

# Designing System Dualities: Characterizing a Web-Supported Professional Development Community

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In this article we focus on the challenges we have encountered in attempting to support the development of an online community of practice for grade 5–12 mathematics and science teachers. Specifically, this project involves the design and evaluation of an electronic knowledge network, the Inquiry Learning Forum (ILF), a web-based professional development system designed to support a community of practice (CoP) of in-service and preservice mathematics and science teachers who are creating, reflecting upon, sharing, and improving inquiry-based pedagogical practices. This research examines the interplay among a variety of variables that characterize the dynamics of building a social network through which participating teachers will seek to share and improve their pedagogical practices. Our research suggests that designing for virtual communities involves balancing and leveraging complex dualities from the “inside” rather than applying some set of design principles from the “outside.” This research provides an illuminative case study from which others can more readily identify patterns occurring in their own interventions and navigate the challenges they face more intelligently.

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**Keywords** design dualities, online community, participatory design, sociability

The advent of cyberspace is apt to be seen in two ways, each of which can be regretted or welcomed, either as a new stage in the etherealization of the world we live in, the real world of people and things and places, or, conversely, as a new stage in the concretization of the world we dream and think in, the world of abstractions, memory and knowledge. (Benedikt, 1991, p. 124)

The idea of “virtual communities” has captured popular, as well as scholarly, attention. Numerous websites and dot.com companies advertise their “online communities.” In hundreds of books and articles, “virtual communities” are championed by educators, cognitive scientists, sociologists, anthropologists, computer scientists, and even CEOs (chief executive officers). This outpouring of interest takes place in an America that is increasingly concerned about the loss of face-to-face community (Putnam, 2001). Advocates of online communities hope that by leveraging technology, they can recreate a “we” that has steadily eroded into many isolated “I’s.” There is confusion, though, about the definition of a virtual community, which includes anything from a tight-knit group of people who share important parts of their lives on a day-to-day basis to an amorphous chat group that can be joined (and left) by anyone with a valid password. Many

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Received 3 January 2002; accepted 29 December 2002.

This material is based upon work supported by the National Science Foundation under grant 9980081 and grant 0092831.

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educators are participating in this movement as well, exploring the educational value of employing a “community” model for supporting learning. The idea is that through participating in a community, novices can learn through collaboration with others and by working alongside more experienced members. Much like in an apprenticeship, newcomers work with “old-timers,” then gradually begin to adopt the practices of the community. This social view of learning involves whole persons, and treats learning as a process of constructing practice, meaning, and identity all in relation to a community of practice (Lave & Wenger, 1991; Wenger, 1998).

Lave and Wenger (1991) advanced the term *community of practice* (CoP) to capture the importance of activity in fusing individuals to communities, and of communities in legitimizing individual practices. Within the context of CoPs, learning is conceived as a trajectory in which learners move from legitimate peripheral participants to core participants of a community of practice. Barab and Duffy (2000) discussed a CoP as a collection of individuals sharing mutually defined practices, beliefs, and understandings over an extended time frame in the pursuit of a shared enterprise. They discussed a CoP as having the following four characteristics: (1) shared knowledge, values, and beliefs; (2) overlapping histories among members; (3) mutual interdependence; and (4) mechanisms for reproduction. Barab (2001) elaborated on this list, suggesting that CoPs also include: (5) a common practice and/or mutual enterprise; (6) opportunities for interactions and participation; (7) meaningful relationships; and (8) respect for diverse perspectives and minority views. Many of these ideas are based on the work of Wenger (1998); however, despite his intense focus on understanding CoPs and the theoretical commitments behind this lens, he does not provide an operational definition for a CoP within this book.

One example of an educational community of practice is a Community of Teachers, a professional development program at Indiana University for preservice teachers working towards teacher certification (Barab & Duffy, 2000; Barab, Barnett, & Squire, 2002). It is highly field based, with each participant being expected to commit to one school where he or she will do all her fieldwork. Preservice teachers are not assigned to a teacher, but rather, spend time visiting the classes of and talking with teachers who are a part of the program. An apprenticeship relation is formed with one of the teachers based on a social negotiation and a mutual determination that the relationship will be beneficial. Hence, each student is paired with an “old-timer” in the first year in the program and continues to work with him or her for the duration. Similarly, each student negotiates membership in a community of students who are studying to be teachers. Students join an ongoing community and remain a part of that community

for the duration of their study. Students in the community attend seminars together and, as with any community, there are wizened old-timers (seniors/students with teaching experience), newcomers (sophomores), and levels between, mixed together in a common endeavor.

In the Community of Teachers program, students are continually negotiating goals and meanings of the community as well as the profession (Barab, Barnett, & Squire, 2002). Further, there is a growing collection of personal narratives that come to embody the canonical practices of the community, and students have developed a shared language to describe particular group practices. The community has a tradition and heritage at Indiana University that captures much of the community’s understandings. This heritage is continually developed and inherited by members as they become a part of the community program. The community also has a trajectory that extends across multiple classrooms and multiple occasions. Individuals view themselves as becoming a part of the community as well as the communities (those formed by in-service teachers) for which the project is nested. Lastly, the community continually reproduces itself as “rolling cohorts” cycle from newcomers to grizzled veterans.

More generally, based on a review of the literature and our previous work, we define a CoP as *a persistent, sustained social network of individuals who share and develop an overlapping knowledge base, set of beliefs, values, history and experiences focused on a common practice and/or mutual enterprise*. CoPs have histories, cultural identities, interdependence among members, and mechanisms for reproduction (Lave & Wenger, 1991). The important point is not whether another researcher can add or delete indicators from the list, or produce a different definition, but the acknowledgment that CoPs are more than a temporary coming together of individuals around a particular goal, for a workshop, or for a course (see Riel & Polin’s discussion, this issue). Much like a living organism, they are self-organizing, and cannot be designed *prima facie*. They grow, evolve, and change dynamically, transcending any particular member and outliving any particular task.

A central conviction underlying the CoP conception is that learning is a social process that involves building connections: connections between what is being learned and what is important to the learner, connections between what is being learned and those situations in which it is applied, and connections between the learner and other learners with similar goals (Barab, 1999; Barab et al., 1999; Lave, 1997; Lemke, 1997). The CoP model supports learners in collaboratively working with others who have similar goals of building a community context that best supports their needs and stimulates them in their learning trajectory (Rogoff, 1990; Roth, 1998; Scardamalia & Bereiter, 1993). While CoPs do not necessarily result in positive outcomes

for members (see Schwen & Hara, this issue), Westheimer (1998) suggests that the anticipated effects of CoP membership for individuals include “a sense of identity and belonging, affirmation, commitment to the group, strong bonds, and the development of both common purposes and collective responsibility” (p. 12). The community-based approach to learning has enormous theoretical and practical potential, but it is imperative that these environments be studied empirically.

Recently, several books have been published about online communities. Some of the topics covered are designing and building of online communities (Kim, 2000; Preece, 2000), researching online communities (Hakken, 1999; Jones, 1999; Smith & Kollock, 1999), supporting online communities (Collison et al., 2000), and the impact of online communities on other institutions (Werry & Mowbray, 2001). These books cover a wide array of topics that are important to those dealing with online communities in their entire developmental cycles. From this proliferation of books we can correctly assume an urgent interest in online communities. Some of the recurring topics in these books are the differences between online and copresent communities. Building and maintaining online communities involves the design and manipulation of technologies in ways that foster human connection (Barab et al., 2001; Kim, 2000; Preece, 2000; Schlager et al., 2002). Indeed, online communities face all the challenges of copresent communities with the additional challenges added by the technologies and by the physical distancing these technologies both permit and cause.

In this article we focus on the challenges we have encountered in attempting to support the development of an online community of practice for grade 5–12 mathematics and science teachers. Specifically, this project involves the design and evaluation of an electronic knowledge network, the Inquiry Learning Forum (ILF), a web-based professional development system designed to support a CoP of in-service and preservice mathematics and science teachers who are creating, reflecting upon, sharing, and improving inquiry-based pedagogical practices (see <http://ilf.crlt.indiana.edu>). A central research goal of our work has been to understand the design principles for fostering, sustaining, and scaling a CoP in which the value of sharing one’s practice and engaging in the dialogue outweighs the “costs” of participation. While the effective use of technology in supporting a CoP provides one focus, it is clear that technological structures are only one component of an overall strategy (Preece, 2000; Ruopp et al., 1993). Thus, our research examines the interplay among a variety of variables that characterize the dynamics of building a social network through which participating teachers will seek to share and improve their pedagogical practices.

Our analytical lens for understanding design decisions and emergent happenings consists of initially identify-

ing system *tensions* (Engeström, 1987), or what Wenger (1998) referred to as *dualities*. Tensions, or dualities, refer to overlapping yet conflicting activities and needs that drive the dynamics of the system (Engeström, 1987). Engeström (1999) viewed tensions as characterizing system activity and driving system innovation, and Wenger (1998) similarly discussed the importance of understanding the design of community in terms of the interplay among four sets of system dualities. Within this chapter, we interpret our data and experiences in terms of the core dualities that were identified by Wenger (1998) as characterizing community dynamics and design, as well as the additional two dualities of face-to-face versus online participation and encouraging community cohesion versus supporting diversity. By characterizing community life in terms of dualities, we hope to provide other educators/designers with an illuminative case study from which they can build what Stake (1983, 1985) referred to as “petite generalizations”—that is, use this discussion to more readily identify patterns occurring in their own interventions and navigate the challenges they face more intelligently (Barab, Barnett, Yamagata-Lynch et al., 2002).

## ANALYTICAL TOOLS FOR CHARACTERIZING COMMUNITY

Traditionally, at least in anthropological circles, ethnography is the common methodological technique for understanding community life (Marcus, 1998). Building an ethnography involves extended engagement with the community being researched, collecting field notes, locating and interviewing informants, examining artifacts, and interviewing community members, frequently as a participant observer (Emerson et al., 1995). Our role as code-signers in this project complicates our roles as researchers, in that at the same time as we are building a thick description of community life, we are also positioned in a role where we have a clear and invested agenda to provide service to that community.<sup>1</sup> Once the data are collected, the researcher sifts through the data, frequently creating descriptive codes and building larger interpretive categories from which themes and patterns are identified. Using this process, the ethnographer can then give a “grounded” and “thick” description of community life (Geertz, 1983; Marcus, 1998). However, there is also an advantage to qualitative research that makes a commitment to an analytical framework that then both guides observations and provides a useful lens through which the data can be interpreted (Schwandt, 1997). When there is a well-documented literature base, having a preexisting analytical lens is especially useful for researchers who are also designers of the work. For researcher-designers, such a lens can serve both an evaluative function while at the same time guiding design.

