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Teaching Teleapprenticeships: Electronic Network-Based Educational Frameworks for Improving Teacher Education*

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ABSTRACT

New technologies can be used to create new educational frameworks for learning that go beyond the standard schooling paradigm. This paper describes research and development efforts to investigate "teleapprenticeships," interaction frameworks that support learning in the context of remote practice. The studies summarized here have focused on teleapprenticeships embedded in teacher education, exploring a range of different "teaching teleapprenticeships," in which education students at a wide range of levels have learned to become teachers within the context of teaching practice. Five kinds of teaching teleapprenticeships were studied: question answering and asking, collaborations, student publishing, web-weaving, and project generation and coordination. Different implementations of these frameworks are compared and contrasted to uncover important general features of successful network use, including the need for institutional support for new learner and teacher roles.

INTRODUCTION

Many have called for a use of learning technologies to foster educational reform (Means, 1994; US Office of Technology Assessment, 1995). However, most such reform initiatives maintain the same isolation of learning from doing that is an essential element of schooling. Even innovative learning frameworks like "cognitive apprenticeships" (Brown et al., 1989; Collins et al., 1989) maintain the separation between learning and the rest of society that is an essential element of classrooms and schools.

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Over the past several years, we have been exploring ways in which new technologies, especially telecommunications technologies, can fundamentally change the nature of learning and teaching. In schools, learning takes place in isolation from the rest of society, and most student activities are exercises, activities with little significance beyond their role in fostering student learning. We have been exploring interactional frameworks which we call "teleapprenticeships" (Levin, Levin et al., 1994; Levin, Waugh et al., 1994a, 1994b; Thurston et al., 1996).

Schooling is such a widely-used paradigm for formal education it is sometimes hard to realize that it is not the only possible paradigm. Apprenticeships pre-date schooling, and are still used at the advanced levels (law and medical internships and advanced graduate study are apprenticeships). However, most proposals to use technologies for educational reform unquestioningly retain the schooling paradigm. We have found, however, ways in which these new technologies allow us to develop new instructional frameworks that go beyond the limitations of schooling, to find news ways to reintegrate learning with doing. We have called these new frameworks "teleapprenticeships" because they resemble in some ways face-to-face apprenticeships. However, since they are based on interactions using electronic networks, they differ from conventional apprenticeships in important ways as well.

Collins et al. (1989) point to the difficulty of applying apprenticeship methods to cognitive skills, since apprenticeships require the externalization of processes that are normally internalized. As more and more work is done by groups, the interactions are more and more externalized.

As telecommunications technologies are becoming more widely used in work settings, the interactions take place as electronic exchanges among the participants in the work. These interactions are much more accessible to novices than the exchanges in face-to-face interactions. This development increases the opportunities for engaging learners in these interactions. The essential interactions are "externalized" by the medium in ways that make them more available for learners as teleapprentices to observe, model and master.

Teleapprenticeships are frameworks for learning that use electronic networks to create apprenticeship-like learning environments without requiring the participants to be in the same places at the same times (Levin et al., 1987). Teleapprenticeships allow novices to learn through participation in a remote community of practice. In this way, learning occurs in the context of remote practice. As more and more adults use electronic networks in their work, there are increasing opportunities for learners to join these interactions, initially observing the interaction, then being given small tasks to accomplish with guidance, and then taking on more substantial roles during the extended interaction.

The naturally occurring role of “lurker” in network interactions (those who read the messages of an interaction but do not contribute), usually seen in a negative light (Williams, 1995), resembles the “legitimate peripheral participation” (Lave & Wenger, 1991) activity of the apprentice, which serves to acquaint the network novice to the “netiquette” (the unwritten rules of participation) of the particular network interaction being observed. In our research, we studied ways in which electronic network interactions could more systematically be used to create “teleapprenticeships” in a variety of content areas, especially in the areas of science and mathematics (Cervantes, 1993; Levin, 1990; Levin, 1992; Levin et al., 1987; Waugh & Brehm, 1989; Waugh & Levin, 1989).

