeks of the project were dominated by concerns with what type of content should go on the Web site, what technology constraints the students faced, what kinds of technical skill each possessed, and what tools they had available. Students went to the library to research wetlands, searched online for related links, and worked with a university professor to further enhance their Web site development skills. In addition, they participated in discussions about pedagogical approaches for using technology in the classroom. This process of Web-site development was one of negotiation as each team member offered ideas. The nature of the project evolved as constraints were realized.

Constructing the process. After beginning a design, the team posted on the Web the following list of questions for the teacher. This list initiated the negotiation process:

1. What would you like your title to be? Your classroom page, a page dealing with wetlands, etc.?
2. Is it okay that we have chosen environmental science to be the main topic of your page?
3. Do you want us to pick some links to put on there or do you want to pick all the links?
4. Is this page for you (including other teachers), kids, or both? . . . What do you imagine your front page to look like? Do you want a general page where you can add other subjects to [sic] later or would you rather it be directed towards the wetlands and environmental science?

Using the ACT, Mrs. Dundee posted feedback on their ideas, allowing the process to go forward. Group members would create a document, post some questions, gather responses and then refine it. Students' experiences, observations, and knowledge combined with Mrs. Dundee's classroom expertise guided the negotiation process.

One of the first discussions to take place in this group was to establish who had what skills. One student remarked,

> Also, as you girls know, I am not at all experienced with this, but I am certainly trying. About our personal Web page, I am not doing good with that at all . . . I don't know what I am doing . . . I am sorry! :)

Mrs. Dundee quickly replied to this response with, "Hey, don't feel bad. I have zero experience, but with 6 computers in my room right now I had better be learning something pretty quick." In this way, students were not only given encouragement, but also the opportunity to see that professional development, specifically learning technology, is an ongoing process that teachers learn on the fly. Unlike in traditional classes, this comment arose naturally from authentic interaction, not from the teacher or from a reading.

After group members decided on their roles in the project, they began to tackle the assignment, the actual Web site production process. Two weeks into the semester the students realized that they had not really agreed on boundaries for this project, and they posted the following:

> Mrs. Dundee, we are meeting as a group right now, and have come up with a couple of questions to ask you. First of all, we don't have a full understanding of what the wetlands project is all about, and were wondering if you could explain more about it. i.e. data collected, what it consists of, what you want to do with it. We were also wondering if you have any ideas about types of on line lessons we could create. Also, we were wondering if you currently have any software in your room dealing with the wetlands, or science in general. We have to do 6 software evaluations to put on this Web page, and thought you might have some.

The student team spent the next few days gathering resources from the library, specifically looking for science software. Team members made a few posts expressing their frustration, and their concern that they would not be able to create an adequate project. Here, the university proessor intervened, providing guidance for the group:

1. Someone needs to go the class and write a summary up of what occurs and post it.
2. Mrs. Dundee, can you summarize what reason your students would say for their collecting data for the Wetlands project?
3. Someone needs to write a summary of the need to be addressed and then the group needs to move on to the next phase of evaluating plans (see next conference).
4. Someone needs to go to the class and develop a storyboard with the kids—also, could someone then post the outcome of this?

Here, the professor was able to facilitate the construction process by helping the team summarize its progress and by pointing out some key tasks that might help the process. In closing interviews, the instructor commented that writing summaries was one way that students could externalize the tricky negotiation process, providing a history of where they had been and a vision for where they plan to go.

Continuing the process, Mrs. Dundee reentered the discussion, highlighting some constraints for the team to consider when dealing with second grade students:

I had not thought about involving my children in planning the Web page. Right now I am having enough trouble just getting used to having all the computers in my room and having the children work on them. Computers are great, but at the age of 7–9 games are the big thing! I have a couple of girls who would probably have the interest and be able to contribute ideas. I'll think about this and get back to you.

Here, the teacher's experience allowed her to bring authentic experience into the process, and the group was forced to change some of its design plans. The week that this post was made, the group members also decided to meet with the teacher, allowing them to gain first-hand experience interacting with the K–12 students. This meeting proved to be a critical turning point in the project's evolution. *At this juncture, the experience changed from simulation to participation, where the university students were now working in response to authentic community dilemmas arising from the needs of those individuals that the community was designed to support.* In closing interviews, team members also commented that meeting the students helped them better understand the students, and made designing a lesson plan easier.

Changing roles. In the grant project, Mrs. Dundee played a more directive role, developing a list of wishes for the students. Students then researched the justification for the grant, searched for potential funders, and eventually wrote the grant. Students ran into many problems trying to find grants. They found grants for districts, grants for larger sums of money, and grants for higher education.

Over ACT, students shared much of their frustration, explaining the "runaround" that they were getting from several companies. Upon finding a suitable grant to apply for, one student remarked,

"We got it!!!

to rely less on Lincoln. However, conversations with each other also began to take on a tone of ownership around this time. Believing Lincoln to be unreliable, they occasionally talked about a conflict between "what Lincoln wants" and "what's best for the kids".

Abandoning the mentor. Near the end of the semester, the students' focus was on writing a grant proposal. In keeping with an overall desire for authenticity, the students were required to actually seek out and submit a grant in their teacher-mentor's name. While the discussion began with a request for information about Lincoln's needs, it quickly moved into the discussion of specifics that Lincoln was unable (or unwilling) to address. This led to some anger on the part of one of the students, and this revealing post:

> Correct me, or help me understand the assignment Mr. Lincoln. For this grant writing project it will require your assistance and participation in the quest for YOUR dollars, collaborating with us on ideas, and writing this proposal? I am just concerned and need to fully understand what is expected of each of us with this joint venture.

