

ISSUES AND TRENDS CONCERNING ELECTRONIC NETWORKING TECHNOLOGIES FOR
TEACHER PROFESSIONAL DEVELOPMENT: A CRITICAL REVIEW OF
THE LITERATURE

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ABSTRACT

Recent educational reforms and research on teacher professional development (TPD) recognizes that if teachers are going to improve their practice, they need to have access to on-going, quality professional development that is situated in their everyday instructional environment. During the past several years, network-based electronic communications have recently begun to be touted as tools that can fundamentally reshape TPD. This manuscript examines recent research concerning how these new technological tools have been used to support both pre-service and in-service TPD. To this end, the research base on network-supported TPD is critiqued. Through this critique of the research base four themes emerged concerning how network based communications has impacted teacher professional development: 1) Networking technologies can reduce teacher isolation and support sharing; 2) Networking technologies can foster reflection on practice; 3) Networking technologies influence on teaching practice; 4) Networking technologies support for the formation of communities of practice. Each of these themes is discussed along with the research base from which each theme emerged as well as suggestions for future research.

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INTRODUCTION

Within the past few years there have been numerous calls for the reform of teacher professional development programs (Darling-Hammond & McLaughlin, 1995; Gess-Newsome, 2001). These reforms emphasize providing teachers with on-going, quality teacher professional development (TPD) during the school year that takes into account teachers' context and needs (Lieberman, 1995; NRC, 2001). To date, however, there are relatively few TPD opportunities that provide teachers with on-going support that is situated in their everyday instructional environment (Schlager & Schank, 1997). To address this failing in current TPD programs, educators have begun to investigate how emerging technologies can be used as tools in supporting on-going and contextualized TPD programs. Specifically, electronic networks supported by e-mail, listservs, synchronous and asynchronous video and text conferencing via the World Wide Web are being touted as technological tools that can fundamentally reshape TPD and in turn reform current teaching practices (Watts & Castle, 1992). The purpose of this manuscript is to examine recent research concerning how these new electronic networking communication tools have been used to support both pre-service and in-service TPD. In particular, this review first discusses how these new information technology tools, coupled with recent educational reform efforts, have created a need for new approaches to TPD. Following this discussion, is a summary and critique of the research base and a discussion of what we have learned as a field based upon this previous research. This review closes with suggestions for future research concerning electronic networking as related to teacher professional development.

BACKGROUND: IS THERE A NEED FOR NEW MODELS OF PROFESSIONAL DEVELOPMENT USING NEW TECHNOLOGIES?

In the past twenty years members of the educational community have accumulated a wealth of information about improving teacher practice through professional development (Lieberman, 1995). However, this knowledge base is a significantly underused resource for teacher development because of the lack of a mechanism to

facilitate *sustained* information sharing and access to distributed expertise such as other teachers, university faculty and curriculum developers (Loucks-Horsley & Matsumoto, 1999). For example, the primary means that most teachers have to distributed expertise are their brief experiences at in-service workshops at their schools or universities, summer institutes, or through their own reading of practitioner-oriented journals (Marx, Blumenfeld, Krajcik, & Soloway, 1998). However, during the past decade, information technology tools have created new ways for individuals to communicate and share information and experiences with one another (Dede, 2000). It is this potential of electronic networking technologies to enhance communication and sharing of teaching practices that that many educators believe can fundamentally reshape the nature of teacher training (Barab, et al., in press).

Recent educational reform initiatives recommend that networking technologies play a more prominent role in K-12 classrooms (NRC, 1996). To this end, numerous projects have been developed that support students engaging in discussions and sharing data with their peers and professionals through electronic networks (Edelson, Gordin, & Pea, 1999; Songer, 1996). These same reform initiatives also expect teachers to reconsider their own practice, to construct new classroom roles for themselves and their students, and to teach in new ways (student-centered rather than teacher centered) that they did not experience themselves as students (Darling-Hammond & McLaughlin, 1995). However, an examination of K-12 teacher practices provides little evidence of a shift in practice (Cuban, 1993; Simmons, et al., 1998). Multiple reasons for this slow change in teachers' practice have been mentioned in the research literature. The two most frequently reported are school culture and lack of quality, on-going TPD. For example, several studies have found that even the most excited reform-oriented teachers typically alter their practice to conform with the prevailing school culture once they are immersed into a school whose culture does not value the sharing and discussion of innovative teaching practices (e.g. Simmons, et al., 1999). As a result, many teachers become disenfranchised because they develop the perception that there is little support for their new conceptions of teaching (Kagan, 1992). However, there is mount-

ing evidence that if teachers are provided access to on-going TPD they are less likely to become disenfranchised, less likely to leave the profession, and more likely to be more innovative and support reform based initiatives in their school (e.g. Bos, Krajcik, & Patrick, 1995). Unfortunately, there are relatively few TPD opportunities that provide teachers with ongoing support for change that are situated in their everyday instructional environment (Schlager & Schank, 1997). As a result, the teaching profession, historically, has lacked rich opportunities for meaningful growth experiences that are so critical for continued development of the profession such as defining what its own members should know and be able to do, or the responsibility for engaging in discourse with one another to evaluate and reflect on their practice (Ingvarson, 1998).

With the growing dissatisfaction toward TPD a number of educators have begun to explore differing approaches to TPD ranging from summer institutes to having teachers work with university faculty on curriculum development projects (Loucks-Horsley & Matsumoto, 1999). However, even the most exemplary TPD efforts have reported difficulties in maintaining support for teachers after an institute or workshop (Carey & Frechtling, 1997). With these concerns in mind, new models of TPD have been proposed that take advantage of the power of emerging electronic networking technologies (DiMauro & Gal, 1993; Shotsberger, 1997). In principle, these TPD programs provide teachers with greater opportunity to access and discuss exemplary reform-based materials, engage in dialogue and share their experiences with reform-based materials during the school year which is when teachers need access to professional development resources the most (Schlager, Fusco, & Schank, 1998; Shotsberger, 1999).

FRAMING THE REVIEW

In the past ten years, there have been many state and national efforts to study, encourage, and support increased use of electronic networking technology (in schools to support students and teachers (see Willis & Mehlinger, 1996 for a summary). However, only recently have educational researchers begun to explore the

strengths and weaknesses of electronic networking technologies to support teacher professional development. As a result, research in this field of educational technology is still in its infancy, but has expanded rapidly within the past few years as more teachers have gained access to the Internet and other local wide area networks. Hence, a review of the current research base is needed to not only summarize recent findings, but also to provide a common foundation upon which future research can be grounded as well as provide guidance to professional development designers as they develop learning experiences for teachers that leverage electronic networks.

The methodology employed for this review entailed a search of peer-reviewed research and practitioner-based journals, peer-reviewed conference proceedings in the learning sciences, teacher education, and educational technology since 1990. In addition, previous reviews such as the one conducted by Bos, Krajcik, & Patrick (1995) in which they reviewed ten studies concerning how telecommunications can support science and mathematics teacher reflection and collaboration were used to locate additional sources. These searches focused on identifying studies that examined or discussed the impact or influence of networking technologies on TPD. In the end, studies were selected that were based upon qualitative or quantitative empirical data collected from pre-service or in-service teachers participating in a project that involved the use of networking technologies to support their professional development. This selection process revealed thirty-five studies. These studies were then summarized in regard to their content, methods, results, and interpretations. The summaries were then examined to identify common themes using the constant comparative method (Glaser & Strauss, 1967). Through this examination and coding, four major themes emerged, and it is these themes around which this review is structured. Further, during this analysis each study was analyzed to determine the quality of the research reports. To this end, each study was examined for the characteristics of good empirical research as described by Wideen, Mayer-Smith, and Moon (1998). That is, each study was examined for a clear statement of intentions, a coherent theoretical framework, detailed information about the study and the study context, methods, sources of data, findings and

whether that data justifies those findings, conclusions that integrated the original theoretical framework, interpretations of the findings, and implications regarding how the research findings could impact teacher professional development. However, this is not to say, that each study specifically addressed a specific theme. Rather, several studies were multi-dimensional which enabled them to illuminate issues that cut across multiple themes and as such a single study may be discussed across multiple themes. In adopting this stance, it is acknowledged that the review presented here may be leaving out TPD programs using electronic networks in exciting and innovative ways (i.e. Carnegie Learning inc. K-12 teacher community, <http://www.carnegielearning.com/k12/community/>). However, by choosing to only focus on those studies that are based upon empirically gathered data this review will be in a better position to discuss the design and use of networking technologies for TPD. Lastly, this review extends the previous review of Bos, Krajcik, & Patrick (1995) by not only focusing on a larger array of studies (i.e. all teacher education rather than just math and science) but also critically evaluates the research and makes suggestions for future research (see Table 1).