TEACHING TELEAPPRENTICESHIP LEARNING FRAMEWORKS

Electronic network technologies have been the most rapidly developing area of educational technology. Our goal has been to explore ways that electronic networks can be used to support extensions of the traditional face-to-face apprenticeships used in teacher preparation. We have explored a wide variety of ways in which teaching teleapprenticeships can provide more powerful contexts for learning in preservice and inservice education courses. Apprenticeships embed learning in the context of practice, vastly reducing the problem of transfer of learning. However, face-to-face apprenticeships are expensive, requiring substantial commitments from the experts and the apprentices.

In the Teaching Teleapprenticeship research project, we have explored a variety of different teleapprentice frameworks integrated into many different courses throughout the range of teacher education curriculum. These have included general education courses that education students take as freshmen, upper division education methods courses, student teaching, and outreach courses for practicing teachers (Levin, Levin et al., 1994; Levin, Waugh et al., 1994a, 1994b; Thurston et al., 1996). These teaching teleapprenticeship frameworks include:

- Question answering and question asking
- Collaborations
- Student publishing

- Web-weaving
- Project generation and coordination

Some of these frameworks were more successful than others. We describe these frameworks below, comparing ones that were more successful to those that were less so.

CASE COMPARISONS

We use as our analysis methodology the technique of "case comparisons." With this technique, we compare and contrast cases implementing similar frameworks which varied in their success. By analyzing similarities and differences in these cases, we have been able to uncover some general principles for effectively using networking technologies to improve education. This methodology has been used previously in an analysis of successful and less successful electronic networks (Riel & Levin, 1990). In this paper, this methodology is applied to a smaller grain of analysis, that of network interaction frameworks. There were a number of different measures of "success" that we used. In some cases, the measure of success was based on the judgement of the university faculty involved. In other cases, we used observations of these frameworks in operation. We also have used other "naturalistic" measures of success.

Question Answering and Question Asking

Question answering

When teachers are successful in fostering active learning, they find they are asked a large number of questions by students that they cannot easily answer. With electronic networks, students have a larger pool of specialized expertise to address questions to. But how does a student find the appropriate person to ask a question, and how can this question asking and question answering process be supported as networks are used by more and more students?

A number of educators have created "ask the expert" frameworks on the Internet (The Mathematics Forum's "Ask Dr. Math", NASA's "Ask a Scientist"). These frameworks are often supported by external funding, with the overflow of questions being handled by volunteers. These "ask the expert" frameworks can become overwhelmed by too many questions for the experts.

It is hard to sustain this framework over time, since it is difficult to recover the cost for these services and it is difficult to sustain volunteer efforts over the long term.

Our Teaching Teleapprenticeship project has explored this question answering and asking process. Over a four-year period, we worked with general education (lower division) science courses taken by freshman and sophomore students likely to become education majors. They were engaged as answerers of pre-college students' science questions for extra-credit course assignments (Boehmer et al., 1996; Levin, Levin et al., 1994). When we first approached the instructor of a biology course that a large number of our education undergraduates take, he was interested because he wanted his students to experience questions about biology from real K-12 students. He reported meeting teachers who had taken the course from him many years previously, who said that if they had known the kinds of questions about biology that they would be asked by pre-college students while taking the course, they would have been more motivated to learn the content of his introductory biology course. But he was at the same time concerned about the quality of the answers generated through this framework, since his freshman and sophomore college students had so little prior biology background.

Supported by the context of the course, these students were able to draw upon the resources of the university (the class, the library, the Internet, content experts on campus) to formulate responses to the pre-college students' questions that were valuable to the students and teachers. Since their participation was integrated into the course and thus had to be graded, there was a built-in quality control mechanism by which the course instructor and teaching assistants could step in to correct the misconceptions that appeared in a few of the responses.

During the first year in which this framework was tried, questions for students in an introductory biology course were selected from biology-oriented newsgroups and made available to the students who volunteered to participate in an extra-credit project. Questions were distributed by e-mail and students were encouraged to communicate with the question askers to clarify the nature of the questions. Their responses were turned in, graded, revised in some cases, and sent back to the question askers.