Two weeks later, the relationship had moved still farther away from a mentor-student role.

> Also, you said that you looked at ACT and had read my posting about the MacArthur Foundation grant. I failed to mention that we had not received any information from you regarding the six questions which MUST be addressed by you in order for us to come up with a proposal . . . Please try (I know you are a busy man) to get us this syllabus and information as soon as possible.

This was, in fact, one of the last substantive exchanges to occur between Lincoln and the students in the electronic forum. While there were a few face-to-face meetings in the interim, these had become less and less fruitful as the semester progressed, and Mr. Lincoln continued to be too busy to act as a true mentor.

It is worth noting that the grades of the students were in no way connected to whether or not they actually received a grant. This group, however, was adamant in trying to acquire funds for Mr. Lincoln's classroom and felt obliged to do its very best. This resulted in their writing a grant, which (as two members expressed during informal conversation) they believed fulfilled the needs of the classroom and had a good chance of being funded, but didn't match very well with Lincoln's initial expectations.

Summary and discussion. While certainly not a smooth transition, the students in this group moved through a stage when they were in consultant mode and eventually entered a phase where they took complete control over the tasks with little consultation with their teacher-mentor. Ownership in the *problem* was catalyzed by (limited) face-to-face interaction with the children who were their primary audience; ownership in the *process* came about as their confidence in their own abilities grew, even as their confidence (and trust) in their mentor-teacher's contributions fell.

It is not clear, however, to what extent the activities of the group were perceived as authentic. When asked about the electronic lesson that resulted from their first project, all believed that "someone could use this in a real classroom," but none mentioned using it in their *own* classroom until prompted. Finally, in interviews they clearly expressed that they viewed the teacher-mentor as a *client*, although perhaps not a terribly helpful client. For feedback on their work, they were forced to turn to their own college instructors, placing them firmly back into the relatively artificial world of the university. In this case, we see how a relatively impoverished, one-sided negotiation process resulted in a lack of legitimate peripheral participation and relatively inauthentic learning experiences. Even though students' practices had task authenticity, their participation in this classroom was ultimately inauthentic, resulting in a learning context less rich than the first two cases.

Case 4: At-Risk Group

Two males and two females collaborated on this project, with one of the males being located at the inner-city school and the other three all at the rural campus. Although all students had at least

three computer endorsement courses, none had any experience with special needs students. Their cooperating teacher, Mr. Zappa, worked at a "school within a school," teaching 11 students of various levels and abilities. All of Zappa's students were "at risk." Specifically, all were one step away from being expelled from school. This classroom was their last chance. Mr. Zappa had two computers in the classroom but was reluctant to allow students to access the Internet, because he feared that they would go to Web sites that were inappropriate for school.

Mr. Zappa made it clear immediately that the efforts of the group were going have a direct influence on his classroom and that he viewed them as useful participants.

> I would like to know if there is any way your program could help me utilize the Web to increase student interaction in specific areas where I as a teacher am weak: math and science. . . . I am interested in working with your group as an instructional tool.

Zappa also stressed the need for the students to take a trip out to his school and meet the class. One member of the group was particularly worried about such a trip: after hearing about the class and some of their histories (which involved fighting and delinquency), she was worried about her ability to help them as an educator and more than a bit frightened of them as individuals.

Unlike Mr. Lincoln, Mr. Zappa made it clear from the beginning that his K–12 students were involved in the Web-site process. "I ran it by my students, and they think that helping to make the Web page is a fun idea." Despite the university students' rapid immersion in the ideas and details of the Web project, they were still deferent to Zappa for all final decisions and even process direction. This was partially because of their unfamiliarity with the needs of at-risk students, but primarily because they had not yet met the students.

> Because it is your class, you would know how to best approach this project. Also since I don't know your class I think that it would be best for you and your class to come up with the subject/topic that you wish to explore. If dividing the group up works for you, then it works for us.

Thus, this group, too, slipped briefly into consultant mode, viewing themselves as inexpert technical consultants. All felt as if they were flying blind, and needed a nudge in the right direction from Zappa. Even so, they were already expressing confidence in their own ability to run with a possible solution and addressed the educational needs of the students.

> We met in class yesterday (Kate, Julie, and myself) and it sounds like John [group member at the inner-city campus] agrees we HAVE to pick a topic so we can proceed. If you or your class can think of one or two or even three to choose from, we, as a group, can determine which one would work best for our purposes. You don't have to feel responsible to work out the details, all you have to due [sic] is come up with a topic. We can then put our heads together and determine where to go from there.

Meeting the students. The consultant-client atmosphere changed immediately upon meeting the students. The young woman who had expressed discomfort (even fear) about meeting the students beforehand became the most excited about the project after the trip to the classroom. In a post titled "Changing Gears," she took charge of the project with newfound confidence after meeting Zappa's students:

> Everyone: I took it upon myself to change a few things on the Web page. We can discuss these changes in class or on here. In general, after visiting Zappa's class and talking with him and Sam (a man who works with Zappa's class), I feel that what they want is for the Web page to be about their program which they have created.

The group took it upon themselves to travel to the classroom several more times during the semester. Further, the student who was initially so worried about dealing with the students was the most frequent participant, and by the end of the semester was planning on changing her focus to at-risk students.

