A Systems Approach To Improving Technology Use in Education

Mark J. Toci
Kyle L. Peck

Abstract: Despite the power of emerging technologies to create engaging and meaningful learning environments, they have had little impact on the way we educate children. Because teachers are busy, isolated, practical people, the motivation to learn about and use technologies simply does not overpower the many existing obstacles. Obstacles including lack of time, availability of learning resources, and lack of incentives limit teachers' professional growth, preventing them from developing the knowledge, skills, and attributes necessary to integrate technology into the classroom. However, through a "systems approach" to the problem, it is possible to overcome these obstacles and to provide viable professional development to thousands of motivated teachers. This paper is a case study of one large-scale project using a systems approach to prepare teachers to use technologies well.

Resume: En depit des possibilites offertes par les nouvelles technologies pour creer des environnements d'apprentissage motivant et remplies de sens, elles ont eu un impact minime sur notre fa9on d'eduquer les enfants. Etant donne que les enseignants sont des gens occupes, isoles et pragmatique, leur motivation pour apprendre et utiliser les nouvelles technologies est nettement insuffisante pour surmonter les nombreux obstacles. Ces obstacles incluent le manque de temps, le manque de ressources pedagogiques et le manque de stimulants limitent la croissance professionnelle des enseignants, les empechant ainsi de developper les connaissances, les habiletes et les attributs necessaires a une integration des nouvelles technologies en salle de classe. Toutefois, une approche systemique fa9e au probleme permet de franchir ces obstacles et de fournir des possibilites de developpement professionnel viables pour les nombreux enseignants motives. Get article presente une etude de cas d'un projet a grande echelle utilisant une approche systemique pour preparer les enseignants a bien utiliser les technologies .

A Systems Approach to Improving Technology Use in Education

Modern electronic technologies are impressive "mind tools" offering the potential first to significantly improve, and then to *revolutionize* education. Around the world, educators and politicians are becoming aware of the potential of modern technologies in education. For example, in the United States, the Presidential Committee on Science and Technology (PCAST, 1997) recently reported that:

"Most researchers and practitioners in the field of educational technology are already convinced that information technologies have the potential not only to improve the efficacy of our current teaching methods, but perhaps more importantly,

Canadian Journal of Educational Communication, Vol. 27, No. I, Pages 19-30, ISSN-0710-4340

to support fundamental changes in those methods that could have important implications for the next generation...."

This potential, though widely acknowledged, is rarely realized in today's schools. While issues of access to technology are being addressed (slowly but surely), little progress has been made in addressing the other major roadblock - the inadequate preparation of educators to put these new tools to work, in either traditional or progressive ways. We need to change educators' attitudes and extend their technology-related capabilities before technologies will improve or transform education.

Unfortunately, technology education for teachers has largely been ineffective. Attempts at professional development for teachers often involve "one shot" sessions with visiting experts, or sessions that focus on isolated technology competencies without serious attempts to use the new skills and knowledge in the classroom, or to change teachers' belief systems (McKenzie, 1991; U.S. Department of Education, 1996). As a result, most teachers can operate computer technologies in basic ways, but they have not been inspired to go beyond the basics or to effectively integrate these new tools into student activities.

Hunt (1971) described two types of professional development. The first type involves incremental approaches designed to change specific teaching behaviors and strategies, while the other approach is aimed at shifting a teacher's belief system and actions. It is a relatively simple task to teach teachers how to use a new technology. It is a much more difficult task to cause teachers to change their belief systems, causing them to embrace new modes of operation in which the power of modern technologies can be realized. Professional development is generally "handled like a passing fad rather than an integral part of a long-term reform strategy." (U.S. Department of Education, 1996).

The purpose of this paper is to demonstrate that a "systems approach" to the design of professional development programming can overcome the tendencies to fragment programming. Systems Thinking during the design of professional development programs can result in a set of resources that encourage the long-term involvement and a shift in beliefs that will be a necessary prerequisite for meaningful reform.

