# Lessons from Exemplary Colleges of Education: Factors Affecting Technology Integration in Preservice Programs

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*This study focused on efforts in four colleges of education deemed exemplary in their approaches to prepare preservice teachers to use technology. The study addressed one overarching question: What are the important pieces of the puzzle that make up the current technology integration efforts at these exemplary sites? Data were gathered during the 1997–98 academic year. Findings suggest that there is a web of enabling factors that supports student learning opportunities and desired technology-related outcomes for preservice teachers. The informed leadership of deans and other administrative and faculty leaders appears to be especially critical to sustain and expand technology-integration efforts. Leadership issues, along with a wide range of other factors, are systematically examined across the four case studies. The authors conclude that while each of the four cases is unique, many of the recommended practices explored in this study would likely prove beneficial if employed in other settings.*

☐ Recent research studies and scholarly reports indicate that teacher-preparation programs are not adequately preparing graduates to teach with technology. A survey commissioned by the Milken Exchange of Education Technology submitted by 416 teacher preparation institutions revealed that most education faculty do not feel that information technology is adequately or effectively modeled for the future teachers they serve (Moursund & Bielefeldt, 1999). The CEO Forum's School Technology and Readiness Report (1999) concurs and builds a strong argument for the need to prepare new teachers to integrate technology into the curriculum. Consistent with these other reports, a task force of the National Council for Accreditation of Teacher Education (NCATE) concluded that institutions of higher education are not fully meeting their responsibility for preparing tomorrow's teachers to use technology. The report states: "Bluntly, a majority of teacher education programs are falling far short of what needs to be done" (1997, p 6). To address this problem, the task force recommends that institutions develop a vision and plan, spelling out both how they will integrate technology in the teacher-education program and how new teachers will be expected to use it in their classrooms.

Many impediments to technology integration in colleges of education have been cited including the lack of technology resources, time, professional development, and support (U.S Congress, 1995; NCATE, 1997). Further, if college of education faculty do not model the integration of technology, then teachers will be less inclined to include technology in their own classrooms (Zehr, 1997). Some teacher-educa-

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tion programs, however, are successfully addressing these obstacles and are making clear advances in their technology integration efforts. In 1995, the Office of Technology Assessment (OTA, U.S Congress, 1995) reported four case studies in which such advances were documented.

Since the release of that report, colleges of education have experienced new technology standards, expanded use of the Internet, teacher-education candidates who are increasingly comfortable with learning technologies, and expectations of school personnel that technology will be a part of K–12 education. The current study investigated how these changes have been addressed by the exemplary colleges of education during the past several years. What are the important pieces of the puzzle that make up their current technology integration efforts? To answer these questions, the authors conducted a follow-up study of the four preservice programs that were identified as exemplary in the OTA Report (U.S. Congress, 1995). Based on four case studies, this article will address characteristics observed and discuss the implications for other teacher-education programs.

## Background

As summarized in the OTA Report (U.S. Congress, 1995), Mergendoller, Johnston, Rockman, and Willis (1994) conducted 4 case studies of preservice teacher-education programs thought to have exemplary approaches to integrating technology—Vanderbilt University, University of Virginia, University of Northern Iowa, and University of Wyoming. These sites were chosen based on recommendations from the OTA staff, advice of experts in the field, and observations of the researchers. Other factors in selecting these sites included geographical and population diversity and types of technology employed. From an original list of 32 potential inservice and preservice sites, 4 preservice programs were selected, along with 3 inservice programs and 1 state technology support structure.

Mergendoller et al. (1994) constructed case studies for each of the sites along with a cross-case analysis that addressed common themes across sites. In the colleges of education portrayed, the researchers described three ways of using technology: (a) as a tool to make the reality of the classroom more accessible (e.g., video cases produced at Vanderbilt University, (b) to facilitate access to and communication with additional human and text or data resources, and (c) as a means of enhancing traditional approaches to teacher-developed curriculum materials and instructional practices. The researchers cited a common vision across sites in which technology was used to "provide curricular and instructional opportunities that could not be achieved as efficiently or powerfully without the technology" (Mergendoller et al., 1994, Chapter 10).

Mergendoller and his colleagues' analysis focused primarily on issues involved in implementing the vision of infusing technology into the respective programs. They noted that, while the dean may not have originated that vision, in each case the dean played an essential role through allocating discretionary funds, hiring "technology savvy" faculty, supporting proposals for external funding, working effectively with central university administrators, and using the dean's influence to further the involvement of the faculty in the use of educational technology. In each case such leadership was a necessary ingredient in establishing the technological infrastructure and attaining long-range goals through a series of small incremental steps. Also, the study reported that it took longer for colleges to establish the technological infrastructure and training program than had originally been expected.

The researchers noted that the programs they observed "accomplished the somewhat tricky balance of establishing a culture that strongly encourages faculty technology use, but does not shame individual faculty members who lag somewhat behind" (Mergendoller et al., 1994, Chapter 10). Such cultural expectations, they explained, provide a sense of direction, but don't force movement. Movement is encouraged by a clear payoff or by providing human support in the form of training and one-on-one help. Other support strategies described include collaborative projects among faculty as well as ventures with school districts and other outside entities.

The authors concluded that the preservice teachers in the programs that we visited experienced educational technology as an integral part of their professional preparation. They suggested that this fact, perhaps above all else, made these programs exemplary. Examples of technology integration described include modeling of technology use by university professors and K–12 teachers, establishing course requirements for using technology to communicate and access information, and using video conferencing and other distance technologies.

One of the common problems cited in the report was the lack of student-teaching placements in technology-rich classrooms with teachers who actively model effective use of technology tools. The researchers concluded that this would likely remain a problem for some time. One solution discussed involved college-affiliated laboratory or professional development schools. While such schools may provide good models for technology use, the authors also cited potential problems that may arise with that approach.

The report concluded with an analysis of the funding necessary to maintain and expand the colleges' technological infrastructures. It stated that while internal funds have been critical, additional funding was obtained through business partnerships and grants. The authors concluded that an entrepreneurial attitude has been, and will continue to be, needed to fund the purchase and maintenance of needed technology for preservice programs.

The present study followed-up on the work of Mergendoller and his colleagues. It sought to answer one overarching research question: What are the important pieces of the puzzle that make up current technology integration efforts at these sites?

## METHODS

### Site Selection

The same four preservice teacher-education sites chosen for the OTA study (U.S. Congress, 1995) were selected for the current study. Our goal was to describe the changes occurring at these colleges of education since the original study. Although we were tempted to explore additional preservice programs that might be considered exemplary, we recognized that it was beyond the scope of the current study to both systematically identify exemplary programs and conduct the case studies. We therefore opted to examine those programs previously identified by the OTA researchers—Vanderbilt University, University of Virginia, University of Northern Iowa, and University of Wyoming.

