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ABSTRACT

This article examines barriers to technology adoption based on the literature and data from two studies. A five-step hierarchical model (familiarization, utilization, integration, reorientation, evolution) of adoption of technology in the classroom is presented, and internal and external barriers to technology adoption are examined. The two studies are then described. In the K-12 study, 1,000 art teachers were surveyed to: ascertain current levels of technology adoption; characterize teaching strategies used for learning in computer-based art classrooms; identify barriers to technology adoption; and propose an instructional model. In the second study, information on the impact of a large-scale initiative, the Electronic Academy, implemented at two- and four-year institutions in a Midwestern state postsecondary system, was collected from instructional technology coordinators. A product of this examination is a visual representation of the interactions and interdependence of elements that contribute to the construction of barriers to technology adoption. The model is intended to clarify internal and external obstacles and to serve as an aid to pre-service and in-service teacher education curriculum designers and developers as they plan for the successful infusion of newer technologies in the curriculum. Three tables contain a summary of research on barriers to technology adoption and data on barriers to technology adoption at the elementary, secondary, and postsecondary levels. (Contains 28 references.) (DLS)

Running head: BARRIERS TO ADOPTING EMERGING TECHNOLOGIES



# Barriers to Adopting Emerging Technologies in Education

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Abstract

The purpose of this article is to examine barriers to technology adoption based on the literature and on data from two studies (the first with K-12 teachers and the second with higher education faculty in a state system). A product of this examination is a visual representation, a model, of the interactions and the interdependence of elements that contribute to the construction of barriers to technology adoption. It is intended that the model will clarify internal and external obstacles, and to serve as an aid to pre-service and in-service teacher education curriculum designers and developers as they plan for the successful infusion of newer technologies in the curriculum.

The first study is funded in part by the Getty Education Institute for the Arts. The second study is funded by the Office of Instructional Technology within the MnSCU (Minnesota State Colleges and Universities) system.

Whether one is excited, challenged, or frightened by the influx of technology in schools, the fact remains that emerging technologies are increasingly being infused in school cultures and do have a major effect on teaching and learning. We can debate the specific educational influences, advantages and disadvantages of using electronic instructional media, and the underlying socio-political nuances later. Right now, emerging technologies, particularly those that are computer-based, raise issues and eyebrows in schools across the country.

In the landmark report, A Nation at Risk (1983), recommendations were made to consider educational computing a necessary basic skill if American children were to be competitive in the global community. Since then, studies have attempted to ascertain the impact of computers in education on a large scale. Often, such studies have simply counted the number of computers in the schools without assessing their importance in the school curriculum, or, at a more basic level, whether or not the units were functioning (Borrell, 1992).

Despite the dire predictions and warnings of A Nation at Risk, entire faculties at some schools and individual teachers in others avoid the use of computer-based technologies. Many teachers in teacher education programs at universities across the country shy away from developing courses on teaching with technology. Why? One might assume that the cause is economic, that the under-utilization of new technologies is directly linked to limited technology funds allocated to schools and universities. Or one might point to a lack of time in a teacher's day for course development or inadequate additional training in the use of newer technologies. While lack of funding is a harsh reality for many schools and a teacher's time is always at a premium, there appear to be other conditions that, considered in combination, slow or even halt the process of adopting emerging technologies in education.

To understand what is happening in schools and universities, something beyond a review of existing literature is needed. This article documents two recent studies (the first with K-12 teachers and the second with higher education faculty in a state system) to provide a solid context for an examination of barriers to adopting technology in education. The underlying purpose of both studies is to "...understand teachers' models of daily classroom activity, what place technology has in those models, and what meaning technology has in the context of the constraints and uncertainties with which teachers must deal" (Kerr, 1990, p. 10). While the studies were not specifically designed to focus on barriers to technology adoption, barriers did emerge from teachers' descriptions of daily activities, perceptions, and attitudes.

The purpose of this article is to examine barriers to technology adoption based on the literature and on data from the two studies described above. A product of this examination is a visual representation, a model, of the interactions and the interdependence of elements that contribute to the construction of barriers. It is intended that the model will clarify internal and external obstacles, and to serve as an aid to pre-service and in-service teacher education curriculum designers and developers as they plan for the successful infusion of newer technologies in the curriculum.