In the second, third, and fourth years, students in several general education science courses were assigned to specific K-12 classrooms that had good network connections, and worked more closely with specific teachers and K-12 students to answer questions related to the content of the science courses they were taking (introduction to biology, plant biology, geology). They used computer-based conferencing systems to interact (initially PacerForum and then later First Class).

We found two major advantages in involving undergraduates as mediators for question answering. First of all, the framework provided a motivating context for their own learning as undergraduate education students. They could see why they needed to learn biology, because of its usefulness in allowing them to answer the kinds of questions they themselves will be faced with when they are teaching a K-12 class. It gave them a chance for "legitimate peripheral participation" in a K-12 classroom, as a "teaching teleapprentice." Secondly, there are many more undergraduate students taking introductory courses than there are content area experts, so this framework is much more scalable than the conventional "ask the expert" frameworks. Since the framework is embedded in a course that is taught year after year, the framework is sustainable beyond any special external support. And the course provides a natural "quality control" mechanism, since student course work needs to be graded, and the grading can serve a secondary function of insuring that questions are appropriately answered.

We evaluated these two frameworks, the "ask the expert" framework and the "teleapprentice question answering" framework, by interviewing the university faculty members involved in each of these frameworks (Boehmer & Waugh, 1997). In the case of the faculty member running a small scale "ask the expert" project, he reported being discouraged in three major ways. First, he found it difficult to have K-12 students generate interesting questions. Secondly, he found that when he was successful in having them generate interesting questions, he was quickly overwhelmed in trying to respond to them in enough depth. Finally, his orientation towards learning was constructivist, and so he found that the "ask the expert" role conflicted with that orientation, since he wanted to foster a more active approach to science learning and less of a dependence on appeals to authority.

In interviewing one of the faculty members involved in the "teleapprentice question answering" approach, Boehmer and Waugh (1997) found that he reported being quite satisfied with the role of this framework in his courses (which he continued for four years until he retired from teaching). Each year a larger number of students volunteered to participate in this extra-credit assignment, and he was quite happy with the depth and helpfulness of the responses that they developed. He also reported that the K-12 teachers found the interactions with his students helpful in their science teaching.

In this comparison of the two ways of using electronic networks for question answering (the "teleapprentice question answering" approach vs. the "ask the expert" approach), a major difference is in the institutional support for the mediator. In the "ask-the-expert" case, the activity was supported by coordinators supported by external funds that were transitory, with the overflow of questions being handled by volunteer efforts. In the "teleapprentice as question answerer" case, the activity was embedded within the context of a course in a program of study. The teleapprentice framework is both sustainable and scalable, while the "ask-the-expert" approach is hard to sustain and difficult to scale.

Question asking

While this "question answering" can be very useful for teachers and students with questions growing out of classroom activities, the process of question asking is often difficult for students and teachers alike.

In our Teaching Teleapprenticeship project, we have worked with several university faculty teaching methods courses. In one case, undergraduate students were serving "early field experience" internships in elementary school classrooms. The faculty member built into his course an assignment for his teacher education undergraduate students to work with elementary school students to generate questions, which they posted to the Internet to be answered. They also took the answers back to the elementary school students, to help them understand the responses they received.

In evaluating these frameworks, we conducted interviews with the university faculty, graduate students, and undergraduates involved (see Waugh & Rath [1994] for more details). The dual mediator role helped the undergraduates learn from their science methods class, in addition to helping elementary school students learn about science and the formulation of science questions (Waugh & Rath, 1994).

In contrast, in the "ask the expert" framework described above, the faculty member found it difficult to get pre-college students to ask questions on their own. The only way he could get good questions was to visit the classroom himself and work with the students directly. While he was more skilled at helping K-12 students generate questions than the undergraduates, he was limited in the number of classrooms he could visit, and found himself overwhelmed as he attempted to "scale up" the activity. While the university students were less skilled at helping pre-college students ask questions, they were in many more classrooms on a more regular basis than the faculty member expert. In addition, the undergraduates received support in their mediation role from their university instructor and graduate teaching assistants.