RESEARCH ON NETWORK-BASED TEACHER PROFESSIONAL DEVELOPMENT

As stated previously, four themes emerged upon examination of the literature base. In this section each theme is discussed with its supporting research base and followed by an interpretive commentary that critiques the research findings in general and suggests areas for future research.

Theme #1: Networking technologies can reduce teacher isolation and support sharing.

Teaching has been characterized as a culture of isolation (Kagan, 1992). However, teachers who are attempting innovative teaching practices in their classroom need contact with mentors, access to resources, and support from their peers and other members of the educational community if they are to evolve their practice (Marx, Blumenfeld, Krajcik, & Soloway, 1998). In one of the

earliest studies on the use of electronic communications by teachers, Kimmel, Kerr, & O'Shea (1988) provided in-service teachers access to a computer networking conferencing tool that had both instant messaging capabilities and an asynchronous component. The researchers, after a review of the conference transcripts, found increased sharing of classroom materials and ideas and increased collaboration between teachers in developing activities for professional development workshops. Likewise, Jinks and Lord (1990) isolated 50 experienced rural K-6 teachers in a dormitory for a month to simulate their normal teaching environment, but provided them access to a computer network to communicate with each other and discuss teaching strategies and domain content. Mostly anecdotal evidence was gathered, but the evidence suggested that telecommunication tools could emerge into a powerful system for informational and moral support. Likewise, Thorensen (1996) examined how the Montana Educational Telecommunication Network (MET-NET) supported rural teachers in sharing and discussing teaching strategies and other teaching concerns. Specifically, Thorensen, examined the relationships and conversations between 20 mentor teachers (a mentor had five or more years of experience) and 20 novice teachers (mentees). Prior to the use of the network mentor and mentee teachers met in face-to-face sessions to get to know one another. Through her formative evaluation she found that novice teachers felt the network was valuable because of the emotional support it provided and they felt less isolated in their schools. Lastly, the mentor and mentee teachers reported that the initial face-to-face meetings were crucial in helping them to develop a sense of collegiality, camaraderie, and trust. This sense of collegiality was considered necessary by the participating teachers as they believed that it promoted constructive and critical dialogue regarding teaching challenges that they were encountering in their respective classrooms. Along similar lines, Merseth (1991) in a year long study with 39 first-year teachers participating in the Beginning Teacher Computer Network at Harvard University found that access to interactive computer networking was valuable in providing moral support for beginning teachers as well as allaying feelings of helplessness and embarrassment. Similarly, Souviney et al. (1995) found e-mail to be easier and more effective in increasing communication over

more traditional methods of communication such as voice mail, print messages, and even face-to-face conversations despite the problems students encountered in using e-mail and the increased time they spent sending and reading e-mail. In general, Souviney and his colleagues reported that secondary education teachers tailored the use of e-mail to their personal needs based on their existing context. Tannehill, Berkowitz, and LeMaster (1996) linked physical education teachers with a group of nine physical education doctoral students charged with establishing a working relationship with each teacher through e-mail and through the use of a newsgroup. Using questionnaire data and analysis of on-line postings Tannehill and colleagues found that the teachers had more success communicating via e-mail than through the newsgroup and perceived the technology as an important factor in decreasing their feelings of isolation and providing them with valuable and increased access to expertise. Thirunarayanan (1996), analyzing over two years of on-line discussion found that pre-service teachers in his class primarily used the electronic network for providing and sharing of information with each other about science activities and completion of course activities. Likewise, Powers and Dutt-Doner (1997) in a content analysis of over 856 listserv postings in a pre-service teacher education course found that nearly 18% of all messages were focused on support and encouragement with another 35% focusing on sharing of information. In a recent study, Roddy (1999) found that beginning teachers who had access to and participated in an electronic mailing list felt less isolated and more willing to engage in idea sharing and discuss classroom issues. However, Waugh's (1996) study on group interactions and pre-service teachers' questioning patterns using an electronic network found contradictory results. Waugh's results showed that the pre-service teachers posted questions that were predominately concerned with technical issues concerning the performance of the network and network strategies than with pedagogical and personal support questions.

One particular use of electronic networks that has shown great potential in encouraging participation and discussion has been teleapprenticeships (Levin & Waugh 1998; Thurston, Evangeline, & Levin, 1997). According to Levin and Waugh a teleapprenticeship is a framework that

takes advantage of the unique affordances of electronic networks to create apprenticeship like learning environments without requiring the participants to be in the same places at the same times. Levin and Waugh (1998) using a case comparison technique in which they compared and contrasted how different pre-service teachers used an electronic network to access expertise from their more experienced peers and subject matter experts found that beginning teachers could more accurately and completely answer their students' questions about the content under study after participating in the on-line discussions. Levin and Waugh (1998) also found that mediators (in this case, graduate students) were crucial in supporting and focusing their pre-service teachers' discussion. Similarly, Weis (1997) matched up pre-service teachers with a content area mentor using e-mail and a listserv. Her results indicated that her students believed the content mentor was quite beneficial in helping them develop lesson plans and other classroom activities, and felt such a resource would be invaluable once they begin their teaching careers. In another on-going project, the Students and Teachers Electronic Productivity Systems (STEPS) network have developed a system in which in-service teachers have access through an electronic network with their peers, content experts and more experienced teachers. The participants in this project have reported that they found the mentoring relationships to be useful and gave them additional confidence to try new and innovative teaching strategies in their own classrooms (Lehman, et al., 1992). Waugh & Rath (1995) also implemented the teleapprenticeship framework in six elementary science methods courses and collected data concerning pre-service attitudes toward the use of electronic networks. The majority of students indicated that they perceived the networks as useful tools for enhancing teacher training programs and supporting work in their schools. In another study that used networking technologies to link pre-service and in-service teachers, Norton and Sprague (1997) from a cohort of 40 in-service teachers enrolled in a technology integration course at the University of New Mexico, 15 were randomly paired with another in-service teacher taking a graduate level instructional technology course at George Mason University. The remaining 25 New Mexico students were then paired with 25 pre-service teachers enrolled in an introductory educational tech-

nology course at George Mason. A central aspect of Norton and Sprague's program was the use of e-mail to support the collaboration between pre and in-service teachers to develop lessons. Using surveys to assess their students' and the teachers' beliefs about the use of electronic networks, their results showed that the pre-service teachers' perceptions and attitudes toward the use of electronic networks for teaching improved and that all participants found the experience to be valuable. Then using a rubric, that was created by the researchers, found no significant difference between the quality of lessons created by in-service teams and the quality of the lessons created by the in-service/pre-service teams. In a recent study, with 68 sophomore pre-service elementary teachers Dutt-Donner and Powers (2000) using data from newsgroup postings and a summative evaluation survey found that if students were afforded the ability to self-direct the discussions participation were more active and the pre-service teachers began to rely upon one another for teaching strategies, ideas, and support. In Dutt-Donner and Powers' study the researchers, who were also the instructors of the courses, initially required their students to post to the newsgroup ten times (5 posts and 5 replies to their peers' posts), however their students posted more than were required which is atypical in comparison to other reports of how pre-service teachers actually perceive and use on-line discussion forums that are part of a course (Guzdial & Turns, 2000).