### Data Sources

Data were gathered during the 1997–98 school year from multiple sources using multiple measures. One researcher visited each site over a two- or three-day period of time. A primary data source for the study consisted of 65 audiotaped interviews. Based on the general categories reported by Mergendoller et al. (1994), semi-structured interviews were prepared for teacher-education faculty, university administrators, preservice teachers, recent graduates, and technology-support providers. It was our intent to talk with technology-using faculty and other key players listed. Thus we opted for a nonrandom, purposeful sample of informants that was arranged with the help of faculty or administrators at each of the universities. In some cases additional interviews were scheduled during the site visits based on information gathered during those visits.

For example, the researchers asked teacher-education professors a set of 15 questions including (a) Do you integrate technology in your courses? How? (b) What level of support is available to you? (Also asked of students); (c) Do students use technology in your course? Do you have requirements for students to use technology (in your syllabus)? and (d) Do you think that students find good models of technology integration in their field and student-teaching experiences? Complete interview schedules employed can be viewed at http://www.west.asu.edu/kwetzel/quest.html.

Additional data were gathered via a review of print and Web-based documents and field notes taken by the researchers during observations of classes, open computer labs, and meetings. For example, some interviewees might demonstrate their course or project Websites, or provide copies of articles that they had written addressing topics they discussed. Similarly, in addition to classroom observations that were scheduled by our hosts, impromptu observations were arranged during our interactions with various informants.

### Data Analysis

All audiotapes were transcribed. Using the constant comparative method (Strauss, 1987), data analysis began as data were first collected and continued throughout the study. Data were triangulated as our review of documents and field notes from observations served to confirm the trustworthiness (Lincoln & Guba, 1985) of the interview data.

We began by reading and rereading our field notes and transcriptions of the interviews. Guided by the purpose of this study and general categories used in the earlier study (Mergendoller et al., 1994), we began coding the data using *HyperQual2* (Padilla, 1993), a qualitative research software application. In addition, one of the researchers used the ClarisWorks database and word processor components with embedded macros that allowed for coding and searching of the data. As the study progressed, we reformulated our codes to reflect the data gathered. For example, categories that were coded include support and training. Subcategories of training and support included workshops, curriculum-integration specialist, and students working with faculty, grants, and technical support. The set of codes was then organized using *Inspiration*, a software application that generates a visual representation of ideas and concepts entered. This facilitated further analysis of the results and enabled us to represent our findings in Figure 1.

Member checking was also employed as drafts of our report were sent to key informants at each site to check for accuracy of the data and feedback on our analysis of the results. None of the findings in the report were questioned or disputed.

## RESULTS

The overarching research question of this study is What are the important pieces of the puzzle that make up current technology integration efforts at these sites? Data gathered suggest that there is a complex web of enabling factors that supports student-learning opportunities and desired technology-related outcomes for preservice teachers. A description of the results of this study follows, presented according to the factors illustrated in Figure 1. Beginning with the lower portion of the figure, the *enabling factors* that support technology integration will be described. Next, a range of *student-learning opportunities* with technology will be addressed, followed by a discussion of *student outcomes*, the ultimate goal of integration efforts. In addition, throughout the presentation of findings, several of the exemplary practices that we observed in the various programs will be highlighted.

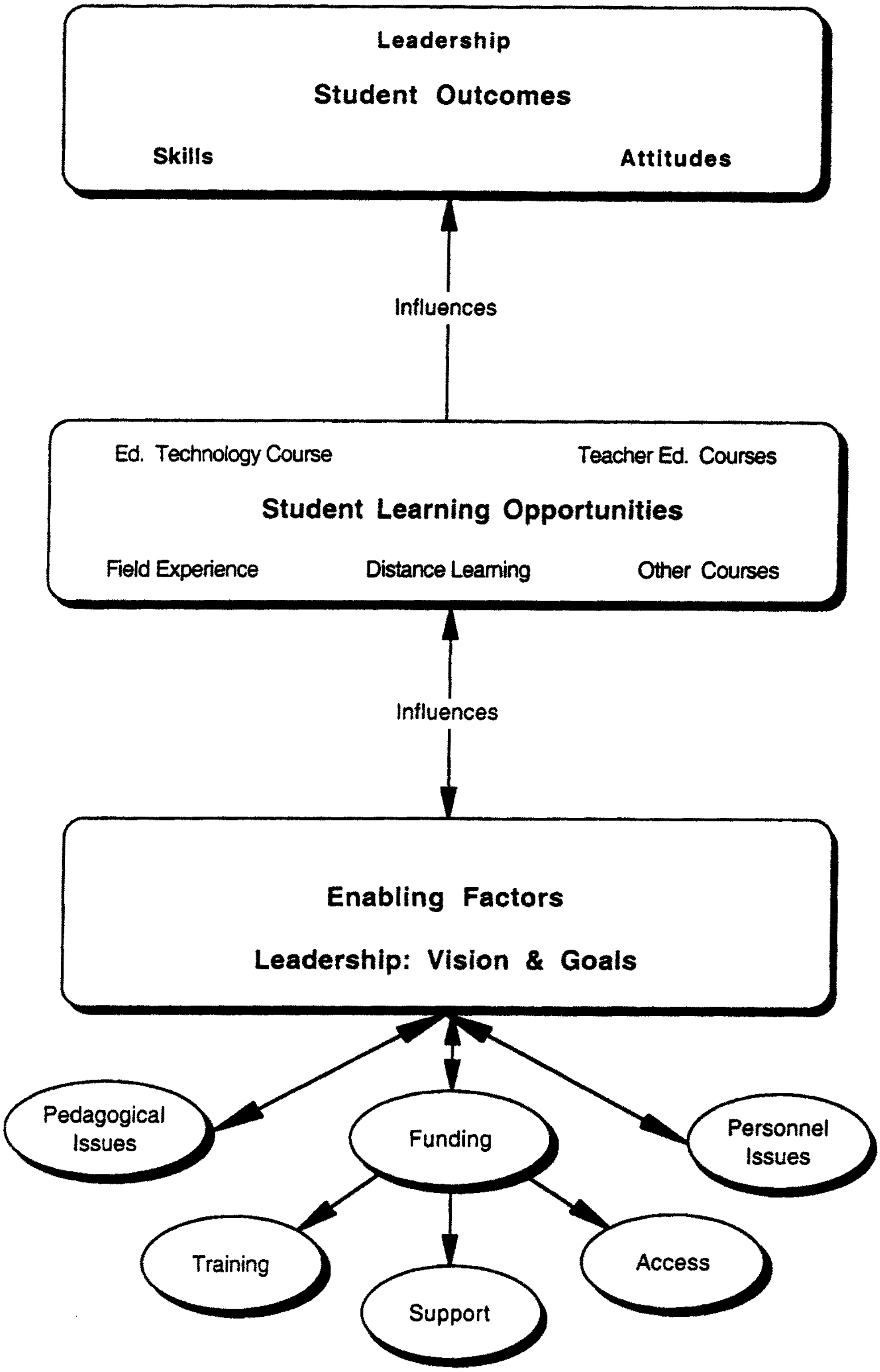
### Enabling Factors

One major theme that emerged across the case studies was the need for strong, committed leadership to support the goals of technology integration. This, and other findings, will be discussed in light of Fullan's (1991) assertion that effective change requires a combination of both pressure and support. Pressure, in this case, refers to expectations, both implicit and explicit, that faculty will integrate technology into their classes. Support encompasses the human and technological infrastructure that facilitates technology integration. Fullan explains that pressure without support leads to resistance and alienation, while support without pressure can lead to drift or waste. Data from the present study suggest that a major function of effective leadership is to obtain a good balance of pressure and support to enable the implementation of technology integration.