We approach our design and research as a series of “design experiments” (Brown, 1992). This process involves carrying out design work, conducting research on its implementation, cycling what we are learning into future design iterations, and then again examining how these innovations impact the learning process. In addition, over the course of our design/research work we have come to adopt two theoretical frameworks that are central to our work and that structure the reporting of the data in this paper. First is the notion of sociotechnical interaction networks (STINS) (Kling et al., 2001), and second is to conceive communities as being characterized by tensions or dualities.

The STIN model, developed by Kling et al. (2001), focuses on the interactions between social and technical, with technology-in-use and the social world viewed as coconstitutive. The concept of STIN highlights the interaction of people and technologies, but encompasses the actors, artifacts, interactions, resources, technologies, and relationships among participants both inside and outside the community. Interactions and activities in any one part of the STIN, and even outside the STIN, may affect interactions elsewhere. When analyzing the evolution of a STIN, one looks at resource dependencies (between actors, between actors and artifacts, and between artifacts) and account taking (other actors or STINS that participants seek to emulate or not emulate in their behavior). Instead of focusing on the most obvious pieces of the online community (the web site or, in our case, what we call the electronic-ILF), we gain a powerful insight into the complexity of online communities by examining interactions among all of the features within the STIN framework. It was the adoption of the STIN framework that shifted our thinking as designers from a focus on usability issues to sociability issues (Preece, 2000), and as researchers we began to conceptualize the ILF as more than the electronic-ILF (e-ILF) (Barab, MaKinster et al., 2001).

The second framework we adopted had to do with an acknowledgement of understanding design/use practices in terms of core dualities (Barab & Schatz, in press; Engeström, 1987; Wenger, 1998). These dualities refer to core struggles that are endemic to system activity and that characterize the design struggles of such a system within these dualities. Engeström (1999), whose work is grounded in Activity Theory,<sup>2</sup> described tensions as characterizing system activity and driving system innovation. In our own work examining learning environments and copresent communities, we have found tensions to be a useful analytical principle to characterize participant behavior (Barab, Barnett, & Squire, 2002; Barab, Barnett, Yamagata-Lynch et al., 2002). Wenger (1998) similarly discussed the utility of understanding community in terms of the interplay of system dualities. He views a duality as a “single conceptual unit that is formed by two inseparable and mutually constitutive elements whose inher-

ent tensions and complementarity give the concept richness and dynamism” (p. 66). Although both sides of a duality are considered separate units, the effective functioning of one pole (e.g., participation) of a duality necessitates and is dependent on the existence of the other (e.g., reification) (Shaw et al., 1992). As such, while the term *duality* implies two separate units, in terms of their usefulness for design, the term also acknowledges their simultaneous bond. That is, while the analytical lens of dualities provides a useful framework for characterizing community dynamics, their usefulness in terms of a design/research framework lies in uncovering the system dynamics and understanding how the interplay between both sides of the duality (as well as among dualities) contributes to community life. Wenger (1998) describes four dualities as being central to understanding community life: participation/reification; designed/emergent; local/global; and identification/negotiation. Given that our community exists, in part, online, we have added the additional tensions of online/face-to-face, and given our commitment to empowerment of all teachers we have added the coherence/diversity tension as well. It is these six dualities that guided our data collection, data interpretations, and the body of this article.

## THE INQUIRY LEARNING FORUM

This ILF is designed to support a virtual community of in-service and preservice mathematics and science teachers sharing, improving, and creating inquiry-based, pedagogical practices (register or take a tour at: <http://ilf.crlt.indiana.edu/>). Founded in our previous research and consistent with our pedagogical commitment (Barab & Duffy, 2000; Chaney-Cullen & Duffy, 1998), we have designed the ILF with the belief that teachers need to be full participants in and owners of *their* virtual space. Specifically, four design principles guided our design.

1. *Foster ownership and participation.* We believe that a truly effective professional development environment must include a community of professional practitioners with varied experiences and skills who accept responsibility for building and maintaining *their* environment.
2. *Focus on inquiry.* Our goal is to foster inquiry, in terms of both inquiry pedagogy in the classroom and teacher inquiry into his or her own practices.
3. *Visit the classroom.* A central strategy in the design and implementation of our knowledge network is the use of video streaming and web-based technologies to situate participants in the social context of other community members' teaching practice.
4. *Support communities of purpose.* We hope to bring together and support groups of teachers organized

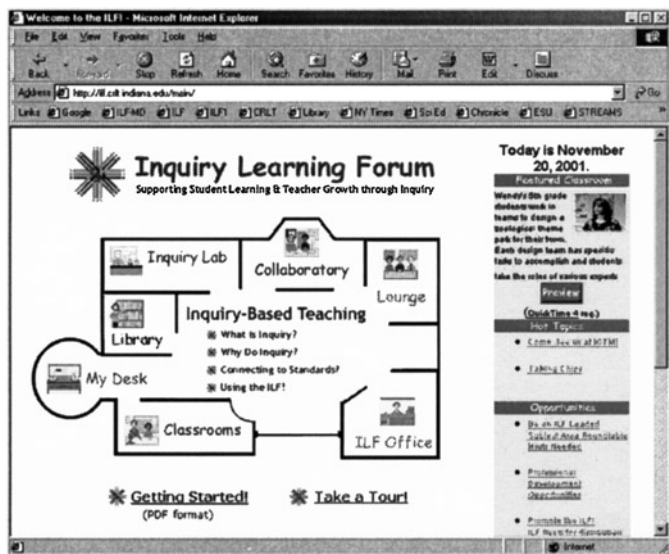


FIG. 1. Current iteration of the ILF home screen, consisting of links to the *Visit Classrooms*, *ILF Office*, *Collaboratory*, *Lounge*, *Library*, *Auditorium*, and *My Desk*.

around some collective experience and/or curricular interest.

The hallmark of this environment is that teachers with a broad range of experiences and expertise come together in a virtual space to observe, discuss, and reflect upon pedagogical theory and practice anchored to video-based teaching vignettes.

The ILF consists of a variety of participant structures, all related to encouraging online dialogue and collaboration. One of the primary areas of interest is the ILF Classrooms that enable ILF members to virtually visit the classrooms of other teachers. The home screen of the ILF is shown in Figure 1, in which the classrooms are available through the *Classrooms* space. When ILF members select a specific classroom lesson, they can watch seven or eight video segments of the implemented lesson. Additionally, they can view an overview of the lesson, reflective commentary from the teachers, descriptions of teaching activity, lesson plans, student examples, and connections to both state and national standards (see Figure 2).

The other primary area of interest in the ILF is the *Collaboratory*. The ILF Collaboratory is a space in which groups of teachers can come together in an online space around some collective experience and/or curricular interest. Each group within the Collaboratory is referred to as an Inquiry Circle (Figure 3) and the contents of the Inquiry Circle are visible only to its members. An Inquiry Circle can be a group of members who are part of a class, workshop, or share a similar curricular interest. Currently there are in the ILF Collaboratory 39 Inquiry Circles that range in focus from elementary science methods classes from 4

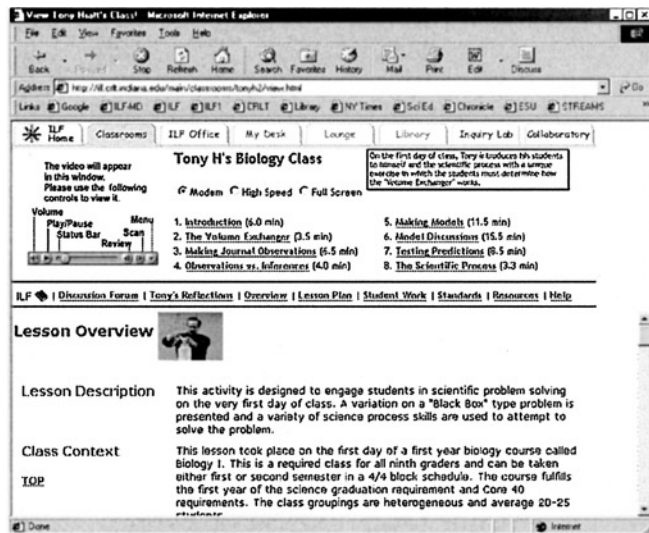


FIG. 2. Current iteration of a specific *Classroom*, including links to an overview of the lesson, reflective commentary, descriptions of teaching activity, lesson plans, student examples, and connections to both state and national standards.

different universities, a group of middle and high school science teachers who participated in a summer workshop on teaching science through inquiry, and teachers who use water ecology and water quality as a focus in their classroom. The important point is that there is a common purpose of the group, whether it be a class focus, a workshop focus, or a topic focus. Each Inquiry Circle space enables

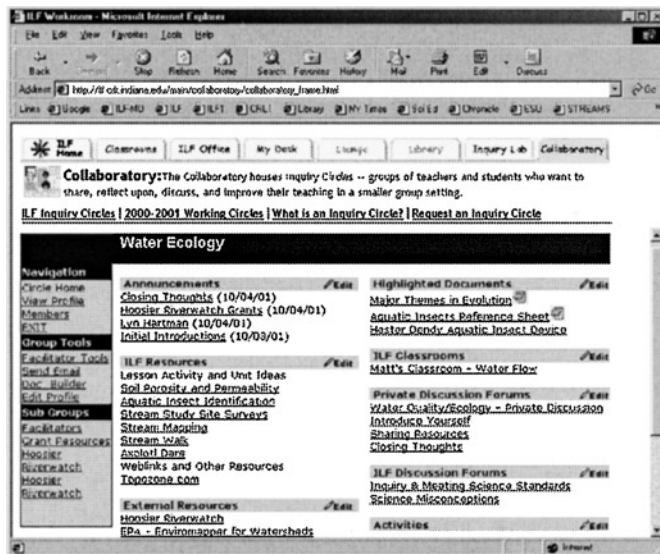


FIG. 3. Current iteration of an ILF Inquiry Circle (Water Ecology). The sections within an inquiry circle include *Announcements*, *Highlighted Documents*, *External Resources*, *ILF Resources*, *ILF Classrooms*, *ILF Discussion Forums*, *Private Discussion Forums*, and *Activities*.

teachers to (a) organize the ILF classrooms, resources, and create discussion forums that are of interest to this group, (b) share announcements, ideas, web links, and electronic documents, (c) collaboratively create and edit documents, and (d) organize the efforts and interests of this group as they use this space as a way to keep in touch. The Inquiry Circles allow for smaller subgroups to collaborate (membership is determined by the facilitator) and gives members control of adding documents, discussion threads, web resources, and other ILF resources without having to contact an ILF staff member.