Interpretative Commentary: Issue #1

Generalizing across studies, electronic networking technologies appears to create favorable conditions for collaboration, sharing, and support that can aid teacher development. In particular, pre-service, novice, and rural teachers appear to benefit the most from having access to an electronic network. For example, a small school in a rural area may only have one physics teacher, but through an electronic network that physics teacher can seek new ideas, feedback on lessons, and discuss teaching strategies for teaching physics concepts which otherwise would be difficult in their local environment due to the lack of fellow physics teachers. Further, novice and pre-service teachers who do not have an experience base upon which to develop their own their personal peda-

gogical beliefs can gain considerable insight through extended discussions with experienced in-service teachers regarding specific teaching situations and strategies. However, in order for such sharing of teaching strategies and expertise the research suggests that the following social and technical structures be in place: (1) teachers have convenient access to computers and be comfortable in using the networking technology; (2) teachers believe that the discussion has immediate relevancy to their teaching and their students' learning; (3) the on-line discussions be focused so that teachers feel that their time is being well spent (this is particularly important for time-strapped in-service teachers); (4) and the electronic network has social supports (i.e. a way to develop trust and collegiality among participants) in place that encourage newcomers as well as experienced users of the network to not only engage in but also sustain longitudinal discussions. It is important to note that these four structures shift in priority when discussing pre-service teachers and in-service teachers. For instance, time and focus is of great importance to in-service teachers whereas pre-service teachers need to see the relevance of the use of an on-line discussion in terms of supporting their professional development rather than simply as another assignment that they must complete for a particular course. Hence, a crucial design challenge when developing professional development that is supported by on-line technologies is to utilize participant structures that represent and facilitate the sharing of tacit knowledge, a process that is central to effective sharing of expertise (Brown & Duguid, 1998)

There are two major limitations to a majority of the studies reviewed. One is technological and the other is methodological. First, methodologically, many of the results presented above are based upon surveys and self-reported data with little triangulation (Lincoln & Guba, 1986) done to examine how teachers use networks in more detail. This is not surprising considering the difficulty of conducting follow up studies, particularly with pre-service teacher populations, yet such studies will contribute much to our growing knowledge base concerning how and why beginning teachers decide to continue or discontinue use of an electronic networking system. Further, most of the studies reviewed have been of short duration usually lasting over the course of a single

semester or single class. This can impact how a new technology is used because it typically takes the average user time to not only learn the system, but also to trust the system and incorporate it into their everyday working culture. Second, technological constraints have limited the type of data collected because it is difficult to track all messages that are exchanged between participants. For example, participants can easily send private e-mails to one another without sending the e-mail to a researcher or posting their message on a listserv. Therefore, there is a need for additional rigorous research that: (1) examines what social and technical structures within an on-line environment support communication and collaboration; (2) examines what are the characteristics of those teachers that do actively participate in electronic networks; (3) are longitudinal and designed to develop an understanding of the conditions that encourage or inhibit teachers use of an electronic network in regard to their professional development activities. For example, do pre-service teachers who used an electronic networking systems in their undergraduate courses (in which use of the network is mandated by the instructor) continue to use the network after the course has concluded and there is no longer a mandate by the instructor to use the network? Further, if pre-service teachers do continue to use an electronic network what are their reasons for doing so and how can professional development designers reify the teachers' reasons into the design of a professional development program that leverages electronic networking tools? Some possible avenues for exploration could be to examine if teachers continue to use electronic networks because they have access to expertise such as more experienced teachers or university educators, or because the facilitator of the forum or listserv is particularly skillful in engaging teachers in discussing their practice, or is it simply because of teachers desire to communicate with teachers outside of their local environment? Finally, there needs to be an examination of teachers' social network (i.e. do teachers who use networks have colleagues who support them) to determine what factors influence, support, or inhibit the use of an electronic network for the sharing of teaching practice.

Theme #2: Networking technologies can foster reflection on practice

It is widely believed that effective professional development must provide teachers with opportunities to reflect on their teaching practice with other teachers and educators. The opportunity to reflect on practice must not only occur during the summer when time is available but also throughout the year when professional development programs must compete with teachers' other numerous and time consuming responsibilities (Darling-Hammond & Lieberman, 1995). Hence, a number of TPD programs have incorporated electronic networking technologies to support teachers reflection on their practice when time permits throughout the school year. In one of the earliest studies on the use e-mail, Merseth (1991) surveyed first-year teachers who used an e-mail network to keep in touch with their peer group. He reported that that the teachers primarily used the network for peer support rather than reflecting on teaching strategies or pedagogical practices. In later studies, this finding was supported by Gunn (1995) and Roddy (1999). Both Gunn and Roddy reported that when beginning teachers engaged in dialogue over an electronic network their conversations primarily focused on giving and receiving emotional and moral support rather than on curriculum and teaching concerns or other professional development related questions. In addition, Thomas, Clift, & Sagurmoto (1996) suggested that electronic communication is likely to influence the content of the message depending on who the messages were focused at rather than being reflective in nature. They found that most of their pre-service teachers posted responses only because use of their electronic forum was a course requirement. Further, Thomas and colleagues found that the instructors' messages had the highest priority whereas their peers' messages had relatively low priority unless a student sent a message that was specifically addressed to another student. Lastly, through extensive analysis of the interactions that occurred over the network the researchers determined that reflective exchanges typically only occurred between faculty and students and were not shared with their peers. As a result, there was little opportunity for developing a shared understanding of what it meant to be a deliberate practitioner, and perhaps reinforcing pre-service teachers' perception that learning

about one's practice only comes through private reflection rather than prolonged social discourse with other teachers.

A few studies have gathered evidence that electronic networks do, at times, support reflection on practice. For example, Casey's (1994) study on TeacherNet at California State University reported that pre-service teachers using a telecommunication network spent more reflecting on what they were learning and felt less isolated in student teaching. In addition, in a preliminary study of ten in-service teachers, McDonald & Songer (2000) found that when teachers collaborated with one another through an electronic network while planning the implementation of the One Sky Many Voices curriculum, they tended to reflect more on the pedagogical strategies that would be most beneficial to improve their student learning. DiMauro & Gal (1994) as part of the multi-year LabNet project examined the discourse between eight Teacher Liaison Consultants (TLCs) (teacher leaders) and practicing teachers. The ensuing dialogue was examined and categorized into one of three modes, informative, responsive, and reflective. They classified a reflective mode as a message that engages the authors self, is stated in a nonjudgmental manner, and invites inquiry. However, they found that the reflective mode was rarely encountered in the network dialogue. They also found that reflective postings tended to be longest of any type of posting though the researchers did not investigate the reasons behind this phenomenon. In another recent study, Schlagel, Trathen and Blanton (1996) examined the on-line conversations between sixteen pre-service teachers and five professors in a pre-service teacher education course. They found that if reflective dialogue was to occur the participants needed open, thematic prompts, focused messages from one another, and time to reflect. When these conditions were met they found that most students engaged in an iterative reflective process of fine-tuning their thinking about their teaching practice. Piborn and Middleton (1998) examined whether a listserv can promote pre-service teacher reflection. Specifically, they examined whether a listserv could replace more traditional journal keeping. Through a content analysis of the listserv postings Piborn and Middleton found that postings that focused on an integration of content and pedagogy facilitated considerably more reflective dialogue

that other types of posts. They also concluded that the listserv posts were as complex, thoughtful, and as meaningful to the process of learning to become a teacher, as any they had seen in traditional journals. In another study with 28 elementary and middle school teachers in ten suburban Chicago schools Hawkes (2001) found that collaboratively produced network-based communication was significantly more reflective than face-to-face discourse between teachers. Upon closer inspection, however, Hawkes found that neither face-to-face nor on-line communication supported high overall reflective discourse, yet in comparison the network-based discussions had higher reflective discourse than did the face-to-face discussions. Specifically, Hawkes used Simmons et al. (1989) taxonomy to determine whether an exchange was reflective and in what manner the exchange was reflective. Through his analysis, Hawkes determined that the network-based discussions were mainly used by teachers to discuss and on occasion reflect upon the effects and impact of specific types of instruction. Through an analysis of the network logs, Hawkes found that two-thirds (66%) of posts categorized as reflective occurred while teachers were at home or outside of school hours. Similar to previous studies, Hawkes also found that there had to be a focused topic to promote discussion and reflection. For example, there needed to be a discussion about a specific subject such as classroom management or another similarly focused topic if reflective discussions were to emerge in the network-based environment. In another study with thirty-five prospective elementary teachers enrolled in an undergraduate teacher education program Levin (1999) studied four different types of message exchanges ranging from (a) student-to-peer e-mail journal entries exchanged between self-selected pairs in her class, (b) student-to-keypal e-mail exchanges with a teacher candidate in another state, (c) e-mail exchanges between students and their university instructor/supervisor, and (d) student-to-group messages exchanged as part of an asynchronous, Web-based, threaded discussion. Through her content analysis of the discussions Levin found that the major uses of the electronic communications included opportunities for personal reflection, sharing teaching activities, and offering support. However, primary use of the web-based discussion forum was for reflection. For example, reflection served as the purpose for only 26% of

student-to-peer exchanges, 14% of student-to-keypal communications, and 13% of student-to-instructor messages. Levin speculated that the reason the web-based discussion supported reflection were three fold: (1) an appreciation of the chance to learn from others, (2) a sense of validation because their feelings and experiences were similar to others, and (3) enjoying feedback on their ideas from more than one person.