A two-way street. One of the striking differences between this case and the previous one is the explicit concern by the teacher-mentor for the needs of the university students. Not only did this show his support and understanding of the dual role the students were playing, but it may

have been the key factor in discouraging the consultant-client relationship that hindered the Social Studies group's sense of participatory authenticity.

As the semester progressed and the products began to come together, the students spent more and more of their time discussing their own ideas of the needs and abilities of Zappa's students, and less time asking for direction or approval. When the last project began, a slight role reversal became apparent.

> Mr. Zappa has also said that he would like to be involved with the grant writing because he wants to learn how to do it.

. . . which was followed by an unintimidated offer of assistance and resources by the students:

> Mr. Zappa, Kate mentioned that you wanted to learn more about grant writing for future reference. In our last class we spoke with some experts on the subject and received some handouts that you might find useful. Perhaps we can scan them for you, fax them, or just send you copies if you would like.

Once the grant-writing process was underway, discussion with Mr. Zappa became rare. Unlike the previous group, however, this did not reflect dissatisfaction with the amount or quality of help offered. Rather, it showed that the students were more comfortable in their own abilities as well as in their knowledge of the classroom and school for which they were requesting money.

Summary and discussion. In this case, we saw a richer negotiation process and a much smoother transition by the students between their role as members of a college class to that of workers on the periphery of the community of teachers. Key to this was their ability to avoid the consultant-client relationship with their teacher-mentor. The strong emotional connection they made to Mr. Zappa's students served to focus them on the act of being teachers responsible for the learning of a group of children; the time they spent with the students gave them confidence that they could make good decisions about what Zappa's classroom needed to help those students. The electronic posting also showed a much stronger emphasis on the part of Zappa to frame the tasks as a collaboration between himself and the student team. He expressed concern about what members of the group needed to fulfill their own course requirements, and generally took a tone that was collaborative in nature instead of the cooperative (division-of-labor) approach we saw in Lincoln's group. Thus, through collaboration and negotiation, authenticity emerged in this case.

Cross-Case Discussion

This course was designed so that the course content might be situated in authentic learning experiences, working in response to authentic community dilemmas arising from the needs of those individuals (K–12 students and teachers) that the community was designed to support. Students and teachers learned about using technology through collaborative work on the assigned projects. Although the focus of this paper was on the collaborative process and not gains on pre-post measures, it is important to briefly overview some of the exciting benefits of course participation. First, in closing interviews the professor who previously taught the course without a university–K-12 teacher collaboration indicated that student final projects this semester were superior to those completed in previous course sections. Our case studies revealed that projects evolved in relation to university students' discussions and conceptualizations of actual, not hypothesized, classroom needs, giving rise to products that embodied the university students' appreciation of the tension between creating lessons at the university and implementing them in K–12 classrooms. Many of these projects demonstrated students' competence with respect to using the technology (PowerPoint and the WWW), and their facility at instantiating various pedagogical frameworks discussed in class (anchored instruction, integrated units, problem-based learning, constructivism) into practical lessons for K–12 students. It is our belief that because these understandings were situated as part of practices occurring in actual K–12 classrooms, there will be a large impact on the continual usage and significance of what was learned: an issue to be investigated in future research.

In closing interviews cutting across all four case studies, university students summarized their experiences, emphasizing that they valued experiences working in real classrooms. One student commented, "It's real life, we're working, hands on, real needs, not just because we need to learn it. Not just another assignment. You could do it for yourself someday." Another student said, "It's geared toward actual students making something they'll like." Another student commented, "Doing the software is beneficial . . . it's easier to see what I don't want with actual class in mind." The same student commented, "[Doing the] grant is a really good experience . . . it's better to make it for an actual teacher and real class . . . it feels much more real, and you know you might be doing someone some good." Some students did, however, express that it was frustrating doing lessons, on topics they would not teach in their own future classes, "for someone else." Regardless, all students expressed that they learned the real challenges of using technology in real classrooms, and were able to put the theories discussed in class to use.

Besides university students' building a contextualized appreciation of the challenges and opportunities of integrating technology in the classroom, the collaborating teachers also improved their understanding of the potential of technology integration to impact learning. In fact, three of the four teachers discussed in the case studies are currently designing new lessons using the same software that the university students used in their class. These teachers have now developed their own Web-site pages and lessons, with all collaborating teachers stating that, since the course, they have increased the amount of technology usage in their classroom. During the course, all but one of the teachers requested copies of the primary articles that the university students were expected to read, indicating the occurrence of simultaneous renewal. Further, three of the four collaborating teachers discussed in the above case studies have continued to work with the university professors in future course iterations, and one of the teachers has successfully written and received an additional grant to integrate technology into her classroom: a task she had not undertaken previous to the course. More recently, another collaborating teacher currently teaching in Cambodia is working with the university instructor and his students to set up technology-based collaborations between her students in Cambodia and the K–12 students in Indiana.

Course participants also learned about using ACTs to collaborate with other teachers. Although the 34 students were only expected to post 2 comments a week for 9 weeks (total N = 612 postings), there were more than 1,000 postings during the course of the semester. These included specific postings related to the task at hand, but also included more general comments and concerns about integrating technology in the classroom. The K–12 teachers clearly differed in their commitment to the projects; for example, the teacher discussed in the third case study had only 9 postings while the other three teachers ranged from 21 to 43 postings. Clearly, teacher buy-in was an important issue that was not fully acknowledged in this initial course design. Future course iterations have received stronger teacher commitment by working with teachers who need continuing credits, have a strong desire for technology-related grants, or have expressed a commitment to life-long learning. We have also realized the importance of creating a virtual space for the collaborating teachers to talk with each other, affording them the opportunity to build a sense of online community with their colleagues.