Systems Thinking

"Systems thinking is a discipline for seeing wholes, recognizing patterns and interrelationships, and learning how to structure them in more efficient ways" (Senge & Lannon-Kim, 1991, p. 24). Systems thinkers consider the complexity of the organizations they are working to improve, in an attempt to understand how a change to one component is affected by and will affect other components of the system. Education, as an "open system" (Banathy, 1991), is made up of many complex parts that extend well beyond the walls of the school itself. Teachers, students, administrators, parents, businesses, taxes, curriculum, calendars, unions, laws, and relationships are but a few of the components that make up a school

system. The ability of educators to effectively use technology in the classroom depends on would-be "change agents" taking a systemic approach to how they go about implementing and integrating technology. Reigeluth (1994) discusses the importance of a systemic view when approaching change in school systems:

Systemic change is comprehensive. It recognizes that a fundamental change in one aspect of the system requires fundamental changes in other aspects in order for it to be successful. In education, it must pervade all levels of the system: classroom, building, district, community, state government, and federal government. And it must include the nature of the learning experiences, the instructional system that implements those learning experiences, the administrative system that supports the instructional system, and the governance system that governs the whole educational system (p. 3).

As leaders of Pennsylvania's "Link to Learn Professional Development Project," we were responsible for the creation of resources that will lead to the effective use of learning technologies in schools. As systems thinkers, we assessed many factors that will influence the use of the products we create, and thought about the relationships among these factors. As a result of several planning sessions involving an Advisory Board composed of 35 representatives of schools, higher education institutions, and professional organizations, we concluded that effective use of technology in the classroom is dependent on three equally important factors: a) *availability* of the technologies; b) the *ability* of the professionals to use them well; and c) the *willingness* of educators to invest the energy and take the risks involved to change what they are doing. As a result, we realized that "access" to technologies was increasing rapidly and was not our responsibility, but that if we were to be successful, we must succeed in developing both ability and willingness. Ability without willingness produces people could achieve, but don't. Willingness without ability produces who people who try, but fail.

We realized that we could succeed only by developing and distributing products and services that cause teachers to want to engage in professional development and that lead to quick success, while teaching topics of importance to them and their students. If teachers and other professionals don't know how to use technologies or what to do with them to improve teaching and learning in their subjects, the investments in equipment, networking, and software are lost. Likewise, if teachers and others are *unwilling* to use them, the investments in tools and professional development are lost. Our analysis continued.

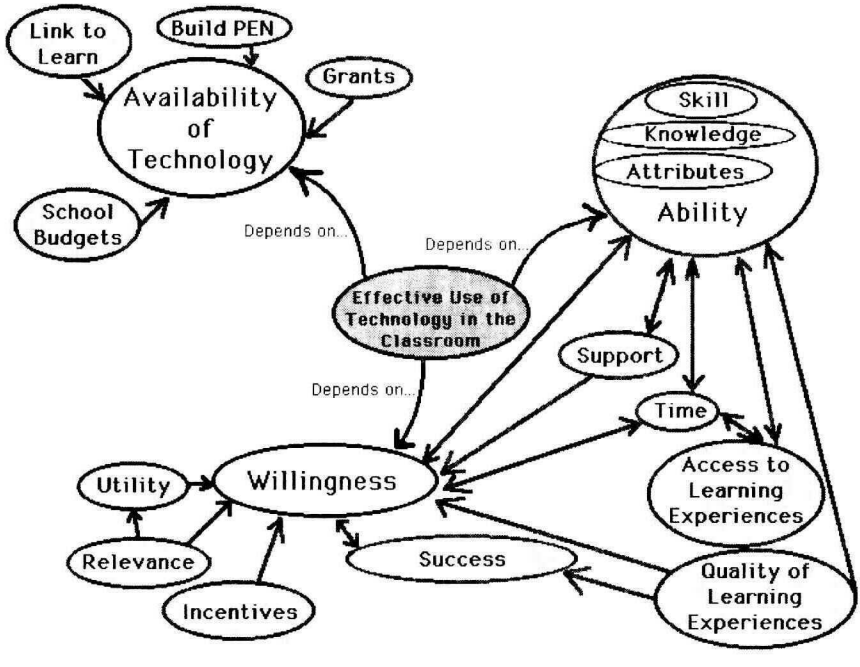
"Ability," we determined, consists of three major components, knowledge, skill, and attributes. Yes, computer users need to know "which buttons to push." They also need to know something about how computers work, how networks operate, and most importantly, how other educators in similar settings use these tools well. Teachers have little opportunity to see inside other classrooms, and even innovations implemented by teachers down the hall are often unknown to them. Important skills to be acquired are numerous, including obvious skill with different software tools, but more importantly skills like troubleshooting and on-line research skills.