In an ongoing project, Barab and colleagues (in press) have developed a Web-based professional development system called the Inquiry Learning Forum (ILF). The ILF is a Web based professional development system designed to support a community of in-service and pre-service mathematics and science teachers sharing, improving, and creating inquiry based pedagogical practices. Further the ILF is designed to support science and math teachers in observing other teachers' classroom through on-line video vignettes of their classroom. Around the video vignettes is an on-line discussion system through which teachers can discuss and reflect upon pedagogical theory and practices shown in the video vignettes. Research to date concerning how participation in the ILF has impacted teacher practice has primarily been conducted through interviews with teachers. Through interviewing three participating ILF teachers (one in-service mathematics teacher, one pre-service teacher, and one in-service science teacher) revealed little evidence that these teachers felt the ILF had impacted their practice. Specifically, the pre-service teacher who was doing her student teaching practicum at the time of the interview believed the idea of having student teaching reflections posted on an ILF discussion board was a good idea, but mainly viewed the exercise of posting a part of her instructor's course assignment and did not engage in a prolonged reflective dialogue with her peers about her teaching practice.

Interpretative Commentary: Issue #2

Many educators are touting that electronic networks can be used as a tool to support teachers in reflecting on their teaching and through their participation in electronic networks become reflective practitioners. This belief is grounded on the premise that through engaging in discussions with their peers' teachers can make their implicit

beliefs about their pedagogical beliefs explicit and public. Through this self-reflection and sharing process it is believed that teachers will develop a better understanding of their teaching practices and develop strategies regarding how to improve their teaching (Barab, et al., in press). The research findings, however, are mixed regarding the efficacy of electronic networks to support reflection. This is not surprising, when one considers the number of variables that need to be taken into account such as the context in which the teacher is teaching, the personality of the teacher (i.e. are they reflective by nature?), the time during the school day when the teacher uses the network, how much time they have to dedicate to the time-consuming process of articulating their teaching beliefs, and do the teachers consider reflection an important of their profession. However, research to date does suggest that teachers may be more reflective when participating in electronic network forums in part because such forums afford teachers opportunities to engage in conversation with a group of non-threatening peers who can be supportive, provide multiple perspectives (i.e. pre-service teachers discussing with in-service teachers or other pre-service teachers at different universities), and give feedback to each other as they learn what it means to be a teacher (Levin, 1999).

The reviewed studies did bring up critical issues, however, most of the studies reviewed were of short duration typically lasting the duration of a single course. In addition, there needs to be a more rigorous discussion concerning what constitutes reflection in an on-line environment. DiMauro and Gal begins to address this issue, by defining reflective dialogue, but the other studies do not describe how they determined which statements in the on-line dialogue were reflective. One exception is the study conducted by Hawkes in which he specifically describes the taxonomy used to categorize teachers' posts as reflective in nature. Yet, there should be additional studies to investigate the reliability of the taxonomy with a larger and more diverse set of teachers.

Additional research is needed to understand how telecommunication tools can be used in pre-service classrooms to support pre-service teachers in becoming reflective practitioners rather than simply using the system to meet course deadlines, and how pre-service teachers' needs differ from in-service teachers' needs when com-

municating through electronic networks. Lastly, there is a need for design research that examines how networking technologies can be utilized to not only support, but also to promote teachers' reflection on their practice. That is, will teachers reflect in an open forum where their thoughts are visible to all members of the network or do they need a private workspace where they can share their reflections with a smaller group, as DiMauro and Gal (1994) suggest? These questions need close examination in the design of any on-line environment to support teachers in sharing their teaching practice.

Issue # 3: Networking technologies influence teaching practice

Eventually, the goal of professional development activities is its impact on actual teacher practice. With this goal in mind TERC's (<http://www.terc.edu>) two-year Star Schools Project set out to examine if access to telecommunications tools could support teachers in changing their practice from teacher-centered to practices more aligned with current national standards (i.e. inquiry-based). Specifically, Star Schools provided teacher support and training in technology and telecommunications software, along with curricula and on-line projects. In all, 932 teachers participated in a survey evaluation and reported that they had actively changed their teaching style from more traditional to more cooperative based and student-centered. However, the study did not report on any classroom observations of actual teachers or interviews with teachers, and did not describe the context in which the teachers were teaching. Understanding the context in which teachers are teaching is crucial to understanding if telecommunications tools can impact teachers' practice as was found by Sunal and Sunal (1992). Sunal and Sunal (1992) grouped fifty-eight pre-service teachers into control and experimental groups by placing them in schools with varying administrative schemes for incorporating local area networks. They found that in school sites where the administration supported (experimental) network use, the pre-service teachers communicated more often (5 more message per week) than those in non-supportive (control) schools. In addition, the pre-service teachers in the administrative supportive schools communicated more with their

peers than with university faculty, and the discussions focused on seeking help and approval in lesson planning, selecting alternative classroom activities, and implementing those lessons within their specific teaching context. Generally, the authors concluded that participants in schools with administrative support developed a more favorable attitude toward use of technology in schools, communicated more frequently with their peers, and were more willing to try innovative practices in their classroom. The authors also examined the teachers' lesson plans and found those of the experimental group tended to be more student-centered than those in the control (non-supportive) group. Therefore, the electronic network in Sunal and Sunal's study served as a tool to support the evolution of teacher practices who were placed in schools with administrators who supported the use of electronic networks for teacher professional development.

In a new project, the Secondary Teacher Education Project (STEP) uses web-based video cases to demonstrate innovative teaching practices (i.e. inquiry-oriented teaching). In this project, pre- and in-service teachers are expected to discuss and argue about possible solutions and search the STEP database for relevant information to support their point of view on what the teacher in each case is trying to do and what they would do in that particular teaching situation (Siegel, et al., 2000). Preliminary results suggest that through this discussion pre-service teachers were encouraged to consider how they would teach in their own classroom and the system supported making teachers' implicit beliefs about teaching more explicit and hence facilitated teacher reflection on their epistemological beliefs about teaching. In a similar vein, Bliss & Mazur (1996) examined the interactions between six experienced history teachers and six student teachers as they used computer videoconferencing to discuss history teaching in actual classrooms. Through interviewing and analysis of the dialogues they found that participants valued talking with someone not connected with their immediate school situation and that the in-service teachers liked having the opportunities to actually discuss instructional strategies concerning how to teach history in the context of real classrooms. The mentors also found the mentoring experience beneficial because it provided them the opportunity to think more

deeply about their practice and how they could improve their teaching. In a similar project, Johnson (1997) used e-mail to connect students in her reading methods course with in-service teachers. Johnson reported, that her students to gain a deeper perspective on different philosophies of teaching and also helped them to become more comfortable with using technology. Johnson also reported that the participating in-service teachers found the experience valuable because the discussions over e-mail provided them with opportunities to reexamine their own classroom practices and the effects of accepted instructional techniques on the teaching/learning process. However, Johnson did not discuss whether the in-service teachers had actually made changes to their teaching after participation in her study. Barab, et al. (in press), however specifically investigated whether participation in an on-line discussion did impact teacher's practice. In their on-going project, the Inquiry Learning Forum (ILF), they reported that teachers believed that participation in the ILF was helpful to them in thinking about their practice, but that participation in the ILF had yet to have any impact on how they actually teach. Finally, McGinnis (1996) using comments from his students in an graduate elementary science methods course found that many of the students believed that network-oriented communication technologies could enhance their teaching practice and lead to increased teaching professionalism.

Interpretative Commentary: Issue #3

How professional development impacts teachers' practice is crucial in evaluating the effectiveness of a TPD program. However, to date, little research has been conducted concerning how electronic networks impact actual classroom practice and those that have their results have indicated that participation in an electronic network often does not influence teachers' practice. To date, with the exception of TERC's Star Schools most electronic TPD programs have relied on self-reports from teachers concerning how the TPD impacted their practice or brief interviews asking teachers to reflect on the value of the network in which they were participating. While, teachers may indeed be gaining useful knowledge from electronic networks it would be beneficial to conduct more site-based research including inter-

views and extended classroom observations so that the educational community can better understand the impact of teacher participation in an electronic network on teaching practice. This line of study will expand our knowledge base concerning whether participation in an electronic network actually facilitates and supports teacher change because there are numerous accounts of teachers reporting that they are student-centered when in fact their actual practice is still teacher-centered (Simmons, et al., 1999). There is also a need for longitudinal studies that examine how teachers' beliefs, reflective activities, and practice evolve over time as they use electronic networks through their student teaching and into their first few years of in-service teaching. Further, research is also needed that examines teacher practice from multiple perspectives. First, researchers need to conduct pre-interviews and pre-classroom observations of teachers to develop a grounded account of teacher beliefs and practices prior to participation in an electronic network. Then over time researchers need to observe teachers' on-line dialogue, conduct follow-up field observations and interviews with the teachers to determine how they believe participation in the network has impacted their practice and how their practice has actually changed or if participation in the network has simply amplified and reinforced their existing practices (Miller & Olson, 1994). The findings from these longitudinal and in depth studies will enable educational researchers and professional development designers to develop better understandings concerning how electronic networks can support teachers in examining and reforming their practices.