CONCLUSIONS

Using the framework of legitimate peripheral participation (LPP) (Lave & Wenger, 1991), it was the instructors' intention that the course collaborations would support the university students in becoming legitimate members of the K–12 classrooms with whom they were partnering. However, unlike most conceptualizations of LPP, this class was unique in that the collaborating teachers were not truly experts under whom the students were expected to apprentice. While the cooperating teachers might be considered expert teachers, they were essentially beginners in teaching with computers. The university students were more knowledgeable, having taken

at least three university courses on computers and education, and most having grown up with computers, unlike the practicing K–12 teachers. We conclude by examining the case studies focusing on three themes: (a) authenticity with respect to communities of practice; (b) authenticity as an emergent property occurring through social negotiation; and (c) issues of power and control.

Communities of Practice and LPP

In reflecting on the findings of this study, two communities of practice that the university students participated in could be examined: (a) the university teacher education community, and (b) the community of K–12 teachers. For the purposes of this study it is useful to view these two communities as relatively distinct; membership in each community entailed different practices, and there was a different set of experts for each community. To fulfill the requirements of the university community, students completed projects for grades and fulfilled requirements for their computer endorsements. Students participated in the community of K–12 teachers through using technology to help a K–12 teacher. Not only were the university students becoming, in some cases, participants in the K–12 teaching community, but they were also helping to transform it.

Communities of practice are dynamic, open systems (see Banathy, 1991; Barab et al., 1999; Barab & Duffy, 2000; Hutchins, 1996); they constantly change as new members enter the system and existing members evolve. In this way, the community is reciprocally defined by and defines its members. In this study, university students brought skills and expertise to share with the teachers, which ultimately might change the community. In agreeing to mentor university students, the teachers were explicitly opening themselves and their classroom to change. *We see this openness and willingness to change as essential components of successful partnerships and life-long learning in general.*

Even though these preservice teachers were welcomed into the K–12 communities, and were expected to participate in the communities, the university students in this study experienced difficulty entering and viewing themselves as legitimate participants of their classroom communities. They were not automatically members of the community of teachers, because they were not teachers but education students who would one day become teachers. Unlike the apprenticeships described by Lave and Wenger (1991), where a person begins practicing a trade with the clear role of a "less-knowledgeable professional," these students were frequently considered *more* knowledgeable by the K–12 teachers (at least with respect to using the technology). Further, they were not going to become members of the particular school community that they were working with during the course. As indicated in the interview data, many of these students did not feel as if they were (even marginally) members of the community of K–12 teachers. However, visiting and participating in the classroom served as critical moments, potentially changing the student's role from that of an outsider to that of a participating member.

Authenticity Emergent Through Collaboration

Central to the perspective being forwarded in this paper was that students would participate in the development of authenticity, constructing the outcome and the tasks with the classroom teacher. It is our contention that authenticity emerges as participants engage in practices of value to themselves and to others in the community at large. Although none of these university students participated in the larger K–12 community of teachers in particularly meaningful ways, some groups did become legitimate members of their classroom communities. Again, as gleaned from the interviews and Web postings, visiting their cooperating teachers' classrooms seemed to be the most critical factor in determining to what extent students were able to become members of the classroom community. In each case, the students displayed a noticeable difference in attitude, excitement level, and perspective once they visited the classroom. In the final case study, visiting Mr. Zappa's classroom appeared to transform the students from the role of consultant toward a teacher role. In interviews, all students cited visiting the classroom as a key factor in the success of their project. By participating in legitimate social interactions, students encountered a richer learning experience with a high degree of authenticity.

This feature of student participation in the actual K–12 community by working with a real classroom appeared to have the effect of (to some degree) legitimizing the learning-doing process. In contrast, many problem-based or case-based learning environments rely solely on task authenticity; the problem parameters are established for the student and then student buy-in is established. We have discussed the differences between simulation and participation models for supporting the emergence of both task and ecological authenticity. Whereas the former has the potential to support task authenticity, doing what real-world practitioners do but in the context of the classroom, participation models are developed to support ecological authenticity in which students work in context with, and on tasks that have direct implications for, real-world practitioners. We have discussed limitations with both models in terms of establishing robust learning experiences that will be perceived as genuine to all involved. Specifically, whereas practice fields do not engage students in practices that have direct real-world use (ecological authenticity), full participation models such as apprenticeships are not practical to carry out for each course.

With respect to this course, instructors incorporated a co-evolution model for establishing both task and ecological authenticity. *We believe that working with a real K–12 classroom that valued, participated in the development, and actually used the outcome of the university students' labors allowed our learning environment to move from a practice field to an authentic learning environment with ecological validity, without requiring a full apprenticeship.* The semester-long negotiation process and resultant collaborative vision allowed for a shared authenticity that had aspects of both simulation and participation authenticity. The constraints of the project were not artificially imposed, nor did they arise solely from students' knowledge of technical issues or the experience of the cooperating teacher. Rather, the constraints and issues in constructing the Web site developed as a result of the project, from real or authentic considerations as perceived and constructed by both the students and their cooperating K–12 teachers. Difficult issues were identified, discussed, and handled by the team as a whole, each member contributing individual expertise. In this way, authenticity was not something inherent to the design of the students' course, or something imposed on them by their cooperating teachers; it arose through students designing their Web sites and interacting with their collaborating teachers.