In addition to the *Classroom* and *Collaboratory* spaces, there are also four other virtual spaces designed to support the professional development needs of ILF teachers. The *ILF Office* is the place where new participants can secure a password (the site is password protected), get help with technology, or make suggestions. The *Lounge* contains general asynchronous discussion forums that are not tied to a particular classroom. The *Inquiry Lab* entails a series of professional development activities that members can use to address their current professional development needs. ILF Labs are based on the Concerns-Based Adoption Model, commonly referred to as CBAM (Hall, 1979). This model of teacher change suggests that teachers go through various stages of change characterized by different concerns they have regarding a particular change or innovation. Our Professional Development Labs are organized around these stages and the types of concerns teachers have at each stage. Teachers can go to the *Library* to access resources and reference materials, including teaching resource materials (software, other classroom artifacts like the graphing calculator, manipulatives, sensory probes), state and national standards, grants, applied research and theory, relevant state initiatives, and other materials the ILF teachers identify as relevant. Finally, *My Desk* is the teacher's "office" (since entry into ILF is password protected, the office is that of the person who logged in) in which he or she can store bookmarks to resources and classrooms that are of personal relevance and return to those at a later visit. The owner can also maintain a journal that he or she can later e-mail to any ILF member, a feature that has been especially useful in preservice classes.

## CORE DUALITIES

### Designed/Emergent

A core challenge in fostering a CoP is to manage the interplay between the designed and the emergent (Wenger, 1998). At one level, Wenger's (1998) argument is that community cannot be designed; however, at another level he attempts to provide educators with a conceptual and architectural framework for facilitating the development and perpetuation of CoPs. In addition, as has been known in the systems design literature, there is an inherent uncer-

tainty between design and its realization in practice. In terms of designing a CoP, as opposed to a simple computer program, the challenges of bridging design and use are further complicated because "no community can fully design the learning of another . . . [however] no community can fully design its own learning" (Wenger, 1998, p. 234). Communities, in a very real sense, are self-organizing, emerging in response to local conditions and the needs of their users (Barab et al., 1999). The challenge for designers is to not overdesign but instead work to accomplish what Wenger (1998) referred to as a "minimalist design." The idea behind a minimalist design is to create a tentative platform and then facilitate the community in growing and evolving its own space, a process that involves walking the tightrope between designing the community and allowing it to emerge from the needs and agendas of its members.

While working toward a minimalist design, one of the first challenges is to determine what constitutes minimalist design. We wanted the space to evolve based on teacher participation and individual negotiation while at the same time retaining some sense of an identity. As in the development of any web site or piece of software, we began with a needs analysis in which we talked with teachers about what they wanted (MaKinster et al., 2001). The design then began in earnest with the university team mocking up a website based on a school metaphor. Despite our best intentions (including usability tests), this first iteration of the ILF took a production path that was likely to cause problems of overdesign. The design team was proud of their production and, consistent with notions of participatory design, we even worked with our users in developing the site, but unfortunately this early conception of the e-ILF was heavily critiqued by the Teacher Advisory Board. An interview with one of the designers revealed the state of the project at that time.

There's always a tension between over designing something, rather than doing some minimal stuff and seeing what happens. I think in the first iteration of this we tried to do too much. We tried to anticipate what teachers would think. What the teachers told us was "that's confusing, we don't need all that. First thing you should be able to do is go right to those classrooms." That's where the heart of it is. It became more user-centered. We got our design slapped. In a project where there's a lot of talented designers there's always this need to design. Sometimes you worry about over designing vs. letting the participants in the community decide what the site ought to be. (Cunningham, interview, 2/15/00).

The teachers unanimously expressed that the current virtual hallway look of the system was too complicated, and they wanted something very simple. They wanted an interface that would allow them to obtain the information that they wanted in a single click.

It was at this time that the design team became more aware of the clear divide between the design team and

the contributing teachers (whose classrooms were being videotaped and digitized so there would be some initial classrooms to visit on the ILF). At one meeting, the project teacher liaison expressed, with discomfort: “I feel like a funnel, with all comments coming through me. I am the go-between, talking to teachers and telling you all and then talking to you all and telling the teachers” (Haas, Field Note, 2/23/00). With this rocky start, we began to work more closely with a subset of teachers from our Teacher Advisory Board. The feeling was that if we simply included more members from our target population we could design the “correct” framework. Over the next couple of months the design team developed a site that was usable by teachers, but did not necessarily support social interactions.

It was at this period, 6 months into the project, that one of the co-principal investigators shared his paper regarding sociotechnical interaction networks (Kling et al., 2001). At design and research meetings, earnest discussions began about better understanding the social issues as opposed to simply technical issues of participation. A distinction occurred between the larger ILF community and the web site, which was now referred to as the electronic-ILF (e-ILF). One design team member commented, “I was gone for a couple of weeks and when I came back, everyone was talking about the e-ILF and I wasn’t sure if this was something new, or a new label, or what” (Moore, Interview, 4/25/00). Additionally, another team member returned from an academic conference where he had heard the distinction between usability and sociability (Preece, 2000). A greater acknowledgment of the social component of online community brought a shift in the thinking of the design team. This shift changed the focus from supporting human–computer interactions to supporting human–human interactions as mediated by computer interactions (Barab, 2002; Nardi, 1996). Additionally, there was a growing appreciation within the design team that sociability could not necessarily be designed, only supported.

Elsewhere we discuss the resultant changes (Barab et al., 2001), some of which were in the e-ILF and some of which had to do with interactions fostered outside the e-ILF. The important point is that even with participatory design, the current iteration of the e-ILF and our conception of the ILF as a STIN have evolved over time. This project is a design experiment and, as such, we have continually supported the emergence of the ILF based on a cycle of design, research, and redesign. This responsive type design, while allowing for community member input, has in some sense kept primary ownership in the university team’s hands. An interesting phenomenon occurred when a classroom teacher suggested he would like to start and moderate a new discussion topic in the ILF lounge. During that semester, that forum (Useless Math) became the most active and

potentially interesting of the lounge discussions; all the others had been initiated by the university designers. This suggests that emergent topics introduced by teachers may prove more meaningful to community members than those predesigned or formatted by the developers.

As stated earlier, while we cannot expect to fully design the learning space for the teachers successfully, they cannot be expected to fully design their own space either. The challenges of being university designers with a reform agenda has meant that the identity of the site, with its need for prolonged engagement of the user, has in some ways been at odds with the needs of teachers who frequently simply want a place to acquire lesson ideas that can be used the following day (this issue is discussed more fully later in the other dualities). The design challenge is to understand the interplay among these multiple agendas and to support a space that meets both needs and agendas. We initially chose to build a space and then work with teachers to modify it so that it would better meet their needs. It is our current realization that this may have resulted in overdesign in that we developed a large and complex space that may often appear daunting to the user. Due to the lack of exit costs and perceived gains, it is much easier to simply log off of the ILF than to grapple with the complexity with the expectation of some long-term payoff.

Given the challenges of fostering sustained participation and the importance of local support, we believe that a more bottom-up approach in which we developed trust and community support first might be a more effective design trajectory when attempting to foster an online CoP where the practices being fostered (i.e., critical dialogue among teachers, inquiry-based teaching, ongoing interactions online) are somewhat inconsistent with the current culture. Toward this end, we have been working to develop bounded “communities of purpose” (Schagler & Fusco, 2001). These bounded groups have a shared agenda and interest in terms of a particular project or curricular unit (e.g., create a water quality curriculum). We are providing these groups with a semi-private online space that is customized to address their local needs.

Consistent with Barab, Squire, and Dueber’s (2000) co-evolutionary model, we view the design process as self-organizing, beginning with a minimalist design and then working collaboratively with members as they are using the designed space to evolve participant structures that meet their own needs. This process does not result in a designed end state but is a continual process of remaking based on users’ changing localized needs in conjunction with the designers’ more global reform agenda.

### Participation and Reification

The term *community of practice* highlights the centrality of *practice*<sup>3</sup> in defining the community and of communities

in legitimizing and supporting individual practices. This is because it is through participating in community-recognized practices that members become part of the larger community. It is in this way that participation reflects both *action* and *connection* and that participation is both *personal* and *social*. Wenger (1998) writes that participation

involves our whole person, including our bodies, minds, emotions, and social relations . . . [and that] . . . a defining characteristic of participation is the possibility of developing an "identity of participation," that is, an identity constituted through relations of participation. (p. 56)

In this way, the concept of participation captures the social character of our experience of life, as well as the notion that through participation we create meanings and identities; that is, individuals are fundamentally constituted through their relations with the world (Barab & Duffy, 2000; Lave, 1993; Lemke, 1997). It is this realization that led Lave (1993) to conclude that "developing an identity as a member of a community and becoming knowledgeable skillful are part of the same process, with the former motivating, shaping, and giving meaning to the latter, which it subsumes" (p. 65).

Frequently, participation results in some outcome, whether it is an idea, a tool, drawing, an online post, or simply becoming more knowledgeable skillful with respect to the practice. This process of transforming experience and the outcome of experience into a thing is known as reification. According to Wenger (1998), the process of reification allows CoPs to capture and share meanings as they turn their local experience into something that is portable and potentially has global significance. However, the power of reification—its conciseness, portability, potential physical form, focusing effect—is also its danger, in that the reification itself can come to replace a deeper understanding of and commitment to that for which the reification stands. Wenger (1998) writes:

Reification as a constituent of meaning is always incomplete, ongoing, potentially enriching, and potentially misleading. The notion of assigning the status of object to something that really is not an object conveys a sense of mistaken solidarity, of projected concreteness. It conveys a sense of useful illusion. The use of the term reification stands both as a tribute to the generative power of the process and as a gentle reminder of its delusory perils. (Wenger, 1998, p. 62)

Reification is an abridged and concise representation of a typically messy, convoluted practice, making practice easier to share, while at the same time offering an incomplete account of that same practice. It is in this way that reification provides a double-edged sword, at the same time it allows experience to be captured and shared it undermines the very experiences that give the reification value and use.

Wenger (1998) argued that participation and reification form a duality that is fundamental to the negotiation of meaning and that design for practice must be distributed between participation and reification with its realization being dependent on how these two sides fit together. In this section, we begin with a discussion of ILF participation, followed by discussion of the challenges of avoiding reification in a community of practice that primarily exists online.