One important lesson learned from this comparison is that undergraduate students can serve a useful mediator role in both helping pre-college students develop questions to ask and in helping them to interpret answers to their questions. This activity is sustainable and scalable when integrated as part of field-experience embedded in their teacher education curriculum. It is justified when its primary goal is to support the learning of the undergraduate students. At the same time it has the positive side-effect of helping pre-college students learn how to formulate questions about science or other curricular content domains, involving them more actively in the processes of the content domain.

Collaborations

Network-based learning often draws upon collaborative discussions. In several cases, we tried to foster network-based discussions to build a collaborative community of learners. For example, e-mail reflectors were set up for most of the university courses involved in the Teaching Teleapprenticeship project, so that e-mails sent to a single address went to the entire class. For several of these classes, the e-mail reflectors were effective means of coordinating class discussions, and, in some classes, they were used for collaborative student work, both within the class topic and for coordinating student activities outside of class (Thurston et al., 1996).

However, in some cases, these collaborative discussions failed to materialize. In a science methods class, the instructor tried to generate a discussion of issues using this class's reflector list. The discussion never developed. The students reported that since they saw each other many times a day (they had several shared classes), it was easier to talk face-to-face than to send e-mails. The benefit from using e-mail was not enough to overcome the cost, since there were easier alternative means available for them to communicate. So one interpretation might be that proximity is in fact a barrier to the use of networks for collaboration. Yet the next case shows that this is not always true.

In another case, a student teacher and her cooperating elementary school teacher extensively used e-mail to collaborate, even though they spent many hours a day in the same room. The student teacher wrote up her lesson plan for the next day after school and sent it as an e-mail to her teacher in the late afternoon. In the evening, he read it and sent her feedback on it. The student teacher read his feedback the next morning before school and was able to incorporate the feedback into that day's lesson. Even though they spent many hours in the same classroom each day, the busy classroom schedule allowed no time for them to go over the next day's lesson plan. E-mail allowed them to communicate in a way not available given the constraints of the classroom context.

The comparison of these two cases, collaborative class discussions vs. collaborative teaching, demonstrates that it is not proximity that is the important determiner of whether networks will be used for collaboration, but rather the availability of alternative opportunities to communicate. The lesson to be learned from this comparison is that networks will be used when they serve a function that cannot easily be accomplished by other easier-to-use communication media. Only a careful examination of a particular context will enable us to predict when network-based collaboration will prove to be beneficial in a given instructional context.

Student Publishing

Publishing exemplary student work

Several research studies have pointed to the importance of "publishing" as a final stage in network-based learning (Cohen & Riel, 1989; Levin et al., 1987; Levin, Waugh et al., 1992; Waugh et al., 1994a, 1994b). In the Teaching Teleapprenticeship research project, we have studied several different frameworks for student publishing.

The first involves the publishing of exemplary student work, a model that has wide applicability. In one of our student teaching programs, the undergraduates create integrated mini-unit lessons, which they implement in their K-12 classrooms. They write reports of these lessons, including evaluation from their cooperating teachers, their university supervisors, and self-evaluations. These mini-unit reports are turned in as class assignments (both in print form and electronically) and graded by the university faculty member.

In 1995, the faculty member selected twelve exemplary mini-units from the 48 units these students created, and these units were posted on a website for the class, <http://www.ed.uiuc.edu/ylp94–95/>. Since that time, these twelve units have been accessed tens of thousands of times by people from all over the world.

Why would these units, created by undergraduates, be of interest to people all around the world? One reason is that these units were actually conducted and evaluated by several different people (the K-12 teacher in whose classroom they were conducted, the university supervisor, the faculty member), which sets them apart from many other lesson plans found on the Internet. Secondly, since they were part of a course, they were graded, and only the exemplary units were selected for publishing. This "quality control" mechanism is built into the context of a course. With other frameworks for generating knowledge, it is expensive to add this level of expert selection and assessment.