In each case study, we see how the emergent process of negotiating tasks played a key role in defining the group's experiences. In the first case study, Little Tree and her students negotiated tasks throughout the entire semester, resulting in two very successful projects. As a result, the team members showed a high degree of ownership over the experiences, and felt that these learning experiences would be valuable to them in their future experiences. Dundee and Zappa's groups followed a similar negotiation pattern, also resulting in a high degree of participation for both the students and the cooperating teacher. Although the cooperating teacher played an active role in specifying the grant project, for both Dundee's and Zappa's groups the partnering university students took ownership over the project and indicated that the grant project was an authentic experience. In the third case study, the collaborative process was not as rich as in the others, appearing more as a cooperative process. Students did not participate in the actual classroom community in a legitimate fashion, and characterized their role in the classroom as that of consultant.

In general, these case studies indicate a degree of participation authenticity, but not in the manner of traditional apprenticeships. The tasks students engaged in were *not* already undertaken by the K–12 teachers, and they did not have years to spend as apprentices. Instead, the university students drew from their previous course work and computer experience to collaborate with the classroom teachers, supporting a co-evolutionary model of course development. In this way, both the university students and the K–12 teachers benefited from each other, sharing their respective skills to co-evolve Web sites and grants that would be of use

in a K–12 classroom. In addition to relying on previous coursework and experience, the university students also continually consulted with the course professors, who served as coaches and project facilitators. The instructors remained flexible, evolving coursework to the specific needs of the students, providing numerous just-in-time lectures on topics that were central to the work of the students. In this way, course activity was truly emergent. Although there was a preplanned syllabus, particular group needs continuously overrode any prespecified instruction. Course evaluations indicated that the continual evolution of the course curriculum was the most exciting and frustrating aspect to the course. This continually evolving course design contributed to the changing dynamics and tensions that characterized the course.

Power and Control

Complex and unique issues of power and control developed in this course as a result of extending classroom activities into communities of practice. By making K–12 teachers' classrooms the target for doing-learning (instead of creating a practice field at the university), the professors were forced to give up control over much of the learning experience, including course content, feedback, and assessment. In each case, we saw how the important factors in using technology in schools arose from the teacher's needs and were to a greater or lesser extent negotiated with students. Even though there were readings and discussions that reflected the professors' pedagogical beliefs about how technology should be used in the classroom, ultimately, how technology was conceptualized and implemented arose from interaction with the teacher. In all of these cases, there was little explicit reference to class requirements; rather, in all but the Lincoln case, the specific project requirements and constraints resulted from interactions with the mentoring teacher. In the Lincoln case, the students reacted by abandoning their mentor, and relying more heavily on their own understanding of Lincoln's classroom and on advice given by the university instructors to complete their project.

Similarly, in most groups, but particularly in the Native American group, feedback and assessment occurred by the teacher in situ. As the K–12 community expert, it was the teacher's role to determine where the projects were successful and where they needed improvement, as well as how well the projects were meeting classroom needs. Only in the social studies case, where a consultant-client role emerged between the university students and Mr. Lincoln, did feedback and assessment come primarily from the university instructor. In this case, the university students turned to their university instructor, in absentia of emergent project requirements.

In the cases where project requirements and assessment occurred by K–12 teachers and in situ, notions of grading and evaluation became problematic. Who had the right, power, and ability to assess the success of the projects? In these four cases, it became apparent that the nature of the relationship that emerged between the students and their cooperating teachers could not be prespecified. Therefore, the success of each project, which ultimately was tied to the success of the partnering teacher–university-student relationship, was highly contextualized and dependent on factors uncontrollable by the student. How much time does the partnering teacher have to spend on the project? Do the personal styles, pedagogical beliefs, and values of the group members match well to those of the partnering teacher? These are but a few of the many issues that might contribute to the success of a group. In these four cases, the professors negotiated this power with students, facilitating interactions, providing feedback, encouraging reflection, and more artificial constraints when necessary. Whenever possible, the professors did give up control over the curriculum, and allowed the K–12 classroom context to drive all phases of the instruction.

IMPLICATIONS

Within communities of practice the overall focus is on the completion of particular tasks that have a specific real-world outcome (e.g., masons want to build houses, doctors want to help people get

healthy, tailors want to make suits). In order to develop a community that is competent with respect to the community practices, it is important that less-experienced members have opportunities to learn from experts (a process characterized by Lave & Wenger, 1991, as LPP). As educators, our focus has been less on the act of participation and authentic outcomes and more on increasing the knowledge acquisition of the learner (performance on classroom assessments). As such, the value of the learning tasks is assigned to the students' learning, not authentic outcomes, and the students may or may not value such learning. Schools have developed external motivations, such as grades, and structures, such as tests, that learners can engage in to validate those tasks and indicate that learning has occurred. This process sets up an exchange value in which the value of a particular activity or understanding occurs in terms of its ability to be exchanged for something else (Barab, 1999; Barab & Landa, 1997; Lave & Wenger, 1991). This process undermines the legitimacy of activity, making practices that potentially would have task authenticity inauthentic.