#### *Leadership, vision and goals*

One commonality among the sites that we observed was the influence of informed, committed leadership. While virtually all university

Figure 1 ☐ Factors affecting preservice teachers' use of technology in teacher-education



administrators tend to voice their support for technology integration, we observed examples at each site of what we shall refer to as *believers in high places*—leaders whose knowledge and commitment go well beyond the rhetoric of support. At the core of informed leadership is a person who has internalized the complexity of effective technology integration and who exercises influence over time to ensure that the various enabling factors are in place or being addressed. Further, knowledgeable leaders articulate the technology, teaching vision, and goals of their colleges. Examples of such leadership are illustrated below. Some details were intentionally omitted to conceal the identity of the individuals.

The chair of one of the college of education's two divisions at the University of Wyoming began working with teacher-education faculty in 1987 to help them integrate technology into methods courses. Under her leadership, the faculty decided that one required educational technology course was not sufficient to impact technology use in the content areas. For several years this individual was granted released time by the college of education dean (who has since assumed the deanship) to perform this function. Her passion for technology integration is exemplified by her doctoral emphasis in this area, her recent grants supporting innovative applications of technology in the curriculum, and her leadership in using the ISTE/NCATE standards (International Society for Technology in Education, 1996) to plan for technology integration in the University of Wyoming program.

Knowledgeable leadership makes a difference in establishing a vision and goals for the college. Vanderbilt University has been a high-profile program in application of technology in teacher education, with its dean leading the charge. The dean at the time of our visit was very active in making presentations with his faculty at national conferences regarding their work with technology. An example of his leadership can be illustrated by his collaborative work with the director of educational media services in developing a schema for technology integration in teacher preparation with specific innovative program goals that include providing opportunities for students to become producers of technology-rich applications for use in their teaching, and providing opportunities for students to teach K–12 students using the technology.

At University of Northern Iowa, the dean of the College of Education has also been an active leader in the area of technology in education as evidenced by his national presentations on the topic. In addition, the chair of the Department of Curriculum and Instruction at the time of our visit had a specialty in the area of educational technology, and several other chairs were active in this area.

Knowledgeable leaders can help to articulate the technology and preservice education goals at the national as well as the local levels. The former dean of the school of education at the University of Virginia recently served as the chair of the NCATE Task Force on Technology and Teacher Education, which recently published it's report (1997), *Technology and the New Professional Teacher: Preparing for the 21st Century Classroom*. At the University of Virginia, the stated end goal is ". . . to ensure that preservice teachers will be prepared to integrate appropriate uses of technologies in their own teaching after graduation and serve as leaders for other teachers" (The Curry School Technology Strand, 1997, p. 2).

As we interviewed administrators and faculty we found that knowledgeable leadership played an important role in establishing a vision, planning, and securing funding. One faculty member at the University of Northern Iowa characterized what he saw as effective leadership for technology. While he recognized that the provost would not be considered a "techie," he noted,

> She has the vision of what the potential is from a practitioner's point of view. You know, supporting the professors to a point that they can have the technology that they need. And I think that's what the dean does as well. You know he's continually finding little pots of money . . . to help support innovative ideas and experiments that we want to try. I think it's very important in the way that he supports using technology and sees the need for it.

Leadership, however, is not only top-down. Individual faculty members also provided important leadership. For example, one faculty member, who has been a national leader in the field, has been an innovator in TeacherLink, an early telecommunications network of the state's teachers, and subsequently, Virginia's Public Education Network (PEN), which connects all 2,000 of the state's public schools. He is also the codirector of the University of Virginia's Center for Technology and Teacher Education. Rather than emphasizing separate departments, the new center stresses the integration of technology in teaching areas with cohorts of students from different teaching disciplines working together to achieve program goals. The center concept was also supported by an impact grant that sponsored faculty and student collaborations.

Bottom-up leadership was also a factor in decisions made by the college of education technology committees. In each of the cases studied, we found active college-level technology committees comprised of teacher educators, instructional technology educators, students, and support personnel within the college and university wide. Their work was to prioritize technology needs, share promising teaching-with-technology practices, and make recommendations to the dean regarding hardware and software needs for faculty, labs, and classrooms. These committees provided local input to take care of immediate and longer term needs.

*Training and support*

Committed, informed leaders provide the direction and resources for training and support needed for faculty to develop working knowledge of technology applications and their uses in teaching and scholarly endeavors. The provost at the University of Northern Iowa, another example of a believer in high places, explained the need for faculty development to integrate technology in the curriculum in addition to having people who help the faculty with purely technical support. As at many campuses, there was a debate at the University of Northern Iowa between advocates for a centralized support structure and those favoring a distributed one with staff assigned to the colleges on campus. While acknowledging the need for centralized services, the University of Northern Iowa's provost also recognized the value for staffing support personnel in a decentralized way. The provost explained,

> I came down on [the side] that we need the discipline-specific aspect because we're not going to make progress in terms of integrating technology in the curriculum if we don't have people who understand the curriculum and the needs of faculty from other than a technical, centralized point of view. My own perspective is that this was absolutely needed.

Thus, under the provost's leadership, the university allocated resources to staff a curriculum-integration specialist for each college.

Each institution in this study recognized and addressed the need for faculty training using a variety of strategies. Faculty received support and training through group workshops and one-on-one opportunities. Training and support, located at the base of Figure 1, are clearly critical enablers. Various strategies for the professional development-training and support of faculty are discussed below.

*Group training.* Scheduled workshops for particular technology applications were offered at all of the sites visited. This approach appears to be the most efficient way to provide general, nondiscipline-specific training. For example, a comprehensive three-day workshop was offered by the University of Northern Iowa's Center for Educational Technology (CET) to train instructors to teach distance courses on the Iowa Communications Network, a highly developed fiber optics system of more than 700 sites with full-motion video capabilities. Faculty interviewed who taught on the Iowa Communications Network were uniform in their praise for the comprehensive training that they received. Both faculty and administrators cited the quality of the training as a key factor in the high satisfaction rate and low attrition rate for the Iowa Communications Network instructors.