This mechanism of taking the best work of students and making it available to others over the Internet is one that could be used by teachers and students in courses at all levels in schools, colleges, and universities all around the world. Typically, people think of networks as providing the resources of the world for education. This mechanism of publishing exemplary student work provides a vast untapped resource that education can provide for the rest of the world.

What was the impact of this publication of student work on student learning? We have been able to track at least two kinds of positive impact. First of all, the selection for electronic publication had a positive impact on the students whose work was selected. It provided the same kind of "fame" that print publication can provide, which for some of these students helped them obtain the teaching positions they wanted. A second impact was observed with the next set of students to take this same class the following year. The assignment to create integrated mini-units created a functional reason for these students to learn a Web browser in order to look at the best mini-units created by the previous year's class. When these students learned that the mini-units were being viewed by tens of thousands of people, it provided an additional incentive to create quality mini-units, since there was a real "audience" for their own work. If done well enough, their own mini-units might be selected as exemplary and published along with the existing ones.

Electronic editorial assistants

While the "publishing exemplary student work" framework provides support for increasing the knowledge base in a given domain, it does not directly draw on the knowledge of experts in the context of practice. In many senses, it would be valuable to have the best K-12 teachers contribute their best ideas and practices to a wider audience. However, only a few teachers will acquire the skills and will take the time to do this. A framework we have been exploring is to have education students serve as "electronic editorial assistants" in this process. During the spring and fall semesters of 1996, students in two of our secondary student teaching programs were given an assignment to work with their cooperating K-12 teachers to identify a "best practice." The undergraduates then wrote up these ideas, had them reviewed by their cooperating teachers and their university instructor, and turned them in on paper and in electronic form. The best of these have been selected by the course instructor and published as Web pages, with both the cooperating teacher and the student teacher receiving credit for the publication.

Like the “exemplary student work” framework, this “electronic editorial assistant” framework is one that could be used much more widely, both in teacher education and more broadly. To the extent that these frameworks are embedded in the context of courses, they may be both sustainable and scalable. In fact, frameworks like this may be the only hope for making distributed information servers useful, because they provide built-in quality control mechanisms that can scale up to the massive amount of electronic publishing that the Internet enables.

Web-Weaving

Distributed information server technologies such as the World-Wide Web make it very easy for people to publish on electronic networks. Because of this, the amount of information becoming available on networks is huge and growing exponentially. This means that the efforts required to evaluate and organize information are monumental and thus highly valued. Many have questioned the educational usefulness of the Web because of this lack of organization and quality control. In our Teaching Teleapprenticeship project, we have observed several frameworks that can engage education students in this process of organization and evaluation in ways that contribute to their own learning and also are of benefit to a broader range of people. Since these frameworks generally involve students in searching for information on the Web and building links to selected places, we have called it “web-weaving.”

Web-weaving is a very natural activity. One of the first things a person using a Web browser learns is to use the “bookmarks” feature to save interesting places. When the list of bookmarks gets too large, many users convert their bookmarks into Web pages. Many personal Web pages contain a list of “my favorite places,” a simple form of web-weaving. It is very easy to build this kind of activity into a class. For example, one of our graduate courses introduces students to the Web with the assignment “Find an interesting education-related site on the Web”. These are submitted to the faculty member via e-mail, and they are assembled into a list on the class Web page. The next assignment is more specific—“Find an interesting personal Web page.” This is followed by a discussion of the design of effective personal Web pages and by the students constructing their own personal Web pages as a first step toward learning Web-page creation and design.

Several of our undergraduate education methods courses have had students find websites related to the topic of the course, and these locations were "woven" into a list on the class Web page. For example, in a science methods course, students found Web pages useful for constructing science lesson plans.

Assembling long lists or even organized Webs related to a given topic can be useful as a learning activity, but even more useful is learning to evaluate what is found. The ability to gather and critically evaluate information is more important now that we have a vast amount of information easily accessible through networks. For almost any question, it is likely that a search will yield contradictory answers. The critical evaluation of information found, through the use of convergent validity techniques, reasonableness checks, and logical techniques, will be an important survival skill in the future.

We have found that such evaluative skills can be built into class assignments. "Compare and contrast" assignments have been part of course assignments and examinations for years—extending those assignments to the evaluation of Web resources is straightforward.

Course assignments are usually graded by the course instructor. This natural part of the institutional structure of courses can be used to provide quality control for web-weaving activities. It can also provide a good model of evaluation for students. Once the students' web-weaving assignments are graded, course instructors can decide to make publicly available only "good" or "best" student web-weaving activities without much extra effort. As this kind of course-based web-weaving is extended through more and more courses, it can provide a scalable and sustainable mechanism for organizing and evaluating the growing and changing information on electronic networks in an ongoing and quality-controlled way.

The web-weaving efforts of our undergraduates have been useful but limited in their scope, because the courses have only allowed a limited amount of involvement and because of the limits of undergraduate student expertise. We also have found that involving education graduate students in web-weaving, especially in areas in which they have interest and expertise, has been very productive. Several of the websites created by our graduate students as class projects (and maintained through their own efforts) have been receiving tens of thousands of accesses a month from thousands of different network locations. A good example is the "Resources for Music Educators" website created by Scott, which she created as one of her first Web-creation activities (Scott, 1995). Her site has been accessed tens of thousands of times a month since it was created in the fall of 1994 (16,079 times in March 1996, for example). Once she created the general framework for music education resources, other graduate students in music education have added specific music education resources as class projects: Instrumental Music Education Resources, Resources for Guided Listening, Resources for Wind Band Conductors, and String Education Resources. Each of these was created as a stand-alone class project by a different graduate student, and then, when developed sufficiently, was linked into the general music education website to provide more depth in these specific areas of music education.

Another measure of the positive impact of these web-weaving experiences is that graduate students have continued to maintain these sites, even after the course ended in which they created them. Why would they do this? One reason is professional recognition. Several of our students have reported that experts in their fields have come up to them at professional conferences to thank them for creating these resources, a motivating experience for graduate students. Others have reported that their website has generated e-mail contacts with other professionals around the world with similar interests. Students report that their web-weaving activity has helped them in their job interviews when they've finished their graduate studies. These are important consequences that have motivated graduate students to create and maintain these resources, reasons that can be applied much more widely in other areas and at other universities. Through these experiences, the web-weavers become more and more central participants in these globally distributed professional teleapprenticeships.

The graduate students are, of course, much more advanced in the content domain than undergraduates. We will be working toward an integrated system, in which graduate students serve as "journeymen" in the teleapprentice web-weaving activity and undergraduates as "apprentices," with overall guidance from faculty content domain experts.

Project Generation and Coordination

Many researchers have reported the value of involving students in network-based projects (Levin & Cohen, 1985; Levin et al., 1987, 1989; Ruopp et al., 1993). However, generating and maintaining high-quality projects has been difficult. There are a number of important mediator roles that have to be carried out for a project to be successful (Riel, 1993; Waugh et al., 1994a, 1994b).

Some network-based projects have been generated and coordinated by professional curriculum development teams, supported by the federal government and/or private industry (National Geographic Kids Network, Passport to

Knowledge). A limitation with this "top-down" curriculum development framework is that it is expensive, and so only a relatively small number of projects have been generated and coordinated.

Other projects have been developed through the volunteer efforts of teachers, operating largely on their own using available networks (Kidsnet, FrEdMail, Global Schoolnet Project Registry and Hilites). Although this "grassroots" bottom-up framework generates and coordinates a large variety of projects, many of these projects fail because of the inadequate skills of network coordination by the teachers, and few projects are sustained, because the efforts of the project coordinators are usually not systematically supported.

In our Teaching Teleapprenticeship project, we have been exploring ways in which these critical mediator roles can be embedded as parts of education courses, in ways that support the learning of the education students in these university classes.

We have been teaching an extramural course on educational uses of electronic networks each spring semester since 1989. While most of the course interaction is conducted via the Internet, there are four full-day face-to-face meetings held on Saturdays, and so the course has been referred to as the SatEx (Saturday Extramural) course. Many of the students in this course are K-12 teachers and administrators from around the state of Illinois, some of whom travel for four hours or more to attend the face-to-face meetings. Other students in the class are education graduate and undergraduate students who live nearby.

The SatEx course introduces students to educational uses of networks, especially network-based educational projects. The participants start out by viewing a large number of network-based projects, join a few ongoing projects, and then generate and coordinate their own network project. This gradual movement from "the periphery" to "center stage" is one of the characteristics of apprenticeships (Lave, 1977; Lave & Wenger, 1991). Novices start out by "lurking," observing the practice of experts from the periphery, then they take on more active peripheral roles, and later, as they master the domain, they take on more central roles.

We have found that an impressively large number of high-quality network-based educational projects are developed, implemented, and documented by the students using the teleapprenticeship framework in this SatEx class. During the spring of 1996, for example, of 27 projects conducted by the students in this class, 17 were selected by the Global Schoolnet Foundation for its "Hilites" list of exemplary project proposals. During this academic semester, more than 15% of all the Hilites projects selected were from this course, even though Hilites draws upon contributions nation-wide and in some cases world-wide. Some of these projects were joined by hundreds of classrooms. Twelve of these projects can be viewed in detail at the class's website <http://www.ed.uiuc.edu/courses/satex/sp96/>.

In many cases, groups of SatEx students worked collaboratively on a project, and some of the best projects involved teams which involved a member from the on-campus group and a member from the off-campus group. The on-campus students have easy access to the Internet but often have difficulty finding a class of students to work with; the off-campus students usually have easy access to a class (in many cases, the K-12 students they currently teach) but have more difficulty accessing the Internet. This collaboration allowed the participants to build upon the strengths of their own situations, and to draw upon the strengths of the other members when they had weaknesses. Some of the on-campus graduate students helped by creating Web pages or by locating network resources for a project, while the off-campus students implemented the project in their own K-12 classrooms. These teams allowed each to learn in the areas of their own weakness, while contributing their own strengths in the process of creating and conducting innovative powerful ways of using networks for learning and teaching. These students were able to divide up the mediator roles so that they learned while doing. They learned the subject matter of the course while also mediating the learning of a wider community of students and teachers.

This SatEx model is a hybrid course, using telecommunications combined with face-to-face meetings. It is a model that can be used much more widely for inservice education. It has advantages over the more usual "workshop" model, in which teachers attend either a single or a series of face-to-face meetings, since the course provides a framework for continued goal-directed involvement by the participants in a way often lacking in workshops. The face-to-face meetings provide a community-building mechanism, a way to overcome initial technical difficulties, ongoing "deadlines" for keeping projects on track, and a forum for presenting interim and final results. The fact that these face-to-face meetings are few and are distributed across a 15-week semester more easily permits distant participants to be involved. More frequent face-to-face meetings would serve as a serious barrier to involvement by remote participants.

What lessons can we learn from these case comparisons of frameworks for project generation and coordination? The "top-down" framework produces a relatively small number of high-quality network-based projects, because it con-

Table 1. Properties of Different Project Generation and Coordination Frameworks.

	Institutional support	Diverse participants
Top-down	X	
Bottom-up		X
Teleapprentice	X	X

tains strong institutional support for the activity. The "bottom-up" framework produces a large number of projects of varied quality, because of the diverse number of project coordinators. But the lack of institutional support leads to a large number of unsuccessful projects. The teleapprentice framework leads to the development of many successful projects, because of the support provided for network newcomers to acquire expertise in creating and coordinating projects in this new interactive learning environment. Within this semester-long SatEx course, the practicing teachers and education students have moved from being relative novices at conducting network-based projects, observing from the periphery, to taking the central role in organizing and mediating the participation of many geographically distributed students and teachers.

DISCUSSION

The Teaching Teleapprenticeship project has explored a variety of new frameworks for using networks in learning and teaching. The comparisons that are presented in this paper are the following:

Question answering and question asking
"Ask the expert" vs. "Teleapprentice question answering"

Collaborations
"Collaborative class discussions" vs. "Collaborative teaching"

Student publishing
"Exemplary student work publishing" vs. "Electronic editorial assistant"

Web-weaving
"Undergraduate web-weavers" vs. "Graduate student web-weavers"

Project generation and coordination
"Top-down" vs. "Bottom-up" vs. "Teleapprenticeship"

Each of these case studies strengthens some general conclusions. One key element of the more successful frameworks is that they were integrated into learning activities in ways that make sense for the curricular goals of the students and instructors. Another element is that they involve students in new mediator roles, many of which contribute to the world outside of the classroom while at the same time providing a powerful context for the students' own learning. Unlike conventional schooling, in which most learner activity is an "exercise," with little meaning outside its role in fostering student learning, teleapprenticeships allow for learner activity to make valuable contributions to the rest of society, while at the same time serving its primary role in providing a powerful motivating context for learning.

Mediation has always been critically important for learning (Vygotsky, 1978). Networks make the mediation, both by learners and others, more accessible, because it is often expressed in more tangible ways (e-mail messages, Web pages). In exploring new frameworks for learning, we need to be sure that all important mediator roles are supported and are beneficial for the participants filling those roles (Waugh et al., 1994a, 1994b). Project-based and problem-based learning environments have been proposed as ways to improve education (Ruopp et al., 1993). Teleapprenticeships allow these projects and problem-solving efforts to be embedded in the practice for which the learning is intended to be used.

These new teleapprenticeship frameworks for learning enable a more diverse set of learners to interact collaboratively with practitioners in scalable and sustainable ways. Because of the increased opportunity to interact both synchronously and asynchronously, the diversity of the participants can be turned into strengths instead of barriers to learning and doing.

The problem of transfer has been a challenge to teachers since teaching was invented. Knowledge and skills acquired in a classroom are too often not applied in contexts of practice. Apprenticeships reduce this problem because the learning takes place in the context of its intended practice. As more and more of adult practice uses telecommunications for its functioning, teleapprenticeships will become more useful for allowing people to learn in the context of that practice.

More and more schools use electronic networks to engage their students in network-based learning. This change allows more education students to become engaged in teaching teleapprenticeships. Teaching teleapprenticeships resemble in some ways face-to-face apprenticeships (student teaching, in the case of teacher preparation), but are quite different in other ways. In our four-year research project, we have been exploring a variety of these new frameworks, some of which have worked well and others less so, to discover frameworks that serve important functions for all the participants in the interaction. We have seen ways in which network technologies allow for novice teachers to start as legitimate peripheral participants (Lave & Wenger, 1991), then gradually move toward taking on more central roles in educational interactions. Students can learn in a meaningful situated context, and, at the same time, serve important mediator roles that help other people. By embedding these teleapprenticeship frameworks in institutional contexts and providing support for new mediator roles for learners and teachers, we have demonstrated that these frameworks are both sustainable beyond special funding and scalable to many other institutions across the country and around the world.

SUMMARY

New media enable the development of new learning frameworks. Initially people use a new technology as a way to do the same things that they have done before. And so many attempts to use new technologies have focused on conducting learning and teaching in the same ways as before. This paper has explored new interactional frameworks for learning, called teleapprenticeships, which differ in important ways from the conventional schooling paradigm. These teleapprenticeship frameworks allow the reintegration of learning into the rest of society. Unlike "cognitive apprenticeships," which preserve the isolation of learning from the rest of society, teleapprenticeships provide ways to reintegrate learning with the contexts of practice. Unlike face-to-face apprenticeships, teleapprenticeships allow learners to be supported by multiple mediators, while serving as valued mediators themselves.

This paper has described a number of different teaching teleapprenticeships, frameworks for using technology to improve teacher education. These include frameworks for question answering and asking, collaborations, student publishing, web-weaving, and project generation and coordination. This paper has compared the implementation of similar frameworks to discover important features in determining the successful educational use of new network technologies. The integration of these frameworks into supportive institutional structures and the nature of the new mediator roles for learners and teachers are two important factors for the successful use of new distributed learning environments.

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