In the design of the ILF we have created a number of participant structures that allow members to virtually visit the classrooms of other teachers, participate in online discussions, and develop a sense of belonging to the ILF community. Similar to other online environments, participation in the ILF can take on a variety of forms. *Team members* refers to those individuals at the university level who are involved in either the research or development aspects of this project. *Observers* are those registered members who visit various places in the site, view other members' comments and videos, but do not post their own. *Active members* are those who participate in viewing other members' comments and videos and engage in online discussion with other ILF members. *Contributing members* are those who share their classroom with the community. This involves videotaping a lesson or unit, organizing the accompanying materials, and posing questions within their associated discussion forum. *Bounded group members* are those individuals who join and participate in the ILF as part of some collective experience and/or curricular interest, either a teacher education class, a workshop, or a group of teachers sharing resources and ideas around a particular curricular topic. Their participation is usually centered in an Inquiry Circle. ILF members can move through these levels of membership as their situation and interests allow. In addition, we have begun to identify some of the other roles that ILF members can choose to adopt such as discussion moderators, critical friends, and project facilitators.

In any project that requires production of tools, there is the tension of reification versus participation of function and knowledge in the designed tools. Software is by nature a reification of design and implementation decisions. To date, it has primarily been through our design and member participation that the ILF reified its beliefs, culture, and mission. Much of this is embodied in the ILF classrooms. As discussed later in the Identification/Negotiation section, the process by which these teachers were solicited, their reputations, the video review process, and the structure of the ILF classrooms themselves create an e-ILF identity that frames the socially acceptable types of negotiation and participation. Reifications of practice both support and limit the types of emergent meanings (and identities).

One place we have really struggled with the interplay between supporting participation versus the reification of

our beliefs and commitments is in terms of our individual and collective understandings of “inquiry-based teaching and learning.” Inquiry is the central focus of the ILF community and a term that has come to mean a number of different things to science teachers and researchers. At its core is the idea of affording students some level of ownership over their science investigation in terms of their research questions and/or methods. Fortunately, the science education community has begun to put forth several documents that attempt to describe a current understanding of inquiry and what it looks like in the classroom (Dewey, 1938/1986; National Research Council, 1996).

Since its conception, the ILF has chosen not to put forth an explicit description of what inquiry entails or looks like in the science classroom. Our hope was to support ILF community members in coming to their own conclusions regarding the nature of inquiry through participation and negotiation. For example, one of the main *Lounge* discussions has been *Inquiry Based Learning: So what is inquiry based learning anyhow?* Within the forum there are several lines of discussion that include: the importance of background knowledge, inquiry and the standards, methods of promoting inquiry, and two discussion threads that begin to discuss what “inquiry” is in the first place. In one discussion, we see a member struggling with inquiry:

Alex: My current notion of “inquiry” involves the investigation of a driving question. The question out of which inquiry is born can be either broad or specific, but must be structured such that it provides ample opportunity for investigation. Often, the best questions to investigate are those which provide a discrepancy or ill-structured problem to the inquirer. The method of inquiry need not adhere to scripts or be specific, but should allow for many different paths to arrive at a conclusion. The “scientific method” that is often taught is just one model for investigation of a question, and I emphasize to my students that it is not a prescriptive set of rules by which inquiry must be conducted. One thing I always tell them is that “I am more interested in the questions you ask rather than the answers you give.” This emphasizes my belief that inquiry should open more doors than it closes—successful inquiry leads to many new driving questions, and therefore new inquiries. Truths are relative. The day we have all of the “answers” is the day we stop learning.

Tia: I liked your description of the inquiry-based classroom. I particularly like the comparison of it to opening more doors then closing them. I get really excited when in the process of investigating one question, my students come up with more that they want to investigate. I feel you are right in being more interested in the questions than the answers.

Despite the thoughtfulness of these comments, these posts do not embody a collective understanding of inquiry-based teaching and learning. Consequently, one of the complaints

of users is that it is unclear what the ILF is about, and what is meant by inquiry.

Over the past year and a half, the ILF research and development teams have developed their own understandings of different levels of inquiry (structured, guided, and open) (MaKinster & Barab, unpublished). One debate has been whether or not to “publish” these descriptions within the ILF site as a means of reifying our understanding of inquiry. The fear has been that putting forth such a document will limit conversations regarding the nature of inquiry in the classroom as members simply defer to the “ILF’s reification” of inquiry teaching and learning. The result is a distinct tension of how do we define inquiry in a way that supports ILF members in continuing to negotiate what it is and through participation develop their own identity in terms of inquiry in their classroom. Recently, in response to this tension, we added a tentative definition of inquiry to the front screen with the stated caveat that inquiry is a dynamic process and will look somewhat different for each member depending on their particular context.

An additional challenge faced by the ILF arises out of the way that, as mentioned earlier, identity is fundamentally constituted through participation. Where this is most important is in relation to the ILF’s *contributing members*. As individuals participating in and contributing to ILF, their beliefs, values, and understandings are reified within their videos, reflections, and discussion forum settings. These teachers have chosen to participate in the community by sharing their classrooms and in turn have established their identity through this participation. Within an online CoP, an individual’s identity is reified within any permanent artifact created during participation. A significant problem arises when one considers that the ILF is designed to foster critical dialogue among participating teachers. When one’s classroom practice is the object of critical discussion. In this context, it is impossible to avoid the fact that we are critiquing the identity of that person as well as their practice. This notion is exacerbated in the context of teaching versus other practices. For example, the culture of science accepts, to a certain point, that critical dialogue within a scientific investigation is a natural part of the scientific enterprise (Latour, 1987), whereas within the culture of teaching, a teacher’s classroom practice is much more closely tied to her identity as a person (Cochran-Smith & Lytle, 1999). This may explain some of the ILF members’ reluctance to critique the practice of other teachers. Additionally, posts, like any other reification, run the risk of being later interpreted out of context, and thereby the reader may misjudge the intended meaning. Although we have begun to implement steps to communicate the importance and desire for critical feedback (e.g., contributing members now ask explicit questions of

visitors to their classroom), we see in our research a large divide between face-to-face discussions of ILF classrooms and what gets posted online.

### Local/Global

The third duality described by Wenger (1998) is that between the local and the global. Wenger (1998), while talking about the challenges of sharing one's local practice with others, argued that "due to the inherently limited scope of our engagement, now practice is itself global" (p. 234). As we get more specific so as to highlight the contextualized nuances of practice, we enter into a series of trade-offs in terms of its global significance. In some sense, the more local the unit of analysis (e.g., sharing videos of the interactions in a particular classroom), the less significance this experience may have for other individuals in other locations. For example, suppose a classroom teacher achieves a series of successes with his or her children. How can he or she then share local experience and insights in a manner that will have global relevance to others who have a different context with different constraints and goals? In addition to challenges in terms of local practice having global meaning, there is the notion of local practices being so determined by immediate constraints that teacher practice often remains unaffected by more global reform agendas.

One of the primary challenges that the ILF has faced since its inception is that its global reform agenda does not meet the immediate needs of teachers. Teachers have a persistent need to identify readily available curricular resources in order to meet the day-to-day demands of their teaching. This fundamental need to address what a teacher will teach "tomorrow" led Gomez, Fishman, and Pea (1998) to declare that "the currency of the classroom is curriculum and activities!" The ILF, on the other hand, is designed to support a community of in-service and preservice mathematics and science teachers creating, sharing, and improving inquiry-based pedagogical practices through virtually visiting the classrooms of other teachers. This sharing and critiquing is seen as a means to building relations among teachers who share similar beliefs and classroom practices. The problem is that visiting the classroom of another teacher within this framework of "improving inquiry-based practices" is not relevant to the immediate needs of teachers. Teachers are most concerned about what they will use as a lesson or unit tomorrow or how they will deal with a particular student problem. However, what we have conceived of as meaningful participation in the ILF is something that may take an extended period of time and require multiple visits and interactions before a teacher even begins to reap any tangible benefits. This tension hinges on the local, immediate needs of the classroom teachers versus the global

reform agenda of the university designers. The focus of the ILF is on improving inquiry teaching across the state. We have worked to locate and videotape reform-minded teachers—that is, teachers who have decided to employ inquiry-based pedagogical practices. A central question is how to capture and share these local success stories in a manner that will be useful and motivating to other teachers throughout the state, while at the same time meeting their immediate professional development and curricular needs.

A second challenge in terms of the local/global duality is grounded in the use of the "visiting the classroom" metaphor as a core focus of the ILF. ILF classrooms are very local, intimate portrayals of teachers whose practice is supposed to have relevance to the global reform agenda of the ILF. Because an ILF classroom as a reification of a teacher's practice is so local, it is likely that relatively few teachers can identify with all of the contextual factors in a manner that allows them to meaningfully make connections to their particular classroom. Capturing a lesson or unit through video, text, and graphics leaves out much of what happened in the classroom and most of the contextual factors of the classroom and school. ILF members do not have access to the political climate of the school, the recent activities within the classroom, personalities of the students, and a variety of other elements that would provide a more complete representation of that lesson or unit—even if they did, the climate of one classroom may be very different than that of another classroom. Consequently, both preservice and in-service teachers have argued that it is very difficult to engage in critical discussions without having such an understanding.

One reason that ILF classrooms are often perceived as so local is that there are important aspects to face-to-face conversations and live classroom visitations that are not captured in an online environment and result in a limited representation of that visit. For example, an ILF contributing teacher, Kyle, visited a preservice secondary science methods classroom that had been using the ILF to talk with the students about his experience. Kyle shared his ILF classroom with the students, describing his school, the classroom setting, his goals, and the struggles that he had during this lesson. Together they watched two different video clips from his ILF lesson and talked about what happened in each. As the discussion was winding down, Kyle asked the class what they thought of the ILF, did they think it was useful and would they feel comfortable posting feedback to ILF teachers. Several of the students responded that they would now feel very comfortable giving Kyle feedback on his teaching since they had a chance to talk with him and better understand the context of his classroom and lesson. During the next two weeks, the students in this class visited Kyle's ILF classroom and posted their thoughts and responses.

Many of the students from this preservice class were able to post thoughtful and detailed responses that even contained elements of personal connections, such as using Kyle's first name in the greeting and statements of encouragement or appreciation at the end of the message. For example, here Kyle is asking a question in reference to his ILF classroom.

Kyle: Having gone through so many steps to determine the age of the universe, have the students lost sight of the goal? Should the lesson have been broken up into smaller bits?

Steve: Kyle, after looking at the clip again and your response, I agree more with how you were going around to the specific groups. I at first thought that the reason you should address a problem with the entire class was because everyone had the same questions. If they do, I believe that you should maybe first address the question in class and then go from group to group if it is needed. But, if the students don't have the same question throughout the groups, no reason to address the question to then entire class. I agree with how you're doing things, I just thought maybe you should give an answer to the entire class and then work with groups individually if they're still not grasping the concept.

However, even after this in-class interaction, one or two of the students still found it difficult to provide Kyle with the feedback he was asking for.

Kyle: Did I give them too much information and suggestions about classifying their galaxies? Is this part of the instruction too scripted?