Issue #4: Networking technologies support the formation of communities of practice

Lave and Wenger (1991) used the term "communities of practice" to illuminate the importance of activity in binding individuals to communities, and in communities to legitimize and support the development of individual skills and practices. In the intervening years, the concept of community of practice [see Wenger (1998) for a more complete discussion of Community of Practice] has become a major theme of teacher professional development (Lieberman, 1995). This emphasis on building and designing commu-

nities of practice has recently begun to be explored using on-line environments, which many educators believe can lead to virtual communities for TPD that support teacher change and innovation (Guzdial & Weingarten, 1996). For example, Levin & Waugh (1998) claimed that a community building process emerged when students in a pre-service classroom could communicate with their off-campus colleagues because the network provided opportunities for participants to discuss their situations and develop a joint understanding of each other's teaching context. They found that the off-campus students, who were usually teaching in a K-12 classroom, could request help from their own campus colleagues and discuss how the strategies employed in the classroom worked and then reflect on the process. Over time, the researcher postulated that a sense of collegiality, sense of a shared history, and trust pervaded the system, which are the beginning foundations for community development (Barab & Duffy, 2000). McGinnis (1996) using an action research approach in a graduate level elementary science methods found that use of an electronic mail discussion group enhanced communication between members of the class ($n = 13$) and fostered a sense of community and camaraderie among the class members.

In an on-going multi-year project TAPPED IN (a web-supported professional development site for teachers) researchers have been examining the role that technology has in transforming and sustaining a TPD on-line site grounded in the community of practice concept (Schlager, Fusco, & Schank, in press; Schank, Fenton, Schlager, & Fusco, 1999). Much of TAPPED IN's work has focused on how to design an on-line TPD site, and through this work they have made several interesting observations and findings. First, they have concluded that for an on-line community of teachers to develop there first must be a "critical mass" of users actively participating (Schlager & Schank, 1997). In addition, by observing the interactions of TAPPED IN's members over time they have concluded that for a community of teachers to appear the member teachers must be engaged in thoughtful, focused, and reflective discussions surrounding actual classroom teaching experiences (Schlager, Fusco, & Schank, in press). However, Schlager and Schank (1997), upon detailed analysis of the evo-

lution of on-line messages, concluded that it takes considerable amounts time for teachers to become familiar and comfortable conducting discussions within the TAPPED IN environment. Hence, the formation of an on-line community of teachers is not something occurs over a short period time (i.e. the course of a single year) but rather may take a number of years as teachers slowly develop familiarity and trust with the particular electronic network technology and other members. In another innovative on-line project, LabNet focuses on building a community of practice through engaging science teachers in discussions about innovative approaches (project-based learning) to teaching science. Research on LabNet participants, presented in the form of case studies, shows that member teachers were in a better position to keep up to date on school changes, were more willing to experiment with innovative teaching practices, and even encouraged their non-participating peers to try innovative teaching methods (Ruopp, Gal, Drayton, & Pfister, 1993).

In a longitudinal study Selwyn (2000) examined SENco (Special Needs Coordinators forum) one of the longest established and most heavily subscribed United Kingdom on-line discussion groups for special needs teachers. Using an extensive analysis of 18 months of dialogue ($n = 3,654$ messages and 734 total threads) Selwyn found that the online forum was mainly used as information and emphatic exchange resource rather than as a vehicle for the formation of a community of practice. Specifically, Selwyn found that there was a core group of SENco members that responded to others questions, provided support, and shared their expertise with others. This core group ($n = 26$ of 800 total members) was responsible for nearly one-third of all posts in the forum. However, there were only a few discussions that reflected some type of an attachment to the members of the forum. Based upon these findings Selwyn concluded there was little evidence supporting the claim that sense of community had developed. In fact, many discussions were held between individuals or small groups and when more group-focused messages were posted to the forum they seemed to lack a feeling of cohesiveness or genuine attachment to other members of the forum. In the end, Selwyn concluded that, any manifestation of a community spirit was infrequent and to claim that there was a

sense of community would be to greatly exaggerate the bulk of the online activity.

In another ongoing project, The Inquiry Learning Forum (ILF) project which was designed around the metaphor of allowing teachers opportunities to visit one another's classrooms through the viewing of on-line video clips, critique one another's teaching, and participate in a supportive community of practice. However, based on findings from their formative research, Barab and colleagues (in press) found that teachers wanted a place to share resources and learn from the successes and failures of their colleagues' implementation of various curriculum materials rather than to critique their peers. In addition, their findings also revealed that teachers' desires for professional development were located strongly within their local teaching contexts such as their subject matter expertise, student demographics, local demands, and school culture and that the development of a community of practice extremely challenging and to date has not occurred. Using these findings, the ILF has been redesigned with the goal of enhancing the sociability (increasing interaction between members) of the ILF site through facilitation of sustained active participation and by providing teachers a sense of ownership over their professional development rather than supporting occasional visits to the ILF to simply gather information. However, after two years of implementation the ILF design team has reported that, facilitating a sense of community and commitment has been extremely challenging in part because the ILF has yet to reach a critical mass of participants and in part because of the challenge of getting teachers to log into the ILF on their free time and critique other teachers' teaching.

Interpretative Commentary: Issue #4

The use of electronic networks for building a community of practice to support teachers is truly in its infancy and to date the research has primarily focused on how to design an on-line environment that supports the building of a community of practice. These studies have focused on determining what structures of on-line environments teachers find useful and how to improve them to meet teachers' needs. This research goal is quite valuable; however, considerably more research is needed that examines how to employ on-line

technologies to achieve the goals of recent TPD reforms and to cultivate communities of practice which, to date, has been quite challenging to educators.

There are also a number of questions regarding what a community looks like on-line and why a teacher would choose to participate in such a "community". Schlager et al. (1997) suggested that for TAPPED IN to be a community of teachers the number of participants must reach a "critical mass". However, the concept of critical mass was not defined and Schlager et al., (1997) did not believe that TAPPED IN had reached a critical mass of participants. From studies outside of teacher education there is evidence that for on-line communities to form there must a minimal number of participants. For example, Hiltz and Turoff (1978) conducted observations on computer conferencing systems and found that conferences which did not have at least eight to twelve participants failed because they did not produce significant activity to justify keeping the attention of some of the participants. Later, Palme (1995) argued that if a system was to not only survive but to be productive and active it was necessary to have between 20 and 50 subscribers. He based his estimate by assuming the probability that a user will receive a response is 0.05 and with such a low probability of a response there must be a minimum 21 active participants for someone to receive a response to their post.

To date, on-line teacher communities have reported that a significant challenge has been sustained participation. For example, both the ILF and TAPPED-IN projects have struggled to increase and maintain high levels of participation in their respective on-line communities, despite the large number of users that are registered for each project (ILF 980 members and TAPPED IN 9500 members). Studies of other on-line communities have suggested a tension between having enough participants and having too many members. For example, as the group size increases there is a greater probability of a response, but the hope of reciprocity appears to lessen with the size of the group. This behavior has been attributed to the weakening of the links that bind the participants (givers and receivers of information) together due to the increased volume of posts and discussion threads that each member must sort through (Drot-Delange, 2001). As a result, a member is

more likely to take a passive role rather than an active one. In examining this behavior Smith (1992) through his analysis of interactions and community processes in the WELL (The WELL was founded in 1986 and is one of the older virtual communities with 6600 members) concluded that as the size of an on-line group increases, the costs of an individual's decision not to participate are spread over a greater number of persons. That is, if the lack of being an active participant (i.e. being a lurker) does not affect the group in a major way or if the member feels that their needs are being met simply through lurking then the temptation to be a lurker increases. Finally, when the group reaches a significant size, it is more difficult to coordinate its activities in such a way as to discourage lurking and members can simply fall through the cracks of the system and lose any sense of belongingness to the community. Therefore, it appears crucial that when designing an on-line professional development program that wishes to create a sense of "community" there first must be a minimal core group of active teachers who interact with each other and encourage newcomers to participate as well.