Many cited the value of the CET's courses for training in a range of educational technologies. The director of the college's Instructional Resources and Technology Services stated, "These guys are highly competent Web people, multimedia, and video people, and if anybody wants to dip into the pool, they've got support.

. . . I think there's plenty of support if people want to make the effort to do it."

Similarly, the University of Wyoming offers technology-based workshops through its Center for Teaching Excellence, which was taking the lead in professional development for Web-based courses. Still, several faculty across sites mentioned scheduling conflicts as a reason for not taking advantage of centralized workshops and courses. Many appeared to prefer more individualized support.

*Staff-development specialist.* One-on-one technology support and training was provided through technology–staff-development specialists. Two of the four institutions had an instructional-staff-development specialist located within the college of education. Significantly, in both cases the staff-development specialists were teacher educators who related well with their peers.

As described above, the University of Northern Iowa provost provided the rationale and the resources for the staff-development position housed within the colleges. She maintained that they needed people "who are really more of the interface with the faculty and the curricular aspects," who are familiar with the applications within the discipline and can suggest strategies for employing them. The college of education's technology-integration specialist elaborated that she tries to help faculty in the content areas focus on using those same technologies introduced in the Educational Media class. She does so through one-on-one consulting:

> I met with the professor. She was very interested in how they could integrate technology. . . . We talked through how it actually happens in schools, what's expected of them [K–12 teachers], what's required of them. I thought that was the most appropriate way that it would be integrated in that particular class.

In addition to consulting with faculty, she also is willing to model various technology applications for them in their classes. In either case, her ultimate goal is to get the faculty to institutionalize technology use by making it a regular part of the course objectives. She noted one such accomplishment as the elementary curriculum class added two required skills objectives—(a) to integrate technology literacy, and (b) to integrate information literacy. When asked how this happened, she laughed and replied, "Through much talking."

Similarly, the University of Virginia had a faculty member with a one-half time assignment as a technology–staff-development specialist. He described his duties: "My real responsibility is to help faculty find how they can use the technology to improve or change their teaching, or to improve their publications, to improve their conference presentations." Further, he found that the best way to accomplish this was to have an open door or drop-in policy for faculty members. He explains the *teachable moment:* "If somebody bobs into my door right now and says 'Can you help me with this . . . I'm thinking about doing a presentation for my class?' the best time to get that person to become a real user is right then."

This faculty-development specialist also raised teaching-related questions. For example, a faculty member asked for help getting his office e-mail system to work and, after assisting with the technical problem, the specialist asked: "Do you have your students e-mail questions to you?" He pointed out to his colleague that you could answer questions when you are ready, and if the issues are class related, you can address them in class with all of the students. Looking back on this gentle questioning, he reflected that faculty who took this step with students made significant advances and students appreciated it.

Faculty across cases noted that the one-on-one approach is an effective practice in providing support for professors to use technology in teaching and learning. However, it is important to remember that these practices are within institutions that have been providing technology support for faculty over many years. Thus, the practice is part of a bigger picture in which technology integration has been valued and implemented for some time. As a result, connections among faculty members are made that are facilitated by the one-on-one support, but go beyond that strategy. For example, the technology–staff-development specialist discovered that a reading-methods professor and graduate student were using on-line reading-in-the-content-area news groups, Web-based lessons, Web publishing of curricular units, and electronic journals. The methods professor explained the role of the support person in sharing the course innovations:

> [Our technology-staff-development specialist] wants to put together a little show for faculty who are interested. And I said to him why don't we just invite the new faculty, make them feel special, show them what I've just shown you, and offer them some help if they want to do this.

This example illustrates the interrelated nature of supporting faculty use of technology.

*Students working with faculty.* Other sources of one-on-one support include students working with faculty. Many graduate and undergraduate students are more familiar with technology than their professors. Thus, they provide assistance while themselves learning about curriculum and instructional methods.

At the University of Northern Iowa, a department chair set up an internship in which undergraduate students were assigned to serve as technology consultants for six or seven faculty members to help them create Web pages. First, a workshop on Web-page authoring was offered for faculty, followed by provisions for "just-in-time" help. One student consultant explained that the student interns are "basically on-call." She added that the faculty ". . . are very relieved to know that they could get help. And that's one thing [the Chair] finds to be really important. Whether it be professors or students he wants the availability of someone to come in and help."

At Virginia and Vanderbilt, where there is an ample supply of full-time master's and doctoral students, there were many opportunities for students formally and informally to work with faculty on a variety of projects. For example a University of Virginia doctoral student chose to work with a professor because they had a mutual interest in the content area and the professor wanted to create a number of Web-enhancements for his course. From the beginning there was an understanding that the professor would take over the Web editing and support of the on-line discussion groups as well as the Web-based journals. As they were demonstrating the Web-based lesson for that week's class, the professor said, "I don't think I had to ask for any help with this . . . [the doctoral student's] objective is to make it possible for me to create the Web link myself."

In another interview, a Vanderbilt professor noted that in some cases the graduate students did too much for the professor and that the professors did not learn how to continue to use the technology on their own after the graduate assistants were no longer available. However, this professor also noted that he found the one-on-one approach to be the most effective in helping faculty learn to use technology. Consequently, although the one-on-one approach can be effective, it must be implemented so that both partners realize that the goal is for the professor to become an independent technology user. In their study of staff developers as change agents, Miles, Saxl, and Lieberman (1988), refer to this strategy as *independence building.*

*Grants and initiatives.* All of the universities we visited had provisions for faculty development through various initiatives. At the University of Northern Iowa, "minigrants" were available through the provost's office during a two-week intersession in May. Faculty must complete a "user friendly" one-page proposal that describes their initiative for enhancing their teaching with technology. The provost reported that approximately 80% of the proposals are funded for up to $1,200. She elaborated,

> It's not a huge amount but . . . we provide support where they are working with the technical people [from their CET] on these projects to integrate technology in their classes. So, the real benefit there, I think, is getting that relationship formed between the support people and the faculty because they know who to call. The support people know what their projects are and are able to work very well with them. . . . Just to say to faculty, 'Well, go think about your courses differently.' . . . nothing is likely to change. And that's why I think these minigrants have worked well.

The Provost's Technology Initiative at Vanderbilt was to serve as a catalyst for the integration of technology into the undergraduate curriculum. The first year of the two-year program, the Provost's Technology Initiative provided funding for nine instructional teams, each consisting of a faculty member, graduate student, and support staff. The second year provided support for another set of faculty. The teams had access to a variety of workshops on available hardware and software and effective technology-based models of instruction. The teams were to evaluate introductory courses in each department and explore ways technology could be used to improve undergraduate instruction. In addition, the teams were to explore ideas for expanding the technology integration into other courses in the departments. The Provost's Technology Initiative, funded through the provost's and dean's offices, provided stipends for faculty to work throughout the summer and a technology teaching assistant who would work with the faculty during the summer and the academic year. When finished with the Provost's Technology Initiative year, the faculty members were expected to become agents of change within their departments by sharing technology and course practices and assisting other faculty with the use of technology in their teaching. The recently created Center for Technology and Teacher Education at the University of Virginia also provided stipends for graduate students to work with faculty and for faculty to work together to develop applications of technology across curricular areas.