Rachel: Is this a first year physics class? I wish that I could see more of your class to get a real feel for what you are doing and so I could understand the topic better. It may have an affect on what I write here . . . I think that you did a good job with the section. You obviously have an idea where you want the student to go and you lead the students there—mostly through questions so they have to think about it.

Rachel was still struggling with trying to understand the context of Kyle's classroom and was frustrated with the limited perspective afforded by what was presented within the ILF. This situation becomes compounded when members visit ILF classrooms with lessons or units that are outside of their content area (biology, chemistry, physics, etc.). Not only do these ILF members have to wrestle with understanding the contextual elements of the classroom, they have to make generalizations from a different subject and make interpretations about how it applies to their own area of expertise. Finally, even if a teacher can connect with another teacher, and if they have a common subject and context, teachers seldom have the time to spend determining if this is the case and then responding.

From this standpoint, design decisions create relations not simply between the global and the local but, rather, "among their localities in their constitution of the global" (Wenger, 1998, p. 234). The challenge is to find means

of sharing these local particulars in ways that can have global significance. Conversely, an additional challenge is to communicate a global reform agenda in a manner that will have local relevance and value. We have attempted to identify local particulars through user-centered design and through discussions with teachers in which they share the aspects of the e-ILF are most useful. We have developed video "trailers" for each classroom so that teachers can gain an overview about the local specifics before investing large amounts of time in the classroom. Additionally, we have developed member activities, such as Contrasting Cases, that ILF users can attempt in order to develop particular skills or understandings. For example, in the Contrasting Cases activity, members will be able to examine two classrooms in terms of their level of inquiry, having access to other teachers' comments and then being expected to relate this contrast to their own teaching. In presenting these challenges, we define the task and communicate the local value of completing the challenge. Lastly, we have become more explicit in communicating to teachers our global reform agenda, why the ILF is important, and how the ILF participation can be useful for developing useful pedagogical skills. The success of these efforts remains to be determined.

### Identification/Negotiability

Wenger (1998) refers to identification as that which provides experiences through which individuals can build their identities via "relations of association and differentiation." New members of a community are able to assess the extent to which they can "identify" with the mutual enterprise, culture, and history of a community. The extent to which new members identify with a community, in part, determines the nature of their membership and participation. For example, as a visitor to a church, an individual will assess the extent to which they can relate to its members, beliefs, and mission, which will in turn dictate how this person chooses to participate within this church community. It is through this dynamic and generative process that individuals become identified as something (a certain type of individual), and also identify with something or someone in the community (Wenger, 1998).

Negotiability refers to "the degree to which we have control over the meanings in which we are invested" (Wenger, 1998, p. 235). This includes how an individual perceives his or her ability, facility, and legitimacy to contribute to and take responsibility for the direction of a CoP. In turn, opportunities for negotiability determine the extent to which we develop ownership over the community's mutual enterprise and practice. Community members assume different levels of participation (Lave & Wenger, 1991; Wenger, 1998) or roles (Kim, 2000). Members at the center of the community have typically been able to

identify with the community to a greater extent and thus are willing to play a more integrated role in the future success and direction of the community. Throughout the design and implementation of the ILF, it has become increasingly clear that identification and negotiability can foster participation as well as non-participation.

The ILF was originally designed to support teachers in visiting the classrooms of other teachers, something that teachers at all levels feel is one of the best ways to improve their teaching (MaKinster et al., 2001; Simpson et al., 1999; Strage & Bol, 1996). Despite this recognition, most ILF members appear to be very reluctant to engage in dialogue with the ILF contributing teachers. One potential explanation for this is that the stakes for negotiation within the ILF are high. Unlike many other online communities, the ILF only has limited potential for anonymity. In fact, the ILF encourages its members to create and edit their member profiles so other ILF members can learn more about one another. This enables ILF members to control how they are perceived by others within the community, and ideally, these profiles help ILF members to decide who they want to communicate with and how they might interpret statements or attitudes of others (Kim, 2000). However, at the same time, the ILF is limiting its ability to get teachers to critique the practice of other teachers, perhaps because critical dialogue online may be limited in the absence of anonymity.

Ben: I put my video up, now I know it has only been there for a couple weeks, but there's, you know the only person that has posted any responses to my discussion things is someone on the ILF team. And that's great, and I write back to her, but I email her a couple times a week, so I am not getting that aspect. That larger community criticism. . . . I guess probably one of the challenges is to, you know . . . to keep wanting to do it for some reason, when I am not getting a lot of feedback right now. I mean I am still interested in taping another lesson and putting it up there . . . you know, I think kind of admirable that I want to do that when I haven't had any feedback on the one that's already up there. I mean why would I want to do this? I guess that the selfish reason is that it forces me to really in-depth analyze my teaching. The whole video process and reflecting on my teaching is very beneficial.

An additional risk of designing an environment such as the e-ILF is that it creates fragmentation among the different groups involved (design team members, contributing teachers, ILF members). An increasing focus on design by the ILF team results in new members having fewer opportunities for negotiation because the identity of the community appears already established. This struggle arises out of the fact that teachers do not have the time to create this type of electronic environment on their own and at the same time, we as designers are limited by both our time and resources in terms of enabling all teachers to be full participants in the design process. We have chosen to involve ILF

members in our design decisions by conducting usability tests and interviews with a variety of teachers, as well as having participant advisory board meetings during which several ILF teachers spend 2–3 days giving us feedback in a variety of settings (large group discussions, focus groups, workshops, etc.). Given the sometimes limited nature of our participatory design model, all ILF members are not afforded with opportunities for negotiation in terms of the electronic structure of the ILF. Implicit, and sometimes explicit, within this electronic structure is a specific agenda for participation developed and embraced by the ILF development and research teams. Therefore, participation in the ILF involves the process of exploring, identifying, and potentially embracing the practices and collective identity of both the e-ILF and the ILF community prior to legitimate participation and being able to contribute to the ILF in a way that will effect its future trajectory.

The ILF classrooms embody a significant portion of what it is that new ILF members used to identify with the ILF community. The ILF has been seeded with a number of contributing teachers who have agreed to share their classroom and experiences with the ILF during its initial stages. The goal was to create a critical mass of teachers and experiences with which new ILF members could identify. In the process, the ideas, philosophies, and commitments of the ILF were embodied within these teachers due to how they were selected (most were recommended by university faculty), how their classrooms were presented (all content was reviewed and edited by ILF Development Team members), and electronic structures through which participation takes place. Consequently, there are limited opportunities for negotiation. New members first have the Herculean task of trying to identify what it is that the ILF is about, where and how they can find information that is relevant to their own teaching, and then deciding to what extent they can identify with the mission and commitments of the ILF community.

Our primary solution to the problem of identification in the ILF was to expand and develop the ILF Collaboratory as a space in which groups of teachers can come together in an online space around some collective experience and/or curricular interest. As mentioned earlier, an Inquiry Circle can be a group of teachers who are part of a class, workshop, or who simply share a similar curricular interest. Again we are concerned that supporting the development of such groups may create fragmentation within the ILF community. We may see very little interaction between the different groups of teachers that use an Inquiry Circles as their primary focus and entry point. Many ILF participants may spend the majority, if not all, of their time only using their Inquiry Circle space and contribute very little to the e-ILF outside of this space. This highlights the importance of structuring an Inquiry Circle space as a way of both communicating and sharing things privately, but also

organizing the e-ILF elements and discussions that are of interest to this group. This effort would facilitate focused interactions among this group and other ILF members.

We do believe that the ILF Inquiry Circles offer a powerful way for members to quickly identify themselves with other teachers in the ILF. An ILF member can enter the ILF as part of an existing group of in-service or preservice teachers or can identify teachers who share similar curricular or pedagogical interests. It is our hope that we can support these communities of purpose as they attempt to address their professional development needs. This is not unlike the constellation of communities of purpose in Tapped-In (Schlager et al., 2002); however, unlike Tapped-In, the ILF is focused on working together to share, improve, reflect, and create learner-centered classrooms through better understanding learning and teaching through inquiry and inquiring into our own practices.

### Online/Face-to-Face

ILF presents an additional tension, one that is largely unexamined in Wenger's book: the tension between online and face-to-face. It is a tension that is knotted with the previously mentioned tensions of local/global, participation/reification, and designed/emergent and may indeed be a part of all the other tensions. For instance, when we talk about designed and emergent, we have to acknowledge that an online CoP requires a great deal more design up front than a face-to-face CoP. The technology determines the epistemology. By this we mean that the programming that creates the designed technological interface is composed of decisions that incorporate certain ideologies. At the least, they limit some types of exchange and encourage others. In the e-ILF, a member cannot start a new discussion forum. This has to be done through administrative channels that are friendly, but still serve as filters to participant initiative and enforces a very definite power hierarchy between designers and participants of the ILF. There are literally thousands of design decisions that go into an online project as complex as ILF and each of these decisions could be regarded as a limit—or a boon—to emergent community.

There are so many components to this online/face-to-face tension that many are led to believe it is a binary dualism rather than a duality, as evident in the initial chapter quote by Benedikt. The question of whether being online is fundamentally different from face-to-face communications is a difficult one. While few people dispute that there is a functional difference, characterization of this as essential and ontological raises questions. Both viewpoints have their vocal adherents. If the online is fundamentally different from the real or face-to-face then this leads to a radical re-construction of selfhood, identity, and communication. However, treating the virtual as a continuity

of the real allows for the application of tools and theories that have been in use for decades to understand community. The virtual as an extension, but not fundamentally different from the real, is consistent with the view held by anthropologist David Hakken (1999), who argues against a concept of a computer revolution or essential break between how we think about the online and the copresent. By extrapolation, we can assume that John Dewey, a unifier of Cartesian dualisms, would have found reason to see a functional, but not essential, difference between online and copresent participation. We will take the position that there is a continuity and connection between online and copresent communities, a position that allows us to view online spaces with the knowledge and skills garnered from the study of copresent communities.

The functions that help a community of practice cohere are social functions since communities are overwhelmingly social spaces (Barab & Duffy, 2000; Preece, 2000). The goals of the ILF, to encourage the critiquing of and reflection on teaching practices and to help foster knowledge and use of inquiry pedagogy, cannot occur without communicative functions. This type of critical reflection and public criticism is both personal and social. The work of Jenny Preece (2000) on sociability emphasizes the holistic needs of online communities where the social and the technological interact to form community. This points to the maintenance of sociability as one of the biggest tasks of a successful online community of practice. It is within these social functions that we see the tensions that arise from the online/face-to-face duality.

We see two different issues illustrating this duality. The first is difficulty with the use of ILF online tools. The e-ILF poses difficulties to some users. The digital tools became a hindrance to participation if they block communication. Some teachers talked to us about getting lost in the electronic space. They had trouble navigating to the parts of the web site they were interested in visiting. We supplied help on our web site through an e-mail link to our project director. However, dealing with the technical issues of navigation, firewalls in K–12 schools, and having appropriate software, hardware, and Internet connectivity are all challenges that need to be bridged for online participation to occur.