There are a number of questions remaining concerning how or if an on-line community of teachers can be designed. For instance, if a viable and vibrant on-line community of teachers is to form, is it necessary for the on-line participants to have an established sense of trust first through off-line face-to-face meetings or can trust between participants develop in the absence of off-line face-to-face meetings? In addition, are there differences in the type of interactions between on-line participants that have a pre-established relationship than those who do not already have a pre-established relationship? Further, researchers have found that most users of on-line communication prefer to "lurk" or passively participate (Ogden, 1994; Smith, 1992). Therefore, is it possible for on-line forums and discussion groups to develop a sense of community when, in all reality, the participants have no real shared obligation to each other? Perhaps, such on-line forums and discussion groups would be better characterized as "pseudo communities of teachers" which are merely sites for information exchange or are there specific designs that will transform the "pseudo community" into a vibrant and healthy community where teachers actively participate and examine

their teaching practices? This latter point, speaks directly to the issue of cost of participation for a teacher in an electronic network. Cost in this case refers to both how much time and energy a teacher has to put into such a community and what are the consequences (both personal and professional) for disengaging from the community. For example, the greater the cost (time and energy to get started), the less motivation a teacher has to contribute. Further, if the discussions and other on-line activities lack pertinence, quality, or reciprocity (i.e. a teacher asks a question but receives no feedback) the cost of disengagement is low and a teacher can leave the community without consequence. In addition, to cost there is also an on-line community of teachers should also be heterogeneous. Heterogeneity within in the on-line community increases the possibility of teachers contributing because diversity increases the possible benefits expected from the community due to the convergence of differing perspectives and experiences (Kollock, 1999). Therefore, it appears that significant features that characterize off-line (traditional) communities transfer, at least to some extent, to an on-line setting. However, we still need to better understand in what ways on-line communities differ from traditional communities. In addition, much of a teachers' development occurs in the context of their own classroom and everyday activities, so there is a need to examine how on-line environments can support teachers in meeting their individual needs yet still be useful to a community of teachers in helping them meet the requirements of state and national reforms.

A number of technological issues that are crucial to the adoption and use of an electronic network are just beginning to be analyzed. For example, in working with TAPPED IN teachers, Schlager, Fusco, and Schank (in press) have come to the conclusion that traditional web sites and traditional discussion boards are not sufficient to achieve the desired objectives of on-going professional discourse so crucial to teacher development. Therefore, researchers and designers must consider how new and emerging network technologies might be used to support on-going TPD, particularly how to foster reflective discourse and how to support and to encourage reform-based teaching principles. There is also a need for a comparative analysis of the factors that contribute to the success or failure of on-line teacher com-

munities, particularly concerning how they support the evolution of teaching practice so that guidelines concerning how to design on-line environments can be developed. Lastly, there is a need for longitudinal research that examines teacher's interactions through an on-line network over time so that we can better understand how and why teachers share their expertise with each others, indoctrinate newcomers, and why teachers continue or discontinue their use of the network. For example Levin and Waugh study was conducted over the course of a single semester, which makes the claim that a community of practice was truly formed questionable since community formation is a long and tumultuous process (Barab, Barnett, & Squire, in press; Palinscar, Magnusson, Marano, Ford, & Brown, 1998; Thomas, Wineburg, Grossman, Myhre, & Woolworth, 1998).

CONCLUSIONS: WHAT WE HAVE LEARNED

To date, research on TPD programs supported by electronic networks has shown great potential for supporting teachers' professional growth. In fact, these studies have lead to a number of issues that professional development designers should attend to when choosing to use electronic networks as a central feature of their professional development program. Specifically, the research implies when designing network-based teacher professional development the on-line environment should support the following capabilities: (1) the ability to locate mentors or others with similar interests (2) work in collaborative groups (i.e. in-service teachers working together on a particular task), (3) share resources and information, (4) support and encourage sustained and focused discussions, (5) encourage reflection on classroom teaching, (6) support diverse collaborative groups (pre-service and in-service teachers working together), (7) support trust building and a sense of community, (8) have skilled facilitators or moderators that encourage participation. The following discussion summarizes the general issues that cut across the aforementioned capabilities that networked based professional development should address.

Trust: Trust is often an overlooked aspect when designed professional development, however, it is essential that trust building be central in the design of professional development, particularly for

TPD that emphasizes use of electronic networks. Teachers generally lack opportunities to share their thinking and to construct new knowledge about their teaching practice through discussion with teachers outside of their school (Loucks-Horsley, Hewson, Love, & Stiles, 1998). Across studies the necessity of face-to-face meetings was crucial in developing a sense of trust between participating members. This could be due to the prevalent culture of teacher isolation in schools (Kagan, 1992) because teachers are not accustomed to making their reflections about their practice public with their peers and as such are frequently at a loss on how to engage in meaningful discussions with one another concerning their practice. However, when teachers had face-to-face meetings (i.e. class for pre-service teachers and workshops for in-service teachers) with each other to discuss their concerns before using an electronic network the discussion on the network was much more likely to push teachers in thinking about current reforms and how to improve their practice. For example, Watts & Castle (1992), through their work with the School Reform Network, found face-to-face meetings between participating members served as the central means through which their electronic network could then be used to support further community building. Hence, it appears that if an electronic network is to be successful in supporting teacher professional development there first needs to be an off-line component where teachers meet and discuss their situations, hopes, fears, and develop a sense of trust and collegiality. It is only through this off-line component that sufficient trust will be developed between participants which will allow for the growth of a vibrant on-line professional development program.

Through the use of electronic networks teachers in different geographical regions can share their experiences, reflect on how new teaching standards are impacting their practice, and reflect-in and reflect-on their practice. However, the professional development process of teachers participating in electronic network based TPD programs is slow and complex process as teachers gradually came to trust the network and began to see the value of reflective discourse in improving their students' learning and their own teaching. In other words, teachers must trust that their time spent in the electronic network will directly im-

pact their student learning and improve their students' scores on standardized tests. Hence, in the design of an electronic network for TPD designers must be aware that discussion and in depth reflection concerning teaching practice will not occur instantaneously. Rather, it is a multi-faceted process which requires time for teachers to become comfortable with sharing their thoughts and ideas over a network that has a memory of all interactions. That is, every interaction (i.e. discussion post) leaves a permanent historical trace and most teachers are used to and comfortable with transient interactions (discussions in the teachers lounge and phone calls) that do not leave a record of their beliefs and opinions. Building trust in the system should be the first and foremost concern of TPD designers who plan on using electronic networks to support sustained professional development programs.

Skilled Facilitators and Moderators. Whether participating in an electronic network, a pre-service course, or a face-to-face session, the skill of the moderator or facilitator can make or break the learning experience (Loucks-Horsley, Hewson, Love, & Stiles, 1998). Simply viewing and discussing lesson plans, teacher videos, and other resources is not necessarily supportive of transforming teachers' practice. Searching electronic network for information has the practical value of locating classroom tools and ideas for lessons. However for electronic networks to be effective TPD tools a skilled facilitator or moderator is needed to guide and encourage discussion. It is often the skill and expertise of the moderator in fostering provocative and thoughtful discussions that leads to deeper and more reflective learning on the part of teachers (Levin & Waugh, 1998; Grossman ref, 1998). Conversational facilitation is particularly important in electronic networks that are grounded upon the exchange of dialogue among its participants because the network's strength rests in the regular, reflective contributions of each participant (Guzdial & Turns, 2001). If there is not timely feedback or encouragement conversation will stagnate and participating teachers will grow frustrated because they will likely perceive that their work and opinions are not valued by their peers. In fact, it was these concerns that led McGinnis (1996) to suggest that the instructor's role in a network based environment is to orchestrate discussion by actively posting

messages, encouraging students to participate, and designing situations for all students to use the technology to communicate with each other in ways that are not normally possible within a typical pre-service classroom environment.

Pre-Service and Novice Teachers. Electronic networks appear most helpful for beginning teachers. Through electronic networks novice teachers can access a wide range of distributed expertise ranging from more experienced teachers to university faculty (Johnson, 1997). Further, through on-line discussions pre-service teachers can develop a better understanding of the complexity of real classrooms (Schlagel et al., 1996). This can be of particular help at those institutions whose pre-service teachers are not afforded significant amounts of teaching time before they begin their student teaching practicum. However, instructors who use electronic networks in their courses must pay particularly attention to the factors and structures discussed previously in the first theme (Networking technologies can reduce teacher isolation and support sharing) or else the electronic network will likely be perceived as simply "busy work" by pre-service teachers (Nonis, Bronack, & Heaton, 2000). In addition, through using electronic networks beginning and novice teachers can learn more about technology and how it can be used to support their students' learning. For instance, in the One Sky Many Voices Project (Songer, 1996) students use e-mail and an on-line WWW forum to share and discuss their scientific procedures, findings, and argue over the meaning of their collected data. However, if teachers are not comfortable with using electronic networks themselves then it is reasonable to assume that their studies will not be afforded the opportunity to participate in innovative programs that use electronic networks as their central of means of communication.