Another initiative employed by the colleges to support faculty development was the awarding of sabbaticals focused on technology-related goals. Through sabbatical leaves, universities provided a variety of opportunities that allowed faculty sheltered time to learn new technologies, become comfortable with them, and select appropriate technologies to integrate in their teaching and scholarly work.

*Technical support.* Although there was much variation in the source of the support among the four universities, each provided technical support for faculty offices, computing commons, teaching labs, and classrooms with one or more technology stations. For example, decentralized college-media services may provide the hardware and software updates for faculty offices or they might come from a central university source. The point is that without regard to the source of the support, a large majority of the faculty we interviewed felt well supported.

*Access*

A key enabling factor for students and faculty is access to hardware and software as well as a variety of classroom spaces with varying types and quantities of technology. The institutions could not do an adequate job of preparing beginning teachers to use technology in their future classrooms without an acceptable level of technology access for both faculty and students. Access to technology at the various sites is summarized below.

*Faculty offices.* Access in faculty offices across cases was seen as good. One of the colleges had plans for updating faculty hardware and software on a three-year cycle. The others provided for upgrades on the basis of demonstrated need. In virtually all cases, faculty expressed that appropriate technology was available to meet their needs. However, it should be noted that faculty needs increased as they became familiar with a variety of technologies to integrate in teaching. This was one of the findings of Williams Glaser (1998) who conducted an evaluation of the Provost's Technology Initiative initiative for her doctoral dissertation. She found that with additional new faculty participating in the second year of the program, individual computers needed to be upgraded to handle digitizing of video, and removable drives were needed to store larger files. They were unavailable because of cost.

*Student access.* Students stated that they had good access to technology on campus at general computing drop-in facilities, in their dorms, or both. Access to the Internet was available, but in some cases the networks were slow or could not accommodate all of the students who wanted access at the same time. In one of the schools, access to the college of education labs outside of class time was limited because of the full schedule of educational technology classes in the labs. Student access to common computing areas also was mostly adequate.

*Teaching computer labs.* Space for teaching the required technology course as well as other technology-related courses was deemed adequate by the instructors and the students interviewed.

*Teacher education classrooms.* The availability of spaces for general-methods courses to use a variety of technologies was beginning to be addressed by the colleges that we visited. All programs had some portable multimedia carts available on a sign-up basis or labs that could be scheduled by individual faculty. With increasing demand, however, resources were often viewed as limited and efforts were in place at all sites to improve this level of access. One support person at the University of Northern Iowa assessed:

> I think that we need to have more things happening in the classrooms that is more set up and ready to go. Kind of come in and turn-key operations where you don't have to roll the cart in. [It's a] pain.... I think we need to have a couple more where the faculty comes in, unlocks the podium and flips the switch and away we go. I think that's something we need to work towards.

At the University of Wyoming, funds were recently allocated to create a computer lab for math- and science-methods classes along with a computer-based teaching station in the math and science classrooms. A division chair supported this expenditure of funds and was hopeful that similar teaching facilities for other areas would eventually be secured. She assessed:

> Fifty percent use it [technology] and would use it more if they had it readily available in their classroom area. That's one of our goals.... We have as a division one of our highest priorities to get some more computer stations that can go into the classrooms with Internet connections and Power Point and all of that so that it can be right in the classroom and they don't have to schedule and compete for the lab.

At Vanderbilt University, a science-methods and technology professor said they were in the process of updating most classrooms by adding a technology station with a projection device, video player, videodisc player, and network connection. As a result, they will have a number of classrooms that will allow them to get to the presentation level. They also have been considering classroom space that would allow students to bring laptops so that every student could plug in. University of Virginia was in the process of securing funds for six additional classroom spaces with varying technology configurations. At the time of our visits, these colleges had not provided classrooms with clusters of computers that reflected the configuration expected in many K–12 classrooms.

### *Pedagogical 'fit'*

Pedagogical fit is another factor that influences faculty use of technology and students' opportunities to learn with technology. Earlier we discussed the importance of access to technology for faculty and students, and training and support for faculty to become sufficiently knowledgeable and comfortable with technology to begin using it in their courses. However, knowledge of technology does not necessarily mean that faculty use technology in their teaching. In fact, in a recent survey of the faculty in one college of education, Lewallen (1998) found that 100% of faculty used technology in their offices or at home (e.g., applications such as word processing, e-mail, and Internet), but less than one-third of the faculty integrated the technology in their teaching or required their students to use technology in lessons or assignments. In an earlier study (Wetzel, 1993), one reason for this discrepancy was illustrated by a faculty member's discussion of obstacles to technology use in the classroom. She explained, "I'm open to using technology in my class, but I'm not sure there is a good fit for what I do in my educational psychology course. I don't lecture a lot." In this case the professor thought that presentation software would be a logical use of technology in the classroom, but that application did not match or further the way she taught.

Findings in the current study further confirm that professors must see the fit between their philosophies of teaching and learning and technology applications. In our interviews we found many instances in which faculty used technology in their courses when it matched or enhanced their beliefs. For example, a Vanderbilt professor explained his reasons for using electronic communications:

> The dialogue thing has intrigued me ever since Vygotsky, and I've taught kids from preschool through older people. I kind of had this faith in dialogue, but... I really want to know under what condi-

> tions it actually helps that you talk to people about [multiple perspectives]. So the kind of [Web-based and e-mail] communication presents . . . a new way to examine that. The chat group printout does too.

Faculty did not appear to use technology for technology's sake. Rather they used it because it fit with and enhanced their current instructional styles and practices.

*Personnel issues*

Various issues raised pertaining to personnel policies could be viewed as factors that enable technology integration in the colleges. Probably the most influential regards the focus on technology in the hiring process. In general, the emphasis on technology appears to vary for different positions, but it is increasingly being considered. At the University of Wyoming, it was reported that in the teacher-education program technology is part of the job application. One faculty member noted, "It's not likely that they would hire someone who wasn't into technology." At the University of Northern Iowa, a member of the Curriculum and Instruction Department stated,

> Our department has indicated that we're not going to consider people for a faculty line unless they can model or demonstrate ways in which they are in fact already infusing technology into their teaching philosophy and some of the things that they're doing professionally. And if we can have that demonstrated and modeled, then we have such a support structure to continue to foster that development... But if they're not there already starting it, it's going to be that much harder to bring them up to that level. We hire them with it.

At the University of Virginia, the former dean of education explained that all other qualifications being equal, candidates who were prepared to use technology in their areas would be hired before those who were not as well prepared.