## A Hierarchy of Technology Adoption

> I wonder if there is some kind of 'gestation' period for technology integration into the classroom. Our administration has been very active in ongoing staff development but outside of the Middle School we still have so far to go. (Witte, 1998, December)

Change is never easy. Teachers at all levels will readily admit to wanting a few things in their daily teaching lives to remain the same from year to year or even month to month. But the introduction of new technologies in the classroom forces all of us to assimilate and accommodate new strategies and instructional media very rapidly. Since these changes happen continuously, it is useful to reflect on what happens during the changes.

A five-step hierarchical model of adoption of technology in the classroom is proposed by Reiber and Welliver (1989) and Hooper and Reiber (1995). This model, briefly discussed below, describes the "gestation period" and stages of growth associated with infusing a new technology in teaching and learning. The discussion focuses specifically on the adoption of computer-based instructional technologies, though the discussion could as easily include examples from other disciplines and educational technologies such as word processing, cooperative learning, motivational strategies (Hooper & Rieber, 1995) and so on.

Familiarization. The Familiarization level represents the base-line exposure to a technology. Familiarization may be an in-service workshop offered by the school, an opportunity to try a computer program at a convention or summer institute, or a museum show on computer-generated art. Once the workshop or convention is over, many computer-based technologies are dismissed at this level of adoption. Teachers may not see the relevance or usefulness of the product and technology. Or perhaps, accessibility to the technology is beyond the teacher's means: some schools deny access to the computer lab for projects other than math or science.

Utilization. Utilization occurs when teachers try the technology. A good example is "The Curriculum Navigator" program (Dunn, 1995). This HyperCard stack is essentially a design tool specifically programmed for curriculum development in art education. Many teachers at the 1995 annual National Art Education Association convention took the diskette back to their home schools as "an excuse to try out the Mac" (unidentified teacher, personal communication, April 1995) in their media labs. Teachers at the utilization phase have at least used the technology once or twice, but may never return to it after this initial trial. They may have an idea about the usefulness of the technology and can see its relevance to their classroom, but would abandon it should the computer "freeze" or the diskette malfunction. Or perhaps they use the technology for minor routine functions, such as record keeping, but do not integrate the technology into the art curriculum. Hooper and Reiber (1995) describe this as the highest level most teachers usually reach with computer-based technologies.

Integration. The Integration level marks the beginning of appropriate uses for computer-based technologies, particularly in delivering and developing instruction. Teachers at this level do not use the computer for the sake of using a computer, but have made a choice about instructional delivery that is most appropriately handled by a computer. Should the computer be taken away at this point, teachers at the integration phase would have a hard time re-working their lessons to accommodate some other delivery system.

Often, technology adoption stops here (Marcinkiewicz & Wittman, 1995), though there is less danger of teachers abandoning the technology due to a malfunction or software problem. Teachers who continue to use computer-based technologies at the integration phase find that the technologies provide an opportunity to re-examine the entire learning environment (Salomon, Perkins, & Globerson, 1991). That is, at some point during the integration of any educational technology, the approach to teaching and learning may be influenced by the opportunities afforded by the technology, which leads rapidly to the next level.

Reorientation. Reorientation "...requires that educators reconsider and reconceptualize the purpose and function of the classroom" (Hooper & Reiber, 1995). Interestingly, at this phase the emphasis is on the learner and in how the teacher may best facilitate learning, rather than on which software or hardware is in vogue. Computer-based technologies become a part of the learning context, as an extension of the learner, teacher, and learning experience (Salomon, 1991). The technology is considered in terms of a systemic enrichment of the learning context, rather than as a discrete application of the technology to learning.

Evolution. The final phase, Evolution, is the continued ability to grow and change as the needs of the learner and the learning context change. Teachers achieve this phase in technology adoption when they are willing to change methods and media as necessary to facilitate learning (Jonassen, Campbell, & Davidson, 1994). A prime example of a teachers' use of a technology at this phase is an art teacher's relationship to the camera and film (Lovejoy, 1992). Where once the camera was discounted as a legitimate art medium, photography is now studied as fine art. Where the camera and film were considered mainly for utilitarian industrial purposes, teachers now discuss film as fine art and use slide film as the presentation technology of choice in many art-related classrooms.

Understanding where teachers are in terms of their level of technology adoption is a necessary first step in understanding barriers to technology adoption. Each level on the hierarchy discussed above requires a different set of support services, funding, time, and administrative and student expectations. Mismatches in a teacher's level of technology adoption with certain internal or external sources of potential barriers provide an almost certain failure to adopt a technology in the classroom.