A busy teacher has many demands on his or her time. When a teacher is having difficulty with the forum software, other matters might easily distract him or her from following up on difficulties. This is particularly true if the problem is intricate and might take a fair amount of time to type. ILF is vying for her attention and loses when the cost of logging off is less than the time and energy costs of continuing to the ILF. Like Lankshear and Knobel (2000), we have found that time is a limiting commodity in our world. A messy problem, such as a technical impediment, is more easily mentioned in a copresent situation where words can

be modified until other participants exhibit understanding. Another possible block to asking for help online is the matter of trust. Typing messages online can seem for all practical purposes as if the words are being sent to some unknown place. Without trust of the motives of the recipient, a user might fear inappropriate circulation of their communication, especially in the context of a research project. Asking help from someone who is copresent provides the opportunity to read facial expression and other body language.

The second issue alluded to earlier is trust. Teachers are expected to do some inherently risky things, to put examples of their teaching online in the form of videos, to critically reflect on these videos, and to critique other teachers' videos and beliefs. Whenever a member types a message online there are the issues of: Where will this message be dispersed? How widely will it travel? Who will see it? If it is archived, will it hinder future growth and credibility if one moves away from the currently held (and printed) opinion? This may be a particularly difficult issue for teachers who are accustomed to closing their classroom doors and acting autonomously (Grossman et al., 2000). Opening oneself to criticism almost always arouses a sense of insecurity. This sense may be magnified in the minds of people like teachers who devote themselves to other people's children, often for low salaries and with varying support from administration and parents out of a sense of duty to humanity (Hansen, 1995).

In what could be interpreted as a desire to foster a more trusting environment, ILF members commented on the need for copresent contact before engaging in communications online. One participant advisory board member said, "I've never felt like that [e-ILF] has been as useful as our physical community's use of that electronic community." Another participant advisory board member remarked, "I have not spent a lot of time in anybody's video. Okay? But now that I've met these people, I'll go home and do it. What's missing is I don't want to look at home movies if I don't know the people." Both these statements indicate the need for familiarity with the people in the community before online communications can be substantive or even sometimes initiated.

Online spaces, while having their challenges, also have some advantages over copresent spaces, for example, when teachers' needs for support can not be met in their usual copresent situations. One of our driving commitments is that leveraging the Internet allows for enlarging the matrix of colleagues and thereby increasing the chance that an individual's innovation will find a niche with someone else. This seemed to be true in regard to support for inquiry pedagogy. As one teacher said, "it's [e-ILF] exposed me to at least a community of people out there that are, that I know are intelligent and carry on interesting conversations." Several of the teachers most involved in

ILF work are in rural schools where they feel like they are quite isolated from their peers doing innovative activities. Even those teachers not physically isolated often experience animosity from other teachers in their school who were characterized as "not understanding what we're doing." There were many comments from the participant advisory board that indicated the support and affirmation they got from ILF made a difference in their practice and their perceptions of their practice. In this way, we see the e-ILF's usefulness was enhanced precisely because it is an online space that allows access where copresent communications do not suffice. The separations that online communications potentially bridge include those constructed by time, space, and interest.

### Diversity/Coherence

When those who have the power to name and to socially construct reality choose not to see you or hear you, whether you are dark-skinned, old, disabled, female, or speak with a different accent or dialect than theirs, when someone with the authority of a teacher, say, describes the world and you are not in it, there is a moment of psychic disequilibrium, as if you looked into a mirror and saw nothing. (Rich, 1986, p. 199)

During the characterization of our design decisions we recognized a sixth tension that we view as essential in terms of characterizing our work. The duality of having a system that allows diversity, while at the same time maintaining a certain level of coherence in communities has been noticed and discussed by Joel Westheimer (1998). Gardner (1991, p. 32) explains that "the common good is first of all preservation of a system in which all kinds of people can—within the law—pursue their various visions." This suggests that attempts to support the community development must ensure there are multiple voices and perspectives, even in the face of advancing a particular agenda or framework. This trade off of diversity for coherence is such a basic tension within communities that it may often be accepted as standard cost for building and maintaining communal relations. However, we argue that ignoring this tension endangers the formation, let alone the sustainability and value, of community. Individual needs and opportunities for participation require as much attention as group needs and community agendas.

Communities benefit from diversity in a number of ways. Dewey stressed the need for difference among community members in order to provide multiple perspectives and viewpoints (1909/1965). By having a diverse population, ideas and perspectives are continually challenged, revised, and often result in new collective agendas or beliefs. Lave and Wenger (1991) argue that change over time is a fundamental property of communities of practice and that the knowledge and perspectives of a community are

mutually constitutive. Therefore, as the level of diversity within a community increases, so does the opportunity for collective and individual development. It is the diversity of skills, abilities, and perspectives that drives the growth of the community. As designers, we need to ensure that we are creating a system that is inviting and receptive to individuals with a variety of ideas, needs, and agendas (Barab et al., 2001).

By using convenience sampling to find teacher participants in our initial efforts and by strictly advancing a professional development model that embraces personal reflection and critical dialogue with other teachers, the ILF has failed to adequately address the need for a certain level of diversity. This may have resulted in the ILF participating teachers being an outlier group, those interested in inquiring into their own teaching and those interested in implementing inquiry-based teacher practices regardless of issues of meeting—what Songer, Lee, Hartman, and McDonald (2001) referred to as “maverick” teachers. Additionally, the commitment of the site to math and science inquiry may be excluding other teacher voices that would offer important perspectives and experiences around best practices. Another area in which lack of diversity is apparent is in the gender ratio of the ILF contributing teachers.

At the end of our first year, based on convenience sampling, we realized that there were no ILF classrooms of female science teachers. This is a serious omission, especially since women comprise the majority of ILF members (both preservice and in-service). Since the ILF classrooms are seriously imbalanced in terms of gender diversity, we are not surprised to find that there is a distinct lack of participation by women teachers in the discussions around the ILF classrooms of male teachers and conversely the lack of male participants in the discussion around the videos of female math teachers (Herring et al., 2001). In addition, Herring et al. also found that questions asked by women are less likely to be answered by men than by women.

The other area in which the ILF has struggled in terms of diversity vs. coherence is in regards to supporting the articulation of multiple and varied voices within the ILF discussion forums. Thus far there has been very little critical dialogue within the ILF. Most of the discussion posts are either complementary or are simply people stating their ideas and opinions. It is very seldom that an ILF member challenges the opinions of another person, or gives critical feedback to one of the ILF Contributing Teachers. We argue that, in part, this has to do with American culture in general and the culture of teaching specifically.

The anthropologist Paul Bohannan notes that Americans have two categories of behavior: polite and rude. The British, he says, add a third: civil, meaning that you pull no punches when you criticize, but that you do so without jeering. As he puts it, an American has to be your close friend before giving you anything but praise. (Nader, 2001, p. 15)

American culture is not one where critical feedback is offered and received openly. In addition, as stated previously, providing one another with critical feedback is not something teachers do on a day-to-day basis. The culture of teaching is primarily one of isolation, where teachers are most concerned with and motivated by improving student learning, rather than improving their own teaching practice (Dunn & Shriner, 1999). Fortunately, the culture of most preservice programs encourages these future students to provide one another with feedback on a regular basis—this was consistent with the level of critical dialogue that we observed in the areas of the e-ILF devoted to preservice teachers. However, this practice is usually pushed aside once preservice teachers enter the teaching profession.

These conditions create significant design challenges for the ILF in terms of fostering critical dialogue and supporting multiple and diverse voices. We need to provide our members with a variety of opportunities in which teachers at all levels feel like their ideas and opinions will be valued and respected. Most importantly, we need to provide models and mentors that new ILF members can relate to and interact with in ways that will help them to perceive themselves as valued and legitimate participants. To this end, we are currently make a concerted effort to get several ILF classrooms of women science teachers online as well as initiate new discussion forums that have women science teachers as moderators. Our hope is that the central presence of these women as core members in the ILF will result in more balanced levels of female participation overall.

The other design decision that may have a significant impact on the diversity of ILF members is to support “bounded groups” of teachers that share some common curricular, professional development, or pedagogical interest. For example, we are currently working to support a number of Indiana science teachers who conduct water quality investigations in their classrooms. The new ILF Collaboratory provides these teachers with a virtual space in which they can share resources, identify ILF resources and discussions that are of interest to them, and keep in touch with a growing group of teachers who have similar interests and needs. Ironically, it is our belief, and consistent with our initial observations, that by creating groups with a common focus we will actually increase the opportunity for diverse voices. Our assumption is that these settings allow for more attention to be focused on the needs of individuals and of the nuances of supporting inquiry within the context of a common ground.

At the same time, the semi-private nature of these groups will allow for the development of trust and camaraderie. Establishing a certain level of trust with a particular group of teachers will most likely result in a greater willingness of these teachers to serve as “critical friends” (Costa &

Kallick, 1993) of one another. Critical friends are willing to challenge the thoughts or ideas of one another in a manner that is supportive, yet honestly critical. These types of dialogue and interactions will hopefully encourage a greater level of diversity in terms of ILF membership and in the thoughts and ideas expressed both face-to-face and online. As more and more bounded groups arise, we run the risk of fragmenting the ILF into a constellation of subcommunities, rather than supporting the emergence of a single, coherent, legitimate community of practice. As we initiate our support of these bounded groups, the diversity/coherence is central to our thinking.

## CONCLUSIONS AND IMPLICATIONS

The notion of tensions, or dualities, provides a useful lens for better understanding the life-cycle of community systems more generally (Barab, Barnett, & Squire, 2002; Engeström, 1987, 1999; Wenger, 1998). Wenger discussed these tensions as dualities, with the challenge not being to eliminate tensions or treat the pieces as polarities along a continuum, but to understand their interplay, harnessing it in a manner that invigorates system dynamics and learning. Using Wenger's (1998) dualities as a means for understanding how to support a community of practice can serve as a powerful framework that informs both design and research. We have attempted to provide other educators/designers with an illuminative case from which they can build their own generalizations as they confront and potentially overcome the challenges that they face when "designing for community."