None of the colleges reported that technology was directly considered in its traditional reward structures for faculty—tenure, promotion or merit. Several stated, however, that inasmuch as technology can impact good teaching and scholarship, it can contribute indirectly to faculty rewards, but there was no evidence that any of the colleges had plans to directly link these rewards to technology use.

## Student Learning Opportunities

Supported by the enabling factors described above, the programs provide a variety of technology-based learning opportunities for students. A description of these activities, which make up the middle component of Figure 1, is organized into five parts: educational technology courses, teacher-education courses, other courses, field experiences, and distance learning.

*Educational technology courses*

All of the programs that we visited had a required educational technology class for preservice teachers that was usually designed for students to take early in their sequence of courses. In each case, the course focuses on similar computer-based applications. In addition, the educational media and classroom computing class at the University of Northern Iowa included some more traditional, noncomputer-based media such as television and video.

The University of Virginia employs an interesting approach to this requirement by providing two experiences for incoming students. First, students take a general education course with an introductory unit on computers; then they select from one of two options for their second computer experience. The introductory unit in the general education course covers basic skills needed for the teacher-education program—word processing, e-mail, and Internet navigation. Students have the option to test out of this requirement. Most students then take a three-credit educational technology course, while some opt for a two-credit advanced course called the . In each case, the course is coupled with a practicum experience. The Technology Infusion Project option pairs each preservice student with a mentor teacher to work on technology-based projects for the second half of the semester. In some cases, students who take the beginner's class later also take the advanced Technology Infusion Project class. A preservice teacher commented on the effectiveness of this approach:

> I would like to address the importance of sending the students into the school system . . . . The first-hand experience in the classroom definitely enhanced the class. If I had not gone into the classroom, I would never have been able to observe what a positive response the program evoked from my elementary students. I definitely saw positive results from this program. I had in the past only read about them (Bull, Hochella, Becker, Miles & Tate, 1995, p. 16).

Another benefit of the program was that it led to improvements in the technology integration of K–12 classrooms. Later these classrooms accepted the University of Virginia's student teachers; consequently, the university was better able to provide student-teaching situations with models of technology integration.

At the University of Northern Iowa, undergraduate students have the option to pursue an 18-credit minor in educational technology. While the technology minor tends to attract some techies, it also serves students who are less technologically oriented but recognize the increasing importance of technology in education. A student explained, "I got into the minor because I wasn't totally supportive of technology and I felt like I wasn't educated enough about it. . . . Being a teaching major that's something that we're going to have to deal with whether we want to or not."

*Integration into teacher education courses*

In each institution technology integration was part of the larger plan for preparing students to teach with technology. Although individual faculty efforts to integrate technology in their courses were evident, we noted two major factors that contributed to the institutions' systemic efforts: (a) college-wide planning for technology integration, and (b) the use of national standards.

Educational technology is one of three major strands of the University of Virginia's five-year teacher-education program. As part of an initial teacher-education course described above, students received training in communication tools including word processing, e-mail, and electronic conferencing. In following years they used educational technologies specific to the content areas. Later they participate in a required technology course or an advanced technology course for students with technology skill who were interested in the , or both. Finally, efforts are made to place students in practicums and student-teaching experiences where technology integration is modeled.

An example of integration in methods courses at the University of Virginia includes a secondary social studies and mathematics-methods collaboration in which faculty worked together to identify ways in which preservice teachers in these two programs can use mathematics to explore sociological concepts. An aspect of this collaboration included providing preservice students with graphing calculators to explore questions of interest such as the increase and decline in new AIDS cases.

At Vanderbilt University there was also a sequential plan for technology in the preservice program where later stages of the program build progressively upon students' experiences in initial classes (Pellegrino & Altman, 1997). Students take courses in which they move from consumers and participant observers of technology-based learning applications to producers of content applications appropriate for their own teaching. At the same time there is a shift of technology applications from a supplementary to a central role in a course's learning activities, along with a gradual increase in the sophistication of the technology-based applications that students experience in a course. For example, in introductory courses students see real-life examples of interactive multimedia, electronic communications, and information available from the World Wide Web. In midlevel courses technology is a more integral component of the regular class activity. While students continue to use the technologies employed earlier, they now use interactive multimedia with video footage of actual teaching and they are asked to reflect on the teachers' decisions, the consequences of those decisions, and plan their own teaching experiences. In advanced methods courses, multimedia materials may be used to support a case-based approach where preservice students analyze a three-day lesson and use a multimedia presentation program to present their analysis to the class. Project options for their advanced methods classes allow students to produce their own interactive multimedia instructional materials for use in their teaching.

Vanderbilt faculty members referenced this model in the interviews and explained the fit and purpose of technology in their courses. The students interviewed described the uses of multimedia programs designed by their professors and the extensive use of electronic communication and course Web pages in most courses. Students also provided perspective on the frequency of technology modeling in their classes. For example, one senior stated:

> I think probably half my professors [model technology use in teacher-education classes] . . . I've had probably about four classes, . . . that have said, 'Okay, you know, see how we're doing this and see how [we're doing] this, this and this works, and this CBM works . . . we're doing this on the computer, and you need to do this also to your kids.'

We encountered other systematic and unique efforts to institutionalize integration into methods classes at the University of Wyoming. During the 1987–88 academic year, the faculty agreed that integration of technology into methods instruction was needed to adequately prepare their students to teach with technology. Initiated by discussion of the Curriculum and Instruction faculty, a plan was developed to create an additional methods class that focused on technology use in particular areas. An early advocate and leader for this approach, recalled,

> I think the pressure came from ourselves. I mean we voted to do it. We voted to do it over time and so initially there was no pressure because it was something in the future. And then after the classes got developed, and the first go round I taught them all. And then we started team teaching them . . . . there was still the opportunity to wait until you felt you were ready, but the expectation was sort of always there.

Eventually the teacher-education program was restructured and it was decided that technology would be integrated into the existing methods courses. The informant elaborated on both the pressure and support for making this happen:

> There have been many opportunities made available to faculty to learn how to integrate it into their classroom and in some cases there's been considerable pressure put on them. And that would be in our continuum of courses, it would be the people who do methods. If they weren't already integrating, then they were asked to do that.

One approach at the University of Wyoming to ensure greater integration in methods classes was observed in their elementary program through the creation of a required, six-credit math, science and technology block. Each six-hour block was taught by one methods professor, but team-planned by all of the block faculty. While the faculty were not all equally strong in their knowledge of technology applications in elementary math and science, the planning team provided a natural forum for professional development and support. In addition, the team was provided a new math-science computer lab and a well-equipped teaching station in its classroom. Among the topics addressed were video capturing, video microscopy, and multimedia reports. One of the math-science faculty stated,

> We did a lot of it [last year]. But this is the first year that we've had this kind of constant access to a lab and so we're doing more. We didn't do PowerPoint before. We've always done HyperStudio . . . . We've just been able to expand it a lot more; spend much more time on software. We did a day on software for children, now we're looking at a day for tools, teacher-tools kind of software. And we also talked about—we haven't done it yet—the MBLs kinds of things that we could hook up for science.