"Attributes" that increase an educator's ability to use technologies effectively include characteristics like "independence," "self-discipline," "courage," and "confidence." Several agencies have completed technology initiatives only to find that despite large investments in hardware *and training,* there was little effect on what actually happened in the classroom. Teachers liked having the computers, and enjoyed the training and learned from it, but didn't take the next steps to incorporate these potentially powerful tools on a regular basis. Most computers in these classrooms display "dark screens" or screen savers most of the day, and get occasional use as a supplement to "business as usual." "Willingness" to use technologies is a critical component, most often overlooked. Great progress can be made by working wisely on this factor, with assistance from important organizations, which include teacher unions and school boards" associations.

Influencing Ability and Willingness

The diagram below (See Figure 1) illustrates some of the factors influencing the development and sustenance of ability and willingness.

Figure 1: Factors influencing the development and sustenance of ability and willingness.



How might we improve ability? Obviously, engagement in learning experiences - workshops, courses, on-line tutorials, instructional videos, books, and other sources of training and education can improve ability. The quality of the learning experiences will also effect the results. Less obvious is that fact that the "accessibility" of the experiences will influence their use. If we make these experiences increasingly available to educators, where they work and where they live for example, we can positively influence ability. The first question teachers ask when offered computer training or asked to use new technologies in their classrooms is, "Where am I supposed to find the time?" The "If you build it they will come" assumption is a dangerous one when dealing with educators. They are very busy people with little control over their time. They can't "block out a day" to learn how to use a new piece of software, and their evenings are generally occupied with family responsibilities, phone calls to parents, assessing student work, graduate-level coursework, and planning. Making time available will be a challenge, but will be a powerful contributor to the development of ability. (Ideas for creating time are presented later, as we discuss "willingness.")

Support is also a key variable in increasing ability. Teachers need to get quick answers as they wrestle with technological problems, or they will "bail out" and spend their time in other ways. For this reason, a high-quality support program will influence both willingness and ability.

How might we improve willingness? We must begin by acknowledging that educators are busy, dedicated, practical people and that, at first, it is more difficult to teach with technology than without it. If we are to cause educators to embrace technologies, we must increase the time they have, and support them as they take their first steps. In addition, we must make sure that their first steps lead to "quick success," - lessons in which increases in student learning justify the investment of time and energy. "Relevance" is another key issue. The ideas we promote for teachers must relate directly to things they care about - to important skills and knowledge they are expected to teach. "Utility," a concept related to relevance, refers to the "usability" of the proposal. Can it be done with minimal preparation time? Does it require equipment and software I can get quickly, easily, and preferably free?

Putting Systems Thinking to Work

A quick needs assessment revealed that although teachers believe technologies can significantly improve the effectiveness of education, they perceive that there is simply no time for professional development. Most teachers believe that time spent in professional development should be part of the contracted school day and year, or they should be compensated for the time they spend in professional development beyond the contracted service. Unfortunately, only a few days per year are allocated to professional development, and these days include startup time at the beginning of the year, time to produce report cards, and time to hold parent conferences, and they must include sessions on a variety of issues including, but certainly not limited to technology.

In its "School Technology and Readiness (STAR) Report," the CEO Forum on Education and Technology (1998), reported that only 13% of all public schools in the U.S. reported that technology-related training for teachers was mandated by the school, district or teacher certification agencies. The same report noted that 50% of teachers cited the "lack of time to train" when asked to rate the greatest barriers to integrating the Internet into the classroom.

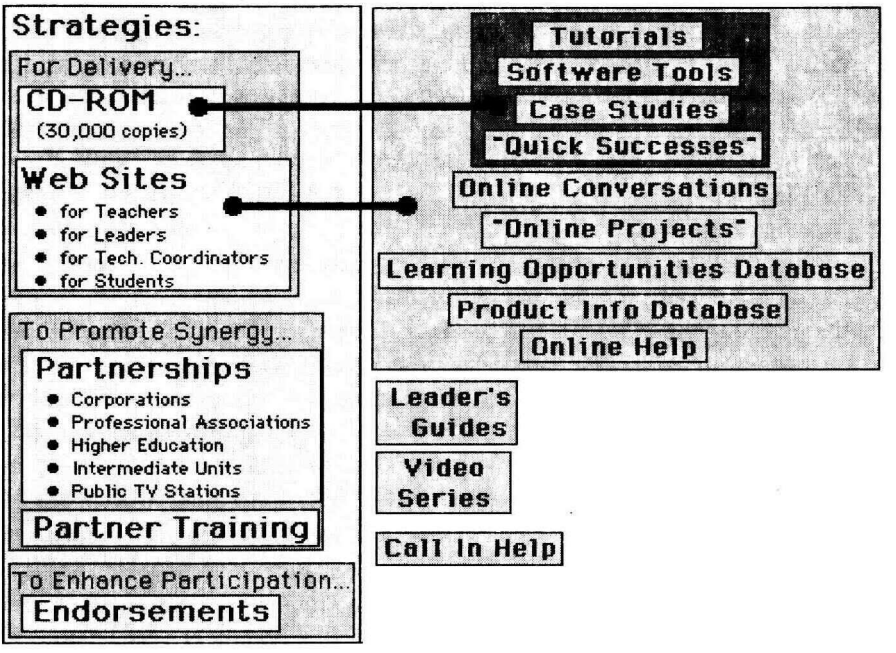
The amount of time that should be devoted to professional development *for technology issues alone* exceeds the total annual professional development time in the vast majority of school districts. The CEO Forum on Education and Technology developed professional development benchmarks for schools. In a "low-tech" school, by their definition, teachers get less than 30 hours per year of training related to the use of technologies, while in a "mid-tech" school teachers get between 30 and 50 hours per year, in a "high-tech" school they get between 51 and 70 hours of technology-related inservice, and in a "target-tech" school (the ideal) teachers would receive 71 hours or more of technology training each year. A survey published in the latest issue of Education Week shows that we are nowhere near that goal, reporting that only 15% of the nation's teachers received more than nine hours of technology-related training per year - an amount that is one-third of the lowest, "Low Tech" rating. Erik Fatemi, Senior Editor for Education Week's "Technology Counts" report said in an Associated Press interview, "The danger in not having teachers trained to use technology is that the money you spend on actual equipment can go to waste... If teachers don't know how to use it, it can just gather dust."

Teachers are busy, isolated, practical people. The base of professional knowledge and beliefs is changing rapidly, but educators have little time or opportunity to engage in professional development. A relatively small percentage of teachers push themselves to work a long day at school and then travel to attend a college or university course one or two evenings a week, but the percentage of teachers who choose to make this sacrifice (often spending as much time in their cars as in the classes they attend) is low. As a result, their professional growth is limited and their students' progress is constrained. The motivation to learn about and use technologies simply does not overpower the existing obstacles.

The Solution

Based on this understanding of what it will take to successfully address the complex problem of professional development for technology use and to accomplish the goals listed above, we developed a plan consisting of twelve products and five strategies, as shown in the diagram below.

Figure 2. Twelve instructional products and implementation strategies for developing technology skills.



Each product and strategy, and its purpose is described below.

Tutorials are comprehensive "lessons" designed to increase ability by developing skill and knowledge. We developed tutorials on the following topics, and published them in the form of a web site and CD-ROM:

- Beginning Guide to the Internet for Educators
- How to Use Netscape Navigator 3.01
- Integrating the Internet into the Curriculum
- Getting Started with Web Pages (HTML)
- How to Create Advanced Web Pages and Sites
- Using Multimedia Tools with the Internet

(These tutorials are available at: http://121.ed.psu.edu/linktuts/tutmain.htm)

"Software Tools" refers to a collection of shareware and trial versions of important software products, all gathered into a single location so that teachers would not be frustrated by missing pieces or by time-consuming searches and download time. The primary purpose of these tools was to increase ability by

providing educators with tools that expand what they can accomplish, and to improve willingness to engage by minimizing the time and frustration involved.

Case Studies are extensive looks at "Featured Teachers" who are using technologies in powerful ways. We produced a set of five in-depth case studies spanning a variety of subjects and levels, and developed in a consistent format. They may be useful individually, or as a set, because the featured teachers are asked a set of consistent questions and teachers can also follow responses to questions across case studies. (For an example of a case study, see http://121.ed.psu.edu/featured/intro.htm) The primary purpose of the case studies is to increase ability by expanding educators' knowledge, not of "how to," but of "what to" do with technologies.

"Quick Success Classroom Activities " are lessons designed to lead to successful implementation of networked computers with minimal preparation. More than 325 lessons demonstrating the effective use of technologies were created, spanning all subjects and grade levels. They consist of a "lesson plan," a student web page/worksheet, and a list of suggestions on how to extend the lesson into a unit or series of lessons. In addition, we created an on-line form through which teachers can expand this library. The Quick Success Classroom Activities serve several purposes: They build confidence, an attribute associated with ability; they build willingness by allowing early steps with technology to be pleasant and productive; they boost the perceived relevance of technologies by offering powerful lessons on things teachers consider important, and they improve teachers' perceptions of the utility of technologies because the amount of preparation is minimal and all required materials are provided. These classroom activities may be accessed through a menu and search engine located at: http://12l.ed.psu.edu/success/

We also created *On-line Conversations* to connect teachers with each other, forming virtual communities of educators with similar interests. We host conversations for teachers of all subjects and levels, as well as for professional organizations, colleges, universities, and our Department of Education's Technology Office. The purpose of these on-line conversations is to provide one level of support, to increase ability by sharing knowledge, and to promote early successes. (See: http://121.ed.psu.edu/confcen/discuss.htm)

Our *On-line Projects* serve mainly as incentives for effective technology use. These projects offer a series of interesting challenges for students and teachers, and promote collaboration among educators and their students throughout Pennsylvania. We host a set of on-line projects, titled "The Great Pennsylvania Quilt Factory," through which classes research problems, and post the results of their study in the form of web pages they create. We also host a project called "PA Picks" that encourages educators and their students to develop skills by creating an online database of copyright free images the students create and offer on line, with descriptions, keywords, and other information that make the images easy to retrieve. These projects may be seen at: http://l2l.ed.psu.edu/projects/ and http://121.ed.psu.edu/papicks/

To help educators find effective learning experiences, we created *"The Learning Opportunities Database."* Suppose, for example, that a teacher wants to learn how to create web pages. A visit to the database might reveal dozens of options, including the Link to Learn tutorial (available on line and on the CD-ROM), a two-day workshop offered by a local provider, a graduate level course, and a series of books on the subject. It might also show that Classroom Connect and Apple Computer will conduct workshops in school computer labs. Information on schedules and costs are provided, as are links to the providers and their products. The purpose of this database is to increase access to learning experiences, so that more learning takes place.

Because video is an effective way to capture emotion and to motivate viewers, we created a *video,* titled "The Kids and Wired," designed to help educators and others see the power of the Internet in the hands of students, and distributed it to public television stations across Pennsylvania and to 29 "Intermediate Units" that deliver media to schools. We allow educators to copy the video for educational purposes without contacting us, to promote the distribution of the information it contains, and we created a "Real Video" version of the 27-minut e video that is accessible through "video streaming" technology at:

To help educators understand how learning technologies can be put to use to transform the educational environment, we also offered a *Model* created by Dr. David Jonassen, that discuses how technologies can help make the classroom more active, responsible, constructive, collaborative, conversational, intentional, complex, contextual, and reflective. We have also added a few reports that help teachers see and understand effective applications of technology. We are also in the process of adding an *Online Conference Center* (http://l2I.ed.psu.edu/confcen/) through which we will offer digital versions of strong technology-related conference presentations to educators, who have few opportunities to attend conferences.

This series of strategic products is completed by two *Workshop Kits* that make it easier and less time consuming to offer effective workshops to other educators. Kits, titled "Browsing and Searching the World Wide Web" and "Publishing on the World Wide Web," include a printable Leader's Guide, online resources for students to use during the workshop, and handouts.

Delivery Strategies

30,000 copies of the *CD-ROM* containing these resources have been produced and distributed, and we are in the process of making another 30,000 copies of an updated version. The Link to Learn Professional Development *Web Site* (http://12l.ed.psu.edu/) contains more than 2,200 web pages and distributes all of the products mentioned above to anyone with Internet access at no charge. We currently receive approximately 3,500 "visits" each week. (A "visit" is a more accurate reflection of site use than the "hit" that is frequently reported. "Hits" count every graphic and page downloaded and result in an inflated impression of value. A "visit" reflects a user moving through the site. A second visit will not be recorded unless a

user leaves the site for more than a half an hour and then returns.) The CD-ROM has proven to be a very inexpensive way to get this information into the hands of educators, and it makes these learning experiences available to teachers who do not yet have access to the Internet at home or in school. The Web Site is also an inexpensive way to distribute these materials, and is easily updated and expanded.

Synergistic Strategies

"Synergy" is the term used to describe a system when the value or power of the whole is greater than the sum of its parts. Our project can become stronger and can ensure its survival by engaging in "win/win"*partnerships* with other organizations, including corporations, professional associations, institutions of higher education, intermediate units, and public television stations. We have developed relationships with organizations in all of these categories, and are working to expand them. The critical importance of these relationships becomes evident when developing and implementing strategies to increase the use of the resources we have developed.

Our Advisory Board developed the concept of *"Technology Endorsements "* - statements describing what teachers of different subjects and levels should know about and be able to do with technology - as a strategy to get teachers and others to expand their understanding and use of learning technologies. Discussions with our Department of Education and other agencies have resulted in unanimous support of this concept.

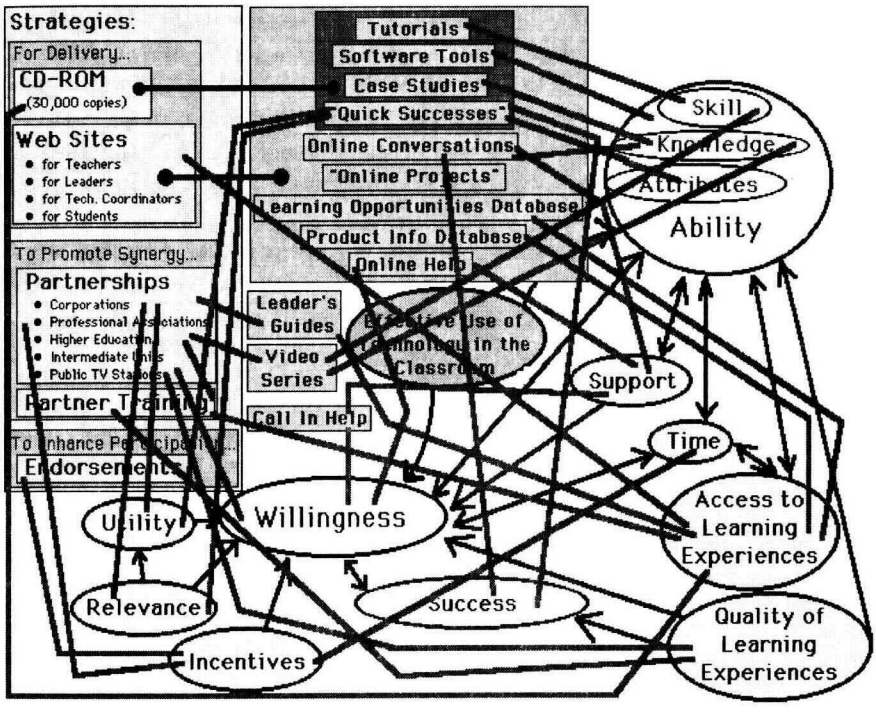
As systems thinkers, we realize that while the concept of endorsements and incentives is potentially powerful, it is also potentially explosive. It must be handled in an appropriate manner, and it must be handled soon. If we do this well, we can influence the willingness of hundreds of thousands of teachers, causing them to "make time" to learn about and use technology. Incentives increase willingness, willingness increases time spent in learning, time spent learning improves ability, ability influences willingness, and the cycle continues. Add to increased willingness to participate access to effective learning experiences at home and at school, and you have the power to "turn the comer" and see progress beyond that accomplished to date.

Conclusion

As we said when introducing systems thinking, "'Systems thinkers consider the complexity of the organizations they are working to improve, in an attempt to understand how a change to one component is effected by and will effect other components of the system." The Link to Learn project looked at professional development for technology as a complex problem, identifying many interrelated variables and creating a solution that address the identified threats to success. Promoting the effective use of technology in education is a complex problem, for which there is no "silver bullet." If we are to make any real progress with technologies in schools, we must cover all the bases, working on all of the variables likely to promote and impede progress. As illustrated in the final (rather complex)

image, our plan does that. As the lines that obscure the image demonstrate, our products are tied to the factors that lead to or prevent effective use of technologies in schools. The decisions we make as teacher educators will determine the value of our investments in technology, and more importantly, will influence the extent to which technologies improve the education of millions. In five to ten years we should begin to see the impact of this comprehensive strategy, and may be ready to make a stronger case for the use of systems thinking in the solution of educational problems.

Figure 3 Interactions between instructional products, strategies, and factors influence in ability and willingness.



References

Banathy, B. H. (1991). *Systems design of education.* Englevvood Cliffs, NJ: Educational Technology Publications.

CEO Forum on Education and Technology. (1998). School technology and readiness (STAR) report: From pillars to progress. Retrieved September 4, 1998 from the World Wide Web: http://wwvv.ceoforum.org/report97.

Hunt, D. (1971). *Matching models in education.* Toronto: Ontario Institute for Studies in Education.

McKenzie, J. (1991). Designing staff development for the information age. *From Now On: The Educational Technology Journal.4(\).* Retrieved September 4, 1998 from the World Wide Web: http://www.fromnowon.org/fnoapr91.html.

President's Committee of Advisors on Science and Technology: Panel on Educational Technology. (1997). *Report to the President on the Use of Technology to Strengthen K-12 Education in the United States.* Retrieved September 4, 1998 from the World Wide Web: http://www.whitehouse.gov/WH/EOP/OSTP/NSTC/PCAST/k-12ed.html

Reigeluth, C. M. (1994). The imperative for systemic change. In C. M. Reigeluth & R. J. Garfinkle (Eds.), *Systemic Change in Education* (pp. 3-11). Englewood Cliffs, NJ: Educational Technology Publications.

Senge, P., & Lannon-Kim, C. (1991). Recapturing the spirit of learning through a systems approach. *The School Administrator,* 23-28.

U.S. Department of Education. (1996). *Achieving the goals: Goal 4: Teacher education and professional development.* Retrieved September 4, 1998 from the World Wide Web: http://www.ed.gov/pubs/AchGoal4/.

Authors

Mark J. Toci is a Senior Instructional Designer at The Pennsylvania State University.
Kyle L. Peck is an Associate Professor at The Pennsylvania State University.