Although we often discussed each of the dualities as if they exist independently from the others, clearly they are overlapping. Not only does each duality serve as an interacting dimension, but the six dualities knot together in ways that make them almost inseparable. This means that when designing online communities it is difficult not to consider at least two or three dualities at a time. Consideration of these dualities and their overlapping nature is both a challenge and at the same time has been instrumental in informing the directions of our design work, helping us to develop the ILF in innovative and meaningful ways. Above we attempted to show how the interplay of the dimensions that constitute these dualities, as well as the dynamic interactions among dualities, have been manifest in the ILF. We view these dynamics as driving system innovations, as well as change, and understanding these dynamics is essential to the future success of the ILF. If we weigh too heavily on one dimension to the exclusion of another, we will undermine the system as a whole. To be clear, we view the potential success or failure of the ILF to be dependent on our (including designers and community members) ability to foster and maintain a healthy dynamic within and among the above discussed dualities/tensions.

Examining our work in light of dualities has resulted in a number of design decisions that have implications for others designing online communities and especially online communities of practice. First, it is clear that online communities are not simply technical spaces, but instead are networks (STINs) constituted by social and technical relations (Kling et al., 2001). As mentioned earlier, it was necessary at one point during the project to distinguish between the ILF as a sociotechnical network and the ILF web site or e-ILF. The e-ILF refers only to the web site, which includes the web pages, videos, online conversations, and the electronic database that serves as the backbone of the e-ILF. One of the primary implications is that designers of online communities need to explicitly acknowledge the sociability issues they face (Preece, 2000). Given the challenges of supporting community development online, we have been attempting to create more copresent opportunities that can then be supported and integrated with online participation. The important point is not to spend time debating whether differences between online and copresent CoPs are ontological or simply functional, but rather to focus on understanding how, in a community context, we can best support social relations so that communication and learning trajectories can flow freely.

Many of the aforementioned ideas have helped us to see that the term *online community* does not really capture the nature of the ILF and most other educationally focused electronically networked communities. Therefore, we have chosen to forward the label of "web-supported communities." There are many organizations or social entities that exist almost exclusively online and can legitimately be referred to as online communities. Online gaming communities such as those within Everquest and Asheron's Call are the most populated examples of viable social networks of individuals that interact and collaborate almost exclusively through electronic networking technologies (Kim, 2000). In addition, there is a long history of social MUDs and MOOs that involve thousands of individuals that interact with one another solely through networked technologies. However, educational researchers and designers are quickly coming to realize that face-to-face and other socially mediated interactions are essential supplements to online interactions in educational settings. We have experienced our greatest success when online interactions in the ILF have served as extensions of face-to-face workshops, meetings, and classes, or when we bring together individuals that had previously interacted only in online settings and allow them to develop relationships outside of the e-ILF.

Another significant issue that arose within this project was the divide between the immediate needs and desires of ILF teachers (for lesson plans, resources, etc.) versus the global reform agenda of the university educators. We made efforts to collapse this tension between the global reform

agenda of the ILF community and the immediate local needs of the teachers. While the goal was not to eliminate this tension, we are university educators who, consistent with the research community to which we are most centrally located, believe that more science and math teachers need to be using inquiry-based teaching techniques in the classroom. This call is consistent with national reform movements and with the focus of the grant. However, teachers are confronted with multiple constraints, including 45-minute class periods, minimal lesson preparation time, 1 teacher to 20–30 students, content-based accountability on standardized tests, and student and parent focus on grades as opposed to meaningful engagement as the measure of success influences the practices of teachers. In the course of the school day and school year, teachers' plates are so full they rarely have the luxury or inclination to consider and learn new pedagogies, reflect on their current practice, decide to change their approach, then revise their curriculum to support new pedagogies. So, a systemic tension between teachers' immediate needs and long-term reform efforts that require learning, reflection, reworking curriculum, and collegial critique exists within the project. The challenge is to balance the local needs of the teachers with the global reform agenda of the university educators. By supporting the interplay of these goals, we support reform that is grounded in practice, not simply in the minds and articles of university educators—what we call *grounded reform*. We have come to realize that some systemic reform work that reduces the constraints in teachers' time and makes "anytime, anywhere" professional development more appealing is necessary before the ILF will have widespread adoption in an in-service teacher context.

Finally, we have clearly been convinced that community cannot be designed a priori or by someone other than the community members. As such, our current commitments in this project are even more focused on a minimalist design through which we collaboratively develop participant structures that will initiate dialogue and then evaluate how our efforts support local adaptation and continued development. This bottom-up approach is consistent with Kim's (2000) discussion of the goal for designers interested in supporting online community being to support a timeline in which staff starts out as very active but drops off relative to the community members in terms of evolving the online space and defining what it means to be a community member. Based on Barab, Squire, and Dueber's (2000) work, we call this approach *coevolutionary design*, a process that is similar to participatory design but with an evolutionary component involving extended time scales and with the focus being to work with community members over time to codevelop and evolve participant structures as well as the norms and rules of participation.

We view coevolutionary design as particularly appropriate, and possibly necessary, when designers are trying to "build" online communities to support learning; this is because within our definition of communities, they are self-organizing systems whose continual health and functioning is dependent upon local ownership and member identification (Barab et al., 1999). This bottom-up, or self-organizing, approach does not result in a static, fixed, "designed" space to which new members can assimilate. Instead, we are arguing for an ongoing collaboration among designers, educators, and users. In this way, designers are supporting the evolution of a community identity, while at the same time creating a space for continued negotiability by individual members. In recommending this approach for design we must still locate and encourage participation from the absent voices. There is a conundrum of wanting both diversity and emergent design. Those participating in the developing design of an online community are those who are comfortable with the hegemony of that space.

We feel that our latest design focus on the ILF Collaboratory reflects many of the aforementioned commitments and ideas. As described earlier, the Collaboratory is a space within the e-ILF in which groups of teachers can come together around some collective experience and/or curricular interest. As such, the Collaboratory is simply a space to organize resources, documents, and ILF areas of interest. Therefore, it is the community or Inquiry Circle members that decide what things are of relevance in each electronic space including what private discussions take place or ILF Lounge discussions are of greatest interest. As a result, each Inquiry Circle member is able to customize their space to meet their local needs and interests. This allows the identity and interests of each group to emerge out of the community members and facilitators, rather than being imposed by designers or project leaders. While this situation also allows for the development of Inquiry Circles that are not at all tied to the global reform agenda of the ILF, we feel that the other, more heavily designed areas of the ILF contextualize the Inquiry Circle activities so they are less likely to discuss noninquiry activities than it might be in other electronically networked settings. Currently there are 39 Inquiry Circles ranging from preservice classrooms at six different universities, to in-service teacher workshops, to curricular focused groups centered around topics such as evolution, water ecology, and elementary teaching with salamanders. The development of the ILF Collaboratory (August 2001) and using the ILF within math and science preservice classrooms (fall 2001) has resulted in a significant increase in activity in ILF private and public discussion forums as members of these Inquiry Circles post inside and outside their circle (see Figure 4).

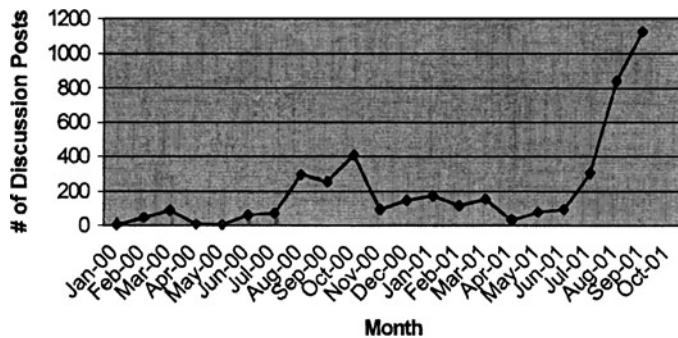


FIG. 4. ILF discussion postings per month since the beginning of the project.

## SUMMARY

In this article we have used six dualities as an analytical lens to characterize the ILF and to illuminate the design struggles that arose in the design of an online CoP in the service of learning. It is through understanding and balancing the interplay within and among these dualities that designers can inform and evolve their design efforts. We have argued that dualities are made up of reciprocal components whose interplay can drive system innovation and are useful for characterizing system dynamics. By examining community life in terms of these dualities, we have been able to better understand the ILF dynamics, and have tried to share these insights in a manner that will provide other designers with an illuminative case study. More generally, we hope that this discussion will allow designers to readily identify patterns occurring in their own community interventions and intelligently navigate the challenges they face when designing for community.

## NOTES

1. We are more than participant observers in that we have an agenda as a change agent with a goal of bringing about transformation (Eden & Huxham, 1996; Grills, 1998; McNiff, 1995; Stringer, 1996; Wells, 1999). We view our roles as having a mix of what Adler and Adler (1997) called “peripheral membership” (referring to our position outside the CoP) and “active membership” (referring to our position as change agent on the CoP).

2. Activity Theory is a psychological theory with a naturalistic emphasis that offers a framework for describing activity and provides a set of perspectives on practice that interlink individual and social levels (see Engeström, 1987, 1993; Leont’ev, 1974, 1981, 1989; Nardi, 1996; Vygotsky, 1978). When discussing activity, activity theorists are not simply concerned with “doing” as a disembodied action, but are referring to “doing in order to transform something,” with the focus on the contextualized activity of the system as a whole (Barab, 2002; Kuutti, 1996; Engeström, 1987, 1993).

3. When we use the term *practice*, we are not evoking some behaviorist notion of activity. Rather, and akin to Schön (1987), we view practice as “chunks of activity, divisible into more or less familiar types,

each of which is seen as calling for the exercise of a certain kind of knowledge” (pp. 32–33).