We have argued that central to both the simulation and participation models of authenticity is a learning environment that can be considered authentic because of its similarity to real-world environments and real-world tasks, where the latter involves apprenticing the learner into actual, real-world environments. We have also argued that both models have limitations; the former requires transfer while the latter is difficult to implement within the confines of school. On a related note, we have argued that central to these models is the view that learning environments cannot be preauthenticated. In our design, the environment had a truly emergent component where project outcomes and requisite tasks developed through negotiation of all parties, including the university students who were the target focus for learning. It was also through this emergent process that what was considered authentic began to take shape. Therefore, we argue that authenticity is not something that can be prescribed or designed, but something that emerges (or does not emerge) from interactions that are meaningful to all participants.

In this research and design, we have described one means of supporting the emergence of a learning environment that can be authentic to both the learner participant(s) and the real-world practitioner participant(s). *This model has aspects of practice fields and apprenticeships, but while practice fields lack ecological authenticity and full apprenticeships are not practical to carry out for each course, we have found our model of teacher preparation to carry benefits of both models.* This co-evolutionary model for supporting the emergence of authenticity allows for collaboration among the learner participant(s) and the real-world practitioner participant(s) so that all parties have legitimate avenues for participation and ownership in a mutually held task that addresses a real-world need. In this study, university students explicitly benefited from becoming knowledgeably skillful at integrating technology within an authentic context. Additionally,many students benefited through working and learning with role models who, even after a decade of teaching, were continually opening themselves, and their classrooms, to change. The classroom educators benefited through a process of simultaneous renewal in which they learned from the university students. We, as university educators, can talk from universities about the importance of life-long learning, but these ideas will have a more dramatic impact when preservice teachers experience it first hand through their collaboration with in-service teachers who have chosen to embrace its spirit.

A major challenge for instructional designers is to develop learning environments that incorporate authentic tasks in realistic contexts. In some sense, authenticity can be said to be the mantra of current constructivist and situativity learning theorists. However, issues of what is authentic and how to design learning contexts that aid the learner in engaging in tasks and outcomes that are authentic are not necessarily agreed upon. The co-evolutionary model being advanced in this study does not place authenticity in the individual, the task, or in a community, but places it in the meaningful relations that connect all three. However, as evident in the third case study, our findings suggest that educators need to be more careful when espousing authen-

tic learning environments, realizing that no model of learning environment is inherently authentic in all cases. More empirical research, examining learning as it unfolds in environments designed to support authentic experience, might lead to a grounded, rather than simply theoretical, notion of authenticity, and to a clearer understanding of the nature and value of authenticity in learning environments.

In this paper we have argued that authenticity flows, or does not flow, as part of the self-organizing dynamics that are uniquely emergent when the individual becomes a member-participant of a community of practice that values the activities being learned, and that uses the outputs of these activities. We have found this emergent model of authenticity to provide a viable model for schools that is more practical than is the full participation model (apprenticeships), and has the potential to provide more realism than simulation models (practice fields). We encourage our colleagues to continue exploring issues of authenticity, and to share their experiences in supporting students in learning-doing practices that are of value to learners, designers, and to the communities of practice outside the classroom. □

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REFERENCES

Banathy B.H. (1991). *A systems view of education.* Englewood Cliffs, NJ: Educational Technology Publications.

Barab, S.A. (1999). Ecologizing instruction through integrated units. *The Middle School Journal, 30,* 21–28.

Barab, S.A., Cherkes-Julkowski, M., Swenson, R., Garrett, S., Shaw, R.E., & Young, M. (1999). Principles of self-organization: Ecologizing the learner-facilitator system. *The Journal of The Learning Sciences, 8*(3, 4), 349–390.

Barab, S.A., & Duffy, T. (2000). Architecting participatory learning environments. To appear in D. Jonassen & S. Land (Eds.), *Theoretical foundations of learning environments.* Hillsdale, NJ: Erlbaum.

Barab, S.A., & Hay, K. (in press). Doing science at the elbows of scientists: Issues related to the Scientist Apprentice Camp. To appear in the *Journal of Research on Science Teaching.*

Barab, S.A., Hay, K., & Duffy, T. (1998). Grounded constructions and how technology can help. *Technology Trends, 43*(2), 15–23.

Barab, S.A., & Kirshner, D. (in press). Introduction to the special issue: Methodologies for capturing learner practices occurring as part of dynamic learning environments. To appear in the *Journal of The Learning Sciences.*

Barab, S.A., & Landa, A. (1997). Designing interdisciplinary anchors. *Educational Leadership, 54*(6), 52–55.

Bertalanffy, L. (1952). *Problems of life.* London: Watts.

Brown, A.L., & Campione, J.C. (1990). Communities of learning and thinking, or a context by any other name. *Contributions to Human Development, 21,* 108–126.

Brown, J.S., Collins, A., & Duguid, P. (1989). Situated cognition and the culture of learning. *Educational Researcher, 18,* 32–42.

Case, C.W., Norlander, K.A., & Reagan, T.G. (1993). Cultural transformation in an urban professional development center: Policy implications for school-university collaboration. *Educational Policy, 7*(1), 40–60.

Cobb, P., & Yackel, E. (1996). Constructivist, emergent, and sociocultural perspectives in the context of developmental research. *Educational Psychologist, 31,* 175–190.

Cognition and Technology Group at Vanderbilt. (1990). Anchored instruction and its relationship to situated cognition. *Educational Researcher, 19,* 2–10.

Cognition and Technology Group at Vanderbilt. (1993). Anchored Instruction and situated cognition revisited. *Educational Technology, 33,* 52–70.

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: Erlbaum.