Teachers, particularly novice teachers, are facing rapidly increasing demands. For instance, teachers are being asked to teach more content more effectively and devote more time to having students engage in inquiry oriented practices, while at the same raising their students' scores on standardized exams (Edelson, 2001). Further, many beginning teachers, often face the daunting task of designing lessons to meet a myriad of national, state, and district content standards that emphasize inquiry, face large class sizes, and

heavy course preparation loads with inadequate resources and without the necessary supports (i.e. on-going professional development) to help them in transitioning from a novice to an experienced teacher. Therefore, it is not surprising that many beginning teachers become discouraged and disillusioned at the lack of support afforded them and fall back to how they were taught or even leave the profession all together (Stansbury & Zimmerman, 2000). Perhaps the greatest potential of electronic networks for beginning and novice teachers is that participants in the network can engage in discussions, share their concerns, reflect upon their teaching practice, and develop collegial supportive relationships with others (Hawkes, 2001). That is, through the use of electronic networks novice teachers can view more experienced teachers' reflections on their classroom practice and share their own concerns and receive feedback from their more experienced peers (i.e. behavior management techniques, inquiry vs. didactic based teaching). Through such discussions with experienced teachers novice teachers can make their reflection regarding their teaching public and begin the process of becoming a deliberate practitioner which is crucial if novice teachers are to develop and refine his/her practice (Dunn & Shriner, 1999). These discussions can then lead to more self-reflection which can support practitioners in coping with the troublesome situations that arise out of their practice (Schon, 1983). Hence, when developing professional development that utilize electronic networks designers should include structures that not only support discussion about current practice but also encourage and support teachers in becoming researchers that inquire into their pedagogical and epistemological beliefs.

Experienced Teachers. Electronic networks, unlike other TPD programs can provide of sustained support. For instance, if a teacher is to attend a workshop during the school year they first must make sure they can get the day off, then find a substitute, and then by the time they have time to implement what they have learned in the workshop more immediate concerns have subsumed what the teacher learned at the workshop and the teacher's practice remains much the way it was before the workshop. However, since electronic networks leverage the communicative power of the internet teachers can log on to a network any-

time and anywhere they have an internet connection as their individual needs and time constraints allow. That is, electronic networks have the capability of allowing teachers to share their teacher experiences and get feedback so they can make modifications to their lesson as well as their teaching practice. This type of interaction is particularly crucial for teachers, particularly for experienced teachers that are neither familiar with nor comfortable with reform-based teaching approaches (Lehman, 1992; Schlager et al., 1999). Hence, discussions over an electronic network can provide teachers with needed reassurance in their struggle to not only understand what current reforms expect of them, but also to shift their practice to be more aligned with those reforms. Electronic networks appear to be well-suited to provide this much needed reassurance, which is important to capitalize upon because without reassurance many teachers, more often than not, abandon attempts at reform-based teaching and revert back to their previous (and more comfortable) ways of teaching (Simmons, et al., 1999). In addition, the use of an electronic discussion can enable in-service teachers to maintain contact with university educators who can help them stay abreast of current educational research on teaching and student learning.

Equity. Despite the advantages that electronic networks appear to have in supporting teachers communicating with each other, it is important to note that technology enhanced professional development can have important and sometimes unanticipated side effects. For example, in many online discussion systems all users have an equal voice, therefore, their opinion and ideas take on an authority. An interesting and unanticipated outcome of this leveling of voices is the lack of quality control. That is, participants with more time to communicate can appear to know more and be perceived as an expert whereas those with more experience and expertise but less time can be marginalized depriving the network of a valuable resource and perhaps even causing experienced teachers to withdraw from discussion. In addition, to these social problems teachers may also experience difficulty in using or accessing the necessary tools to take advantage of electronic networking TPD programs. Lack of appropriate hardware, software, or technology (i.e. high speed internet connection) can impede teachers' access to the

medium which reduces the value of the technology in the eyes of already busy teachers. For example, the Inquiry Learning Forum (ILF) uses streaming QuickTime video for their video clips, but there have been a number of teachers who reported difficulty in viewing the videos at their school due to bandwidth issues or they could not install the QuickTime plug-in on their local computer (Barab, et al., in press). Even though most teachers highly valued being able to view other teacher's classroom, they were unable to view the videos because their school's technological infrastructure was ill-equipped to handle the bandwidth required for viewing of the on-line videos, as a result the ILF was considered less useful than initially perceived. Further, there appears to be a distinct difference between how teachers use electronic networks if they have access to computers in their homes. For instance Hawkes (2001) reported that most reflective posts occurred after school hours when teachers were most likely at home. Hawkes' findings are similar with those of Williams, et al. (2000) in which they surveyed 352 elementary and 329 secondary school teachers in the United Kingdom regarding their use of information and communication technology (ICT) tools. Their findings revealed that most teachers who had a computer at home used information technology at home more frequently than they did at school, and those teachers who used information technology at home were more likely to use it at school for their professional development and also integrate ICT into their teaching by involving their students in projects that used information technologies. Therefore, when designing TPD that uses technology designers should be cognizant of the end users and ensure that all teachers will not only be able to use the technology but be able to easily learn how to use the technology.

EDUCATIONAL IMPLICATIONS

Electronic networks have evolved from simply a focus on the exchange of information to engaging teachers in curriculum development, reflection on their teaching practices, and reflecting on their professional growth. This shift in the goals of electronic networks has occurred in part because of current national reforms and from research on teacher change. From research on teacher change, it is clear that a one-time work-

shop, class, or seminar is unlikely to result in significant, long-term change in teachers' practice (Richardson, in press). Further, even the most exemplary TPD efforts have difficulties in maintaining support for teachers over time (Carey & Frechtling, 1997). Teacher change requires multiple opportunities to learn, to practice, and to interact with other teachers inquiring into their own practice (Gess-Newsome, 2001). Current research has shown that electronic networks have the potential to dramatically impact the way teacher education and TPD programs are conducted and support teachers in reforming their practice. Traditional TPD is based upon a hierarchical model of the expert. That is, teachers go to workshops, institutes, or seminars in which "experts" transmit pedagogically sound teaching skills to the teachers (Loucks-Horsley, et al., 1998). Historically, this model has disenfranchised teachers from their own development and lead to considerable criticism of existing professional development programs from teachers, researchers, and administrators (Guskey & Huberman, 1995). However, with the advent of electronic networks teachers can begin to be active participants in their own development and discuss teaching strategies with their peers as well as university based teacher educators and researchers. This is a radical shift from current TPD models, but a necessary one in this current age of reform. That is, if current reforms are to take hold it is necessary for the voice of teachers to be on equal footing with researchers and professional development designers because if teachers' voices are muted then current reforms are most likely to be unsuccessful (Keys & Bryan, 2001). Hence, we as a teacher education community need to develop ways that teachers' voices remain a strong and vibrant part of the reform movement and electronic networks have significant potential to bring teachers' voices to the forefront.

According to Hargreaves (1994) collaboration and collegiality are widely viewed as ways of securing effective implementation of externally introduced change within the teaching profession. Successful online communication among teachers can be seen, therefore, as a key factor contributing to the implementation of reform efforts. Yet, despite this claim that networks can support teacher development and support reform there are some fundamental questions remaining concerning the

use of electronic networks for TPD. Namely, how, if, and in what way does participation in an electronic network impact teacher practice? What are the design principles that underlie an electronic network system that allow teachers' voice to emerge? Are there on-going TPD? Is it possible for an on-line network of teachers develop a shared sense of community while working toward a common shared goal? What is the impact of teachers' already existing off-line social network on their ability and motivation to participate in an electronic network for professional development? It is through investigation of these questions that we as a research community can not only support teachers' professional growth, but also become more cognizant of teachers' voices and nurture teachers in improving their students' learning.