## REFERENCES

- Adler, P. A., and Adler, P. 1997. *Membership roles in field research*. Thousand Oaks, CA: Sage.
- Barab, S. A. 1999. Ecologizing instruction through integrated units. *Middle School Journal* 30:21–28.
- Barab, S. A. 2002. Commentary: Human–field interaction as mediated by mobile computers. In *Computer supported collaborative learning*, eds. T. Koschmann, R. Hall, and N. Miyake, pp. 533–538. Mahwah, NJ: Lawrence Erlbaum Associates.
- Barab, Barnett, and Squire. 2002. Building a community of teachers: Navigating the essential tensions in practice. *The Journal of the Learning Sciences* 11(4):489–542.
- Barab, S. A., and Duffy, T. 2000. From practice fields to communities of practice. In *Theoretical foundations of learning environments*, eds. D. Jonassen and S. M. Land, pp. 25–56. Mahwah, NJ: Lawrence Erlbaum Associates.
- Barab, S. A., and Schatz, S. In press. Using activity theory to conceptualize online community and using online community to conceptualize activity theory. *Mind, Culture, and Activity*.
- Barab, S. A., Cherkes-Julkowski, M., Swenson, R., Garrett, S., Shaw, R. E., and Young, M. 1999. Principles of self-organization: Ecologizing the learner-facilitator system. *Journal of the Learning Sciences* 8(4):349–390.
- Barab, S., MaKinster, J. G., Moore, J., Cunningham, D., and the ILF Design Team. 2001. Designing and building an online community: The struggle to support sociability in the Inquiry Learning Forum. *Educational Technology Research and Development* 49(4): 71–96.
- Barab, S. A., Squire, K., and Dueber, B. 2000. Supporting authenticity through participatory learning. *Educational Technology Research and Development* 48:37–62.
- Barab, S. A., Barnett, M., Yamagata-Lynch, L., Squire, K., and Keating, T. 2002. Using activity theory to understand the contradictions characterizing a technology-rich introductory astronomy course. *Mind, Culture, and Activity* 9(2):76–107.
- Benedikt, M. 1991. Cyberspace: Some proposals. In *Cyberspace: First steps*, ed. M. Benedikt, pp. 119–224. Cambridge, MA: MIT Press.
- Brown, A. L. 1992. Design experiments: Theoretical and methodological challenges in creating complex interventions in classroom settings. *Journal of the Learning Sciences* 22:141–178.
- Chaney-Cullen, T., and Duffey, T. 1998. Strategic teaching frameworks: Multimedia to support teacher change. *Journal of the Learning Sciences* 8:1–40.
- Cochran-Smith, M., and Lytle, S. L. 1999. Relationships of knowledge and practice: Teacher learning in communities. In *Review of research in education*, eds. A. Iran-Nejad and P. D. Pearson, pp. 249–305. American Educational Research Association: Washington D.C.
- Collison, G., Elbaum, B., Haavind, S., and Tinker, R. 2000. *Facilitating online learning: Effective strategies for moderators*. Madison, WI: Atwood.
- Costa, A. L., and Kallick, B. 1993. Through the lens of a critical friend. *Educational Leadership* 51:2:49–52.
- Dewey, J. 1938/1986. Logic: The theory of inquiry. In *John Dewey: The later works 1925–1953*, vol. 12, ed. J. A. Boydston, pp. 1–506. Carbondale: Southern Illinois University Press.

- Dunn, T. G., and Shriner, C. 1999. Deliberate practice in teaching: What teachers do for self-improvement. *Teaching and Teacher Education* 156:631–651.
- Eden, C., and Huxham, C. 1996. Action research for the study of organizations. In *Handbook of organizational studies*, eds. S. Clegg, C. Hardy, and W. Nord, pp. 526–542. Thousand Oaks, CA: Sage.
- Emerson, R. E., Fretz, R. L., and Shaw, L. L. 1995. *Writing ethnographic fieldnotes*. Chicago: University of Chicago Press.
- Engeström, Y. 1987. *Learning by expanding*. Helsinki: Orienta-konsultit.
- Engeström, Y. 1993. Developmental studies of work as a testbench of activity theory: The case of primary care medical practice. In *Understanding practice: Perspectives on activity and context*, eds. S. Chaiklin and J. Lave, pp. 64–103. Cambridge, MA: Cambridge University Press.
- Engeström, Y. 1999. Activity theory and individual and social transformation. In *Perspectives on activity theory*, eds. Y. Engeström, R. Miettinen, & R. Punamaki, pp. 19–38. Cambridge, MA: Cambridge University Press.
- Gardner, J. 1991. *Building Community*. Washington, DC: Independent Sector.
- Geertz, C. 1983. From the native's point of view: On the nature of anthropological understanding. In *Local knowledge*, ed. C. Geertz, pp. 55–70. New York: Basic Books.
- Gomez, L., Fishman, B., and Pea, R. 1998. The CoVis Project: Building a large scale science testbed. *Interactive Learning Environments* 6(1–2):59–92.
- Grills, S. 1998. *Doing ethnographic research: Field settings*. Thousand Oaks, CA: Sage.
- Grossman, P., Wineburg, S., and Woolworth, S. 2000. *In pursuit of teacher community*. Paper presented at the American Educational Research Association, New Orleans, May.
- Hakken, D. 1999. *Cyborgs@cyberspace: An ethnographer looks to the future*. New York: Routledge.
- Hall, G. E. 1979. The concerns-based approach to facilitating change. *Educational-Horizons* 574:202–208.
- Hansen, D. T. 1995. *The call to teach*. New York: Teacher's College Press.
- Herring, S., Martinson, A., and Scheckler, R. 2001. *A multimodal web-based community for math and science educators: A feminist critique*. National Women's Studies Association, Minneapolis, MN, 13–17 June.
- Jones, S., ed. 1999. *Doing Internet research*. Thousand Oaks, CA: Sage.
- Kim, A. J. 2000. *Community building: Secret strategies for successful online communities on the web*. Berkeley, CA: Peachpit Press.
- Kling, R., McKim, G., Fortuna, J., and King, A. 2001. *A bit more to IT: Scientific communication forums as socio-technical interaction networks*. Unpublished.
- Kutti, K. 1996. Activity theory as a potential framework for human-computer interaction research. In *Context and consciousness: Activity theory and human-computer interaction*, ed. B. Nardi, pp. 17–44. Cambridge, MA: MIT Press.
- Lankshear, C., and Knobel, M. 2000. Why "digital epistemologies"? *Re-open* 11.
- Latour, B. 1987. *Science in action: How to follow scientists and engineers through society*. Milton Keynes, England: Open University Press.
- Lave, J. 1993. Situating learning in communities of practice. In *Perspectives on socially shared cognition*, eds. L. B. Resnick, J. M. Levine, and S. D. Teasley, pp. 17–36. Washington, DC: American Psychological Association.
- Lave, J. 1997. The culture of acquisition and the practice of understanding. In *Situated cognition: Social, semiotic, and psychological perspectives*, eds. D. Kirshner and J. A. Whitson, pp. 63–82. Mahwah, NJ: Lawrence Erlbaum Associates.
- Lave, J., and Wenger, E. 1991. *Situated learning: Legitimate peripheral participation*. New York: Cambridge University Press.
- Lemke, J. 1997. Cognition, context, and learning: A social semiotic perspective. In *Situated cognition: Social, semiotic, and psychological perspectives*, eds. D. Kirshner and J. A. Whitson, pp. 37–56. Mahwah, NJ: Lawrence Erlbaum Associates.
- Leont'ev, A. 1974. The problem of activity in psychology. *Soviet Psychology* 132:4–33.
- Leont'ev, A. 1981. *Problems of the development of mind*. Moscow: Progress.
- Leont'ev, A. 1989. The problem of activity in the history of Soviet psychology. *Soviet Psychology* 271:22–39.
- MaKinster, J. G., Barab, S. A., and Keating, T. M. 2001. Design and implementation of an on-line professional development community: A project-based learning approach. *Electronic Journal of Science Education* 53. Available at <http://unr.edu/homepage/crowther/ejse/ejsev5n3.html>
- Marcus, G. E. 1998. *Ethnography through thick and thin*. Princeton, NJ: Princeton University Press.
- McNiff, J. 1995. *Action research principles and practice*. New York: Routledge.
- Nader, L. 2001. Harmony coerced is freedom denied. *The Chronicle of Higher Education* 47(July 13):B13–B16.
- Nardi, B., ed. 1996. *Context and consciousness: Activity theory and human-computer interaction*. Cambridge, MA: MIT Press.
- National Research Council. 2000. *National Science Education Standards*. Washington, DC: National Academy Press.
- Preece, J. 2000. *Online communities: Designing usability, supporting sociability*. Chichester, UK: John Wiley and Sons.
- Putnam, R. 2001. *Bowling alone: The collapse and revival of American community*. New York: Touchstone Books.
- Rich, A. 1986. Invisibility in academe 1984. In *Blood, bread, and poetry: Selected prose, 1979–1985*, ed. A. Rich, pp. 198–201. New York: Norton.
- Rogoff, B. 1990. *Apprenticeship in thinking: Cognitive development in social context*. New York: Oxford University Press.
- Roth, W.-M. 1998. *Designing communities*. Dordrecht: Kluwer Academic.
- Ruopp, R., Gal, S., Drayton, B., & Pfister, M. 1993. *LabNet: Toward a community of practice*. Hillsdale, NJ: Lawrence Erlbaum Associates.
- Scardamalia, M., and Bereiter, C. 1993. Technologies for knowledge-building discourse. *Communications of the ACM* 36:37–41.
- Schlager, M. S., Fusco, J., and Schank, P. 2002. Evolution of an on-line education community of practice. In *Building virtual communities: Learning and change in cyberspace*, eds. K. A. Renniger and W. Schumar, pp. 112–145. New York: Cambridge University Press.
- Schön, D. A. 1987. *Educating the reflective practitioner*. San Francisco, CA: Jossey-Bass.
- Schwandt, T. A. 1997. *Qualitative inquiry: A dictionary of terms*. Newbury Park, CA: SAGE.
- Shaffer, C. R., and Anundsen, K. 1993. *Creating community anywhere: Finding support and connection in a fragmented world*. Los Angeles, CA: Tarcher/Perigee.

- Shaw, R. E., Kadar, E., Sim, M., and Repperger, D. W. 1992. The intentional spring: A strategy for modeling systems that learn to perform intentional acts. *Journal of Motor Behavior* 241:3–28.
- Smith, M., and Kollock, P. (eds.). 1999. *Communities in Cyberspace*. London: Routledge.
- Songer, N. B., Lee, H. S., Hartman, M., and McDonald, S. 2001, April. *Towards a repertoire of exemplars of classroom science inquiry*. Paper presented at the American Educational Research Association, Seattle, WA.
- Stake, R. E. 1983. Program evaluation, particularly responsive evaluation. In *Evaluation models: Viewpoints on educational and human services evaluation*, eds. G. F. Madaus, M. S. Scriven, and D. L. Stufflebeam, pp. 287–310. Boston: Kluwer-Nijhoff.
- Stake, R. E. 1995. *The art of case study research*. Thousand Oaks, CA: Sage.
- Stringer, E. T. 1996. *Action research: A handbook for practitioners*. Thousand Oaks, CA: Sage.
- Vygotsky, L. 1978. *Mind in society: The development of higher psychological processes*. Cambridge, MA: Harvard University Press.
- Wells, G. 1999. *Dialogic inquiry: Towards a sociocultural practice and theory of education*. Cambridge, MA: Cambridge University Press.
- Wenger, E. 1998. *Communities of practice: Learning, meaning, and identity*. Cambridge, UK: Cambridge University Press.
- Wenger, E., McDermott, R., and Snyder, W. M. 2002. *Cultivating communities of practice: A guide to managing knowledge*. Boston, MA: Harvard Business School Press.
- Werry, C., and Mowbray, M. 2001. *Online communities: Commerce, community action, and the virtual university*. Upper Saddle River, NJ: Prentice Hall.
- Westheimer, J. 1998. *Among school teachers: Community, autonomy, and ideology in teachers' work*. New York: Teachers College Press.