In the University of Wyoming's secondary math program, the same lab and a similar teaching station was used for an eight-semester-hour methods block in which applications of technology were thoroughly integrated.

Another tool to support a more systematic approach to integration involved the use of the ISTE foundation standards for technology skills for new teachers (ISTE, 1996). At the University of Wyoming, the chair of the division was working on a grid of classes and the standards to ensure a more consistent and sequential approach to technology experiences. By doing so, she had hoped to work with the faculty to fill in some of the gaps in students' technology experiences.

At the University of Northern Iowa, the College of Education's technology-integration specialist also was using national standards in technology, as well as other disciplines, to guide her work. She projected, "I think that as we move toward integration of technology standards and content area standards and really looking at how they overlap, [it] will help to put the pieces together for the various content areas struggling to integrate technology."

Interviews with University of Virginia graduate and postgraduate students teaching the required preservice technology course revealed extensive use of the standards in the design of the course and assessment of students' learning.

*Integration into other courses*

Vanderbilt University, through the Provost's Technology Initiative, focused on providing models of technology integration in general requirement courses for all undergraduates. Many of the faculty teaching upper-division teacher-education courses were already integrating technology into their instruction, thus, the focus of the Provost's Technology Initiative was primarily on teaching with technology in freshman- and sophomore-level courses.

At the University of Northern Iowa, technology-integration specialists were staffed in colleges throughout the university. While we did not investigate the work of these specialists outside of the College of Education, this staffing decision, supported by the University of Northern Iowa provost, reflects an appreciation of the importance of technology integration throughout the university's programs.

*Application in field experiences*

While all agreed that it was critical for students to have the opportunity to observe and teach with technology in their field experiences, this area was reported as one that still needs much work. At two of the sites, the University of Northern Iowa and Wyoming, this situation was somewhat controlled through university-affiliated laboratory schools. Such schools, of course, give those universities more control over the teaching-learning environment to which their preservice teachers are exposed. Thus, all preservice students at these universities are virtually guaranteed to have at least one field placement in a technology-rich environment.

Field placements in the surrounding public schools, however, were considerably more uneven regarding the availability and use of technology. A division chair at the University of Wyoming echoed sentiments that were expressed at all of the sites visited: "We've started on those efforts but unfortunately our students don't always get placed in a classroom where they see it [technology] in action and they are working with a teacher who's valuing it."

When asked if technology applications were required in the field experiences, she replied,

> We tried that early on and we got horrible backlash from the teachers. There were teachers who didn't feel comfortable doing it; didn't want to do it. They didn't want us to have that required; they wanted it to be recommended. But the long-term plan . . . is that they will have it [required].

A science methods professor at Vanderbilt also commented on this issue:

> We've tried to be a little more proactive about getting placements where they could see technology. And they'll have at least two placements there. And it . . . varies so widely in town. There are some very, very competent technology-rich classrooms, and there are some that, you know, have an Apple IIe over in the corner and never turned on. I think we're trying to get more and more of the students into the ones that have resources.

Another approach reported that encourages increased technology use in field experiences involves working with "volunteers," that is, those students and mentor teachers who express an interest in teaching and learning with technology. The Technology Infusion Project at the University of Virginia, which was previously discussed, is a good example of providing technology-based experiences for those students who seek them out. At the University of Northern Iowa, students are also given the option to submit preferences for their field placements, including the use of technology.

A simple, yet very promising, approach that supports technology use in the field was observed at the University of Wyoming. Several instructors there employ a strategy, an informal technology inventory, that encourages and helps practicum students use technology in their field placements. One faculty member explained that during the first week of their practicum, students were asked conduct the informal inventory of technology available at their school site and report the results in their university class. As part of the inventory students were asked to find out:

> . . . what kind of software they were using at each school, what kinds of machines they had available and Internet access . . . . Also we had the students talk to their teachers about what their philosophy is about using technologies, whether it's for games, whether it's extra—when you're done with your work you can go over to the computer—or if it's integrated in as part [of the curriculum]. So we would have students discussing that. So that way it could vary depending upon what was available in the schools and then we could give particular assignments on using a particular type of technology.

Another faculty member added:

> We find sometimes unless we ask them to do this survey, the mentor teacher may or may not tell them about the fact that there's a computer lab someplace that's got 30 or 40 networked computers all connected to the Internet. And once the student teacher knows that then they can design a lesson whereby they do a field trip or lab activity where they meet in that computer lab.

He added,

> I look for it. If I see no evidence of it I'm going to follow up. I don't make it a requirement because there are so many contingencies that prevent them from being able to [use particular applications]—and I don't want to put that kind of negative pressure on them with a grade or that sort of thing. So I'm using an informal way. But I do follow up to see that they're doing it.

*Distance learning*

Although distance technology can be a part of each of the components described above, we chose to focus on it separately as a distinct student-learning opportunity. For those students located in remote areas, the distance technologies provided learning opportunities that would not otherwise be accessible. For example, several programs at the University of Northern Iowa were thriving because of the accessibility of classes via the state's fiber optic network, the Iowa Communications Network. The school library program provides a good example of this. The director of that program elaborated:

> Because so many of our people are practitioners, it's real difficult for them to get here, and there are no programs west of Des Moines for our people [in Iowa] . . . . So there's this horrible unserved area of Western Iowa out there. And if our people came only to do our program in the summers it took them four summers. They are community-involved; most of them are women. Most of them have families. It's just a heck of a thing to give up four eight-week summers. So when the ICN [Iowa Communications Network] started I saw it as a real opportunity to get out there to those people. So we were the first program to offer half of our program on the ICN . . . We're finishing our second cadre and ready to start our third in the fall.

Many informants expressed interest in the application of distance technologies to facilitate supervision of students' field experiences. While faculty supervisors in Wyoming are required to cover vast distances to meet with students—sometimes more than 1,000 miles in a week, most faculty noted that access to compressed-video teaching stations throughout the state was not adequate to allow for effective supervision over a distance. One faculty member further noted that the compressed video "doesn't lend itself to supervision." She explained that it could be used for group discussion and debriefing among student teachers, but even if students have access to a compressed video classroom, the teaching environment in those rooms is very different from the typical K–12 classroom.

A special education professor at the University of Northern Iowa described the evolution of her efforts with supervising via the full-motion video accessible on the Iowa Communications Network. At first she attempted to observe students teaching in an Iowa Communications Network classroom. Eventually, though, she accepted that the logistics of bringing students to the Iowa Communications Network rooms were often difficult and that this was not a natural teaching environment in which to observe. She persevered with the technology, however, and worked out a procedure that works:

> Now what I do is schedule appointments and they take the video to the nearest ICN room and we watch the videotape simultaneously and I give them their feedback immediately. And that's improved the quality of the supervision because they're watching it and doing the evaluation themselves, the feedback is immediate, and we have things under the overhead camera. And as long as it's in my [appointment] book, I do it. So now, I won't allow my students to do a long distance supervision or long distance practicum unless they will agree to meet me on the ICN.