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Electronic Networking Technologies for TPD

Table 1: Summary of Studies Reviewed

Authors	Purpose of Study	Methods	Findings
Bliss & Mazur (1996)	Do the use of telecommunications couple with computer video cases support discussion and if so what does that discussion look like?	Interviews, analysis of on-line transcripts.	Teachers engaged in rich dialogue around actual classroom issues rather than CD-ROM.
DiMauro & Gal (1994)	Can network-mediated reflective discourse occur?	Analysis of on-line dialogues.	Reflection rarely occurs. Authors suggested teachers needed a private workspace to share reflective thoughts.
Dutt-Donner & Powers (2000)	Does electronic networks support sharing and discussion of teaching strategies in a pre-service classroom?	Analysis of newsgroup postings and a summative evaluation survey	If students were afforded the ability to self-direct the discussions participation were more active and the pre-service began to rely upon one another for teaching strategies, ideas, and support.
Gunn (1995)	Does the use of electronic mail to support communication between pre-service teachers and faculty?	Mostly anecdotal evidence and reading of postings.	Little reflection on the teaching process was identified. More messages revolved around need for resources and support questions.
Hawks (2001)	How and in what ways does network-based communications support teacher reflection?	Analysis of on-line and off-line posts using a reflective taxonomy rubric	Found that collaboratively produced network-based communication was significantly more reflective than face-to-face discourse between teachers and that neither mode of discourse supported high overall reflective discourse.
Jinks & Lord (1990)	Do networks support teacher communication?	Anecdotal evidence, examination of teacher work	Evidence suggested that telecommunications systems could well emerge into a powerful system of informational and moral support.
Johnson (1997)	What are the outcomes for pre-service and in-service teachers participating in an e-mail discussion?	Analysis of e-mail dialogues	Pre-service teachers gained a deeper perspective on different philosophies of teaching and helped them to become more comfortable with using technology. In-service teachers found the experience valuable because the discussions over e-mail provided them the opportunity to reexamine their own classroom practices and the effects of accepted instructional techniques on the teaching/learning process

Table 1: Summary of Studies Reviewed

Authors	Purpose of Study	Methods	Findings
Kimmel, Kerr, & O'Shea (1998)	Does computer conferencing support increased communication and sharing?	review of the conference transcripts	Increased in sharing of classroom materials and ideas and increased collaboration in developing activities for workshops.
Levin (1999)	What is the content of various types of electronic communication used by preservice teachers? What purposes are served by these electronic communications?	Constant comparative analysis of web-based discussion forums, e-mail exchanges.	The major purposes electronic communications served included opportunities for personal reflection, sharing teaching activities, and offering support. However, the peer-to-group messages fostered more reflective exchanges than other forms of one-to-one electronic communication studied.
Levin & Waugh (1998)	How can (or do) teleapprenticeships can foster collaboration, communication and how the network is used?	Case comparison, analysis of on-line dialogues	Beginning teachers could more accurately and completely answer their students' questions after participating in a electronic community.
McDonald & Songer (1996)	Do teachers when working on a collaborative curriculum project reflect on their teaching?	Analysis of on-line dialogues	Preliminary data suggests teachers reflect on their teaching.
McGinnis (1996)	What are the benefits of using a list-serv in a graduate level science methods class?	Critically grounded action research approach and analysis of on-line postings	Students believed that network-oriented communication technologies could enhance their teaching practice and lead to increased teaching professionalism, and fostered a sense of community.
Merseth (1991)	What is the nature and type of support beginning teachers receive over an electronic network?	Surveys, post interviews, and frequency of computer use data	Interactive computer networking was valuable in providing moral support for beginning teachers
Norton & Sprague (1997)	Will teachers beliefs about telecommunication change as a result of collaboration with other groups of in-service and pre-service teachers? Does interaction with others impact the quality of lesson plans?	Used two likert-type surveys to collect data and also collected and analyzed student lesson plans	Results showed that pre-service perceptions and attitudes toward the use of telecommunications for teaching improved and that all participants found the experience to be valuable. Found no significant different between the quality of lessons created by in-service teams and the quality of the lessons created by the in-service/pre-service teams

Electronic Networking Technologies for TPD

Table 1: Summary of Studies Reviewed (cont)

Authors	Purpose of Study	Methods	Findings
Piborn & Middleton (1998)	Can reflective dialogue occur on a listserv? What conversations were facilitated through the listserv and how did those conversations differ than traditional journaling?	Content analysis of listserv postings.	Listserv supported reflective dialogue when students' posts focused on content and pedagogy.
Powers & Dutton (1997)	Does access to a listserv promote communication between pre-service teachers?	Frequency analysis of postings	Students used the electronic network for peer support, sharing information, and reflecting on their field experience.
Roddy (1999)	Does an e-mail list help maintain contact between student teachers and the university?	Analysis of e-mail exchanges	The mailing list can serve as a useful tool to support student teachers in feeling less isolated and help build their understanding of teaching
Schlager, Trathen, & Blanton (1996)	How do telecommunications can support conversations about student teaching experiences?	Examination of on-line conversations	If reflective dialogue was to occur the participants needed open, thematic prompts and focused messages, and time to reflect.
Schlager & Schank (1997)	What are design issues to develop an on-line TPD environment that supports the formation a community of practice?	Surveys of TAPPED IN members	Preliminary study reported that teachers wanted access to resources such as useful websites.
Schlager, Fusco, Schank (in press)	Would TAPPED IN members conduct their activities using the system?	Analyzed on line dialogue, comments from teachers	Teachers wanted activities that were situated in their everyday experiences. Teachers would develop their own activities.
Selwyn (2000)	Was there a shared sense of community emerging among participants-was there any evidence of attachment to online communities?	Analysis of on-line dialogue	Found that there was little if any evidence to claim the dialogue that occurred in the on-line forum constituted a shared sense of community. Rather, most members used the forum for information and empathetic exchanges.
Shotsberger (1997)	How do teachers used an on-line WWW professional development site?	Analysis of on-line dialogue	Preliminary findings suggested that teachers use the network for sharing and access to information.

Electronic Networking Technologies for TPD

Table 1: Summary of Studies Reviewed (cont)

Authors	Purpose of Study	Methods	Findings
Siegel, Derry, Kim, Steinkuehler, Street, Canty, Fassnacht, Hewson, Hmelo, Spiro (2000)	How to most effectively support learning within complex web sites that contain large amounts of information but still tied to teaching cases?	Analysis of student work	Preliminary results show that teachers are thoughtful and reflective regarding what the teacher in the vignette should do, but also brings the classroom to the pre-service teacher and encourages them to consider how they might actually conduct their own classroom
Star Schools (TERC) Lehman, Campbell, Hall, & Lehman (1992)	Does participation in an electronic network influence teachers' practice?	Surveys of teachers.	78% of teachers reported experimenting with new methods of instruction in their class
Sunal & Sunal (1992)	How does access to local area network resources impact pre-service teachers lesson planning?	Analysis of on-line dialogue and analysis of teacher constructed lesson plans	Pre-service teachers in the administrative supportive schools communicated more with their peers than university faculty and the discussions focused on how seeking help and approval in lesson planning.
Tannehill, Berkowitz, & LeMaster (1996)	What is the impact of electronic communications on teachers, problems they encountered, and their perceptions of electronic communication?	Data were collected through an informational questionnaire, teachers' journals, and doctoral student summary reports	Teachers had more success communicating via e-mail than with newsgroups, and the teachers perceived this technology as a major force in decreasing their feelings of isolation and providing them with access to their colleagues in physical education
Thirunarayanan (1996)	How did students use an electronic discussion forum?	Analysis of two years of on-line postings.	Results showed that students used the discussion forums for a number of reasons ranging from satisfying course requirements to sharing and support.
Thomas, Clift, Sugimoto (1996)	How do university-based instructors and novice teachers integrate electronic mail in their educational coursework?	Interviews and examination of e-mail messages	Students posted responses to strictly meet course requirements, and the instructors' message had the highest priority with their peers having relatively low priority. The exchanges that were considered reflective by the researchers typically occurred between the faculty instructors and was not shared with their peers.

Electronic Networking Technologies for TPD

Table 1: Summary of Studies Reviewed (cont)

Authors	Purpose of Study	Methods	Findings
Thoresen (1997).	Impact of mentoring through an electronic network for rural in-service teachers	Formative evaluation surveys	Found that the both mentor and mentee teachers considered the program valuable for sharing information and that initial face-to-face meetings were very useful in helping them become acquainted with each other before using the network.
Waugh & Rath (1995)	How preservice teachers use computer networks and telecommunications?	Pre-post survey	Students believed network tools would be helpful in their development as a teacher and serve as a support mechanism
Waugh (1996)	What are the type of group interactions and student questioning patterns in an on-line environment?	Analysis of on-line dialogue	Students posted questions predominantly concerned with technical aspects and network strategies than with pedagogical and personal support questions
Weiss (1997)	Does telementoring encourage discourse about teaching?	Analysis of student reflections	Preliminary findings suggested that students did not feel comfortable with electronic mentors, but believed having mentors was a good idea.
Williams & Merideth (1996)	What are student's online communication patterns?	Frequency analysis of postings	Most postings were classified as chatting, but the discourse gradually shifted toward technology and content. Little reflection on teaching strategies was reported.