Barriers to Technology Adoption

What stops a teacher or a student from using a new technology? Those working in school staff development positions would say it is a combination of several factors: Socio-cultural factors (e.g., economics and location) (Bereiter, 1994), "personological variables" (Marcinkiewicz & Grabowski, 1992) of the teacher (e.g., age, gender, attitudes and beliefs or teaching philosophy), and exposure to and adoption of emerging technologies (Anderson, 1993; Becker, 1986; Hooper & Rieber, 1995; Rieber & Welliver, 1989) within the practice of teaching (e.g., levels of technology acceptance and adoption) that are included in the " ... whole 'cloud of correlated variables'--technology, activity, goal, setting, teacher's role, culture--exerting the combined effect" (Salomon et al., 1991, p. 8) on success or failure to adopt a new technology: Table 1 illustrates major topics presented in several recent articles on barriers to technology adoption.

Barriers to successful technology adoption appear to have internal and external sources. Internal barriers may be summarized as "teacher attitude" or "perceptions" about a technology. External sources include the availability and accessibility of necessary hardware and software, the presence of technical personnel and institutional support, and a program for staff development and skill building. Barriers that cross internal and external sources are lack of time and funding.

Scheiman and Fiordo (1990) discuss a sociological model of a normal distribution of technology adoption patterns linked to internal barriers of attitude and perception: innovators (about three percent of any population), early adopters (about fourteen percent), early majority (thirty-four percent), late majority (thirty-four percent), and laggards (about fourteen percent). Harvey and Purnell (1995) suggest that "teacher anxieties" or attitudes contribute to a teacher's position as an innovator or early adopter:

> While technology tools are what is new about professional development, teachers see little benefit in it for themselves. The result is the "17 percent problem," i.e., the technicians and visionaries who make up 17 percent of the population "see" a potential for technology and begin using it. But the majority are not interested until they see some practical benefits. (p. 2)

Barriers from external sources may be categorized under three general headings: availability and accessibility, institutional and technical support, and stakeholder development.

The availability and accessibility category of barriers include limited access to useful, relevant, and appropriate hardware and software. Respondents in studies discussed in seven of the eight articles identified in Table 1 focused on the need for access to hardware that can handle particular software (Appalachia Educational Lab. and Tennessee Education Association, 1991; Quality Education Data Inc. Malarkey-Taylor Associates, 1995), the availability of the hardware or software to teachers (Schieman & Fiordo, 1990, July; Spotts & Bowman, 1993) and the quality of the hardware or software (Hope, 1995; Quality Education Data Inc. Malarkey-Taylor Associates, 1995; Ray, 1991; Spotts & Bowman, 1993).

Technical support (Table 1, item 9) in the form of user services or media specialists who assist staff in using and maintaining different technologies, and institutional support (Table 1, item 4) may be grouped together as a second general category of external barriers. Employing a limited number of technical support staff in a school, district, or university severely hinders technology adoption. Those who are employed as technical support personnel may lack appropriate technical support expertise (i.e., the personnel do not have technical skills to meet the needs of the faculty).

Lack of institutional support, from encouragement by administration to try new technologies to providing funding specifically for technical support and technology purchases, can become a major barrier to the infusion of new technologies in an institution (Appalachia Educational Lab. and Tennessee Education Association, 1991; Byers, 1996; Harvey & Purnell, 1995; Hope, 1995; Quality Education Data Inc. Malarkey-Taylor Associates, 1995; Spotts & Bowman, 1993). Institutional and technical support are inseparable due to the administrative privilege of hiring personnel.

The third general category of external barriers, stakeholder development, appears in six of the eight articles (Appalachia Educational Lab and Tennessee Education Association, 1991; Byers, 1996; Harvey & Purnell, 1995; Hope, 1995; Quality Education Data Inc. Malarkey-Taylor Associates, 1995; Spotts & Bowman, 1993). The term "stakeholder" is used here to include faculty, staff, and students.

Lack of time to develop new courseware, new skills, or advanced applications becomes a barrier at an individual level and at an institutional level. Personal time needed to build skills or create new teaching materials is considerable, particularly for teachers just beginning to use newer technologies. The panic that sets in (internal source), often called the "fear factor," stops many teachers from successful infusion of technology in their teaching.

Lack of time as a barrier from an external or institutional source is often related to a need for release time for courseware and staff development. State and institutional mandates concerning contact hours in both P-12 and higher education institutions create barriers for teachers and administrators. If release time is not available, and if personal time is too fragmented or limited, teachers cannot learn new skills and develop new materials.

Funding issues may also