Dewey, J. (1897). My pedagogical creed. *The School Journal, 543,* 77–80.

Dewey, J. (1963). *Experience & education.* New York: Collier MacMillan. (Original work published 1938)

Duffy, T.M., & Jonassen, D.H. (1992). Constructivism: New implications for instructional technology. In T. Duffy & D. Jonassen (Eds.), *Constructivism and the technology of instruction* (pp. 1–16). Hillsdale, NJ: Erlbaum.

Duffy, T.M. , Lowyck, J., & Jonassen, D.H. (Eds.), (1992). *Designing environments for constructivist learning.* New York, NY: Springer-Verlag.

Edwards, L.D. (1995). The design and analysis of a mathematical microworld. *Journal of Educational Computing Research, 12,* 77–94.

Engestrom, 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: Perspectives on activity and context* (pp. 64–103). New York: Cambridge University Press.

Evenson, D.H., & Hmelo, C.E. (Eds.). (in press). *Problem-based learning: A research perspective on learning interactions.* Mahway, NJ: Erlbaum.

Fodor, J. (1980). *Language of thought.* Cambridge, MA: Harvard University Press.

Gardner, H. (1985). *The mind's new science.* New York: Basic Books.

Gibson, J.J. (1986). *The ecological approach to visual perception.* Hilisdale, NJ: Lawrence Eribaum Associates, Inc.

Glaser, B.G., & Strauss, A.L. (1967). *The discovery of grounded theory.* Hawthorne, NY: Aldine.

Green, K.C., & Gilbert, S.W. (1995). Great expectations. *Change: The Magazine of Higher Learning, 27*(2), 8–18.

Greeno, J. (1998). The situativity of knowing, learning, and research. *American Psychologist, 53,* 5–26.

Greeno, J.G. (1997). Response: On claims that answer the wrong questions. *Educational Researcher, 36,* 5–17.

Guba, E.G., & Lincoln, Y.S. (1983). Epistemological and methodological bases of naturalistic inquiry. In G.F. Madaus, M.S. Scriven., and D.L. Stufflebeam (Eds.), *Evaluation models: Viewpoints on educational and human services evaluation* (pp. 311–334). Boston, MA: Kluwer-Nijhoff Publishing.

Hannafin, M.J., Hall, C., Land, S.M., & Hill, J.R. (1994). Learning in open-ended environments: Assumptions, methods, and implications. *Educational Technology, 34,* 48–55.

Heath, S.B., & McLaughlin, M.W. (1994). The best of both worlds: Connecting schools and community youth organizations for all-day, all-year learning. *Educational Administration Quarterly; 30*(3), 278–300.

Hmelo, C., & Evensen, D. (Eds.), (in press). *Problem-based learning: Gaining insights on learning interactions through multiple methods of inquiry.* Mahwah, NJ: Lawrence Eribaum Associates, Inc.

Hutchins, C.L. (1996). *Systemic thinking: Solving complex problems.* Aurora, CO: Professional Development Systems.

Hutchins, E. (1993). Learning to navigate. In S. Chaiklin & J. Lave (Eds.), *Understanding practice* (pp. 35–63). New York: Cambridge University Press.

Kelso, S. (1995). *Dynamic patterns: The self-organization of brain and behavior.* Cambridge, MA: The MIT Press.

Kirshner, D., & Whitson, J.A. (Eds.). (1997). *Situated cognition: Social, semiotic, and psychological perspectives.* Mahwah, NJ: Erlbaum.

Kirshner, D., & Whitson, J.A. (1998). Obstacles to understanding cognition as situated. *Educational Researcher, 27*(8), 22–28.d

Knorr-Cetina, K.D. (1981). *The manufacture of knowledge: An essay on the constructivist and contextual nature of science.* Oxford, England: Pergamon.

Kommers, P.A.M., Grabinger, R.S., and Dunlap J.C. (Eds.). (1996). *Hypermedia learning environments: instructional design and integration.* Mahwah, NJ: Lawrence Erlbaum Associates, Inc.

Koschmann, T. (Ed.). (1996). *CSCL: Theory and practice of an emerging paradigm.* Malwah, NJ: Erlbaum.

Koschmann, T., Kelson, A.C., Feltovich, P.J., & Barrows, H.S. (1996). Computer-supported problem-based learning: A principled approach to the use of computers in collaborative learning. In T. Koschmann (Ed.) *CSCL: Theory and practice of an emerging paradigm* (pp. 83–124). Mahwah, NJ: Lawrence Erlbaum Associates, Inc.

Lampert, M. (1990). When the problem is not the question and the solution is not the answer: Mathematical knowing and teaching. *American Educational Research Journal, 27,* 29–63.

Latour, B. (1987). *Science in action: How to follow scientists and engineers through society.* Milton Keynes, England: Open University Press.

Lave, J. (1988). *Cognition in practice: Mind, mathematics and culture in everyday life.* Cambridge: Cambridge University Press.

Lave, J. (1993). Situating learning in communities of practice. In L.B. Resnick, J.M. Levine, & S.D. Teasley (Eds.), *Perspectives on socially shared cognition* (pp. 17–36). Washington, DC: American Psychological Association.

Lave, J. (1997). The culture of acquisition and the practice of understanding. In D. Kirshner & J.A. Whitson (Eds.), *Situated cognition: Social, semiotic, and psychological perspectives* (pp. 63–82). Mahwah, NJ: Erlbaum.

Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation.* New York: Cambridge University Press.

Levin, J.A., Riel, M., Miyake, N., & Cohen, M. (1987). Education on the electronic frontier: Teleapprenticeships in globally distributed educational contexts. *Contemporary Educational Psychology, 12,* 254–260.

Lincoln Y.S., & Guba, E.G. (1985). *Naturalistic inquiry.* Newbury Park, CA: Sage.

Milter, R.G., & Stinson, J.E. (1995). Educating leaders for the new competitive environment. In Gijselaers, G., Tempelaar, S., Keizer S. (Eds.), *Educational innovation in economics and business administration: The case of problem-based learning.* London: Kluwer Academic Publishers.

Nicaise, M., & Barnes, D. (1996). The union of technology, constructivism, and teacher education. *Journal of Teacher Education, 47,* 205–212.

Petraglia, J. (1998). *Reality by design: The rhetoric and technology of authenticity in education.* Mahwah, NJ: Erlbaum.

Petrie, H.G. (Ed.). (1995). *Professionalization, partnership, and power: Building professional development schools.* Albany, NY: SUNY Press.

Prigogine, I. (1978). Time, structure, and fluctuations. *Science, 201,* 777–785.

Prigogine, I., & Stengers, I. (1984). *Order out of chaos: Man's dialogue with nature.* New York: Bantam.

Radinsky, J. Bouillion, L., Hanson, K., Gomez, L., Vemeer, D., & Fishman, B. (1998, April). *A framework for authenticity: Mutual benefits partnerships.* Paper presented at the annual meeting of the American Educational Research Association.

Resnick, L.B. (1987). Learning in school and out. *Educa-*

tional Researcher, 16, 13–20.

Richardson-Koehler, V. (1988). Barriers to effective supervision of student teaching. *Journal of Teacher Education, 39,* 28–34.

Rogoff, B., & Lave, J. (1984). *Everyday cognition: Its development in social context.* Cambridge, MA: Harvard University Press.

Roth, W.-M. (1995). Knowledge diffusion in a grade 4–5 classroom during a unit of civil engineering: An analysis of a classroom community in terms of its changing resources and practices. *Cognition and Instruction, 14,* 170–220.

Roth, W.-M. (1998). *Designing communities.* Dordrecht: Kluwer Academic Publishers.

Roth, W.-M., & Bowen, G.M. (1996). Knowing and interacting: A study of culture, practices, and resources in a grade 8 open-inquiry science classroom guided by a cognitive apprenticeship metaphor. *Cognition and Instruction, 13,* 73–128.

Savery, J., & Duffy, T. (1996). Problem based learning: An instructional model and its constructivist framework. In B. Wilson (Ed.), *Constructivist learning environments: Case studies in instructional design* (pp. 135–148). Englewood Cliffs, NJ: Educational Technology Publications.

Scardamalia, M., & Bereiter, C. (1994). Computer support for knowledge-building communities. *The Journal of The Learning Sciences, 3,* 265–283.

Schoenfeld, A. (1996). In fostering communities of inquiry, must it matter that the teacher knows the "answer"? *For the Learning of Mathematics, 16*(3), 11–16.

Schrum, L., & Dehoney, J. (1998). Meeting the future: A teacher educational program joins the information age. *Journal of Technology and Teacher Education, 6*(1), 23–37.

Scriven, M.S. (1983). Evaluation methodologies. In G.F. Madaus, M.S. Scriven., and D.L. Stufflebeam (Eds.), *Evaluation models: Viewpoints on educational and human services evaluation* (pp. 229–260). Boston, MA: Kluwer-Nijhoff Publishing.

Senge, P. (1994). *The Fifth discipline fieldbook: Strategies and tools for building a learning organization.* New York: Doubleday.

Siegel, J. (1995). The state of teacher training: The results of the first national survey of technology staff development in schools. *Electronic Learning, 14*(8), 43–53.

Sloffer, S.J., Dueber, B., & Duffy, T.M. (1999, January). Using asynchronous conferencing to promote critical thinking: Two implementations in higher education. *Proceedings of the 32nd Hawaii International Conference on System Sciences,* Maui, Hawaii.

Swenson, R. (1996). *Spontaneous order, evolution, and natural law: An introduction to the physical basis for an ecological psychology.* Hillsdale, NJ: Lawrence Erlbaum and Associates.

Swenson, R. (1997a). Thermodynamics and evolution. In G. Greenberg and M. Haraway (Eds.), *Handbook of comparative psychology* (pp. 217–228). Garland Publishing, NY.

Swenson, R. (1997b). Autocatakinetics, evolution, and the law of maximum entropy production: A principled foundation toward the study of human ecology. In Lee Freese (Ed.), *Advances in human ecology, Vol. 6* (pp. 1–46). Greenwich, CT.

Vera, A.H., & Simon, H.A. (1993). Situated action: A symbolic interpretation. *Cognitive Science, 17,* 7–9.

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

Whitehead, A.N. (1929). *The aims of education and other essays.* New York: MacMillan.

Wilson, B. (Ed.), (1996). *Constructivist learning environments: Case studies in instructional design.* Englewood Cliffs, NJ: Educational Technology Publications.

Young, M.F., Kulikowich, J.M., & Barab, S.A. (1997). The unit of analysis for situated assessment. *Instructional Science, 25,* 133–150.

Zammit, S.A. (1992). Factors facilitating or hindering the use of computers in schools. *Educational Research, 34*(1), 57–66.