### Student Outcomes

The top component of Figure 1 consists of the student outcomes that were reported as the result of learning opportunities described above. While it was beyond the scope of this study to systematically evaluate these outcomes, we were able to get a sense of students' attitudes and skills through our interviews and observations. Perhaps the most promising result of the attitudes and skills reported is the potential of these students to serve as leaders for teaching with technology in the coming years.

Data gathered suggest that students in the programs visited have a clear sense of motivation about teaching with technology. They reported having both the will and the confidence to apply and develop their use of technology in the classroom. One student explained, "I think I still have more to learn but I'm comfortable with the computer and feel that I could sit down with a program and work through it to figure out how to do it before I teach the kids with it. But yeah, I'm definitely comfortable."

Another student illustrated her sense of confidence in working with application software. She recalled that during her practicum, a substitute teacher came into her class and said, "I don't know what this means, it says HyperStudio in the computer lab." The preservice teacher responded,

> "Oh well, I know a little bit about it. Do you want me to come in?" So I went in and helped the kids. The kids didn't know me, I didn't know them and I knew just vaguely what they were supposed to do. And we played around with it and had a lot of fun. Even though we had no written out lesson plan of what to do with HyperStudio, we made a lesson out of it. It was really neat!

While there was clearly a range of student comfort and confidence reported, many students did appear to possess the "fearlessness" of technology that was set as a critical goal in the OTA Report (U.S. Congress, 1995). Furthermore, it appears that a natural by-product of the attitudes and skills observed is potential for leadership in the use of technology in their classrooms and schools. A faculty member assessed, "As I've been around this state in the last couple of years, I think we're sending our students out with more comfort with technology than most students go out with. They tend to be kind of leaders in the schools."

Another faculty member noted, "I also have students who very proudly talk to me about how they showed their mentor teacher, you know, some particular application with the computer that the teacher didn't know about." A preservice teacher echoed this view and talked about the potential of her peers to take on leadership roles:

> And I think we're going to be mentors for some of the teachers who are out there now. Like my sixth grade [mentor] teacher. You know, she didn't have technology when she started, so she doesn't know a lot about it. So she's really relied on her students and she asked me some questions. I think we're going to be able to mentor some of the people who are out there already.

A recent graduate of one of the programs illustrated her potential and willingness to take on a leadership role. She recalled her experiences during her first month on the job:

> We just got new computers in the boxes on floor today. No one knows how to use them. I'm the only one in there who even thought about using computers in the classroom .... I had ideas of what I'd like to do in my classroom before I got here, but when I arrived they didn't have software like KidPix or HyperStudio. So I haven't been able to do the things I wanted.

She also described her attempts to overcome these obstacles: "I'm trying to get a grant just to get HyperStudio [for the school]. [To get it] I've even offered . . . to teach at least three teachers how to use it and maybe they can teach [with it too]. I mean if I'm willing to do that, I want it pretty badly."

## DISCUSSION

Results of the current study confirm key findings that Mergendoller and his colleagues reported in their 1994 case studies. The informed leadership of deans and other administrative and faculty leaders continues to be a critical factor in the technology-integration efforts at the exemplary sites visited. Expectations for technology use throughout the colleges have continued to increase and a constant stream of resources for hardware, software, training, and support have been essential to keep pace with the emerging needs. Clearly, the goal of technology integration is a moving target that requires ongoing leadership and support. As Fullan (1991) stated, "It takes a fortunate combination of the right factors—a critical mass" (p. 92) to institutionalize desired changes. The integration of technology throughout teacher-education programs appears to be a clear case in point.

Figure 1 provides a framework for analyzing the variables that enable and support technology-based learning opportunities and ultimately affect student outcomes. Analysis across cases confirms that while approaches at the institutions varied, a complex web of enabling factors must be in place to support change with technology.

Research literature on technology integration clearly addresses the need for providing adequate support for users. As Fullan suggests, however, pressure can also be a critical variable. Pressure, in this case, refers to expectations, both implicit and explicit, that faculty will integrate technology into their classes. While pressure without support leads to resistance and alienation, Fullan asserts that support without pressure can lead to drift and waste. Findings of the present study suggest that a major function of effective leadership is to obtain a good balance of pressure and support for faculty integration efforts. Pressure, in the form of expectations, fosters a sense of accountability that increases the likelihood that funding for faculty support will lead to technology-based learning opportunities and desired outcomes for students.

Pressure for technology implementation, however, does not appear to be effective when it comes in the form of a mandate. Rather, as a faculty leader at the University of Virginia, stated, the pressure for change should be like the "wind at your back." Cooper (1999), former Dean of the University of Virginia's School of Education, counsels that we should be patient and not use mandates. Rather, it makes sense to tend to the complex web of enabling factors, use national standards for systematic planning, and continue to communicate appropriate expectations. A commonality among the exemplary institutions in this study is their ongoing, systematic effort to encourage and support faculty to use technology in their teaching.

Rogers's (1995) work on the diffusion of innovations helps us understand how technology integration among faculty will likely grow over time. He documents a natural continuum of adopters from innovators and early adopters to early majority, late majority, and the most resistant of users, laggards. While innovators and early adopters tend to be self-starters and independent, later adopters tend to require more support. Thus, it follows that as colleges of education seek technology integration throughout their programs, the expanding base of adopters will likely require more support than their earlier adopting peers. Despite a trend toward user-friendly applications, the access to user support will likely be an issue for some time. To be sure, access to technology resources and support will require continuous monitoring and adjusting.

A final question to consider is the degree to which the exemplary practices described in this study are exportable to other sites and contexts. Unfortunately, as Fullan (1998) states, "There is no external answer that will substitute for the complex work of changing one's own situation . . . . The first insight is that there is no definitive answer to the 'how' question" (p. 8).

Recognizing the uniqueness of each site, we believe, however, that there are many recommended practices explored in this study that would likely prove beneficial if employed in other settings.

### Recommendations for Further Research

Based on the findings of the present study, we suggest that the following research questions be pursued:

- The present study emphasized a range of enabling factors that supported student-learning opportunities. Student outcomes, however, were not addressed in as much depth. It would be helpful to systematically examine the effectiveness of various student-learning opportunities. What activities have the greatest impact on preservice teachers' eventual use of technology in their teaching? What is the impact of technology-rich field placements? Can Web-based learning opportunities be used to better prepare preservice teachers?
- The present study, along with the prior study by Mergendoller and his colleagues (1994), documents the incremental nature of planning for technology integration in colleges of education. For those colleges less advanced in technology-integration efforts, are there ways to move forward more quickly? In addition to obtaining adequate computer resources, what strategies should be top priorities for those colleges seeking to better prepare their students to teach with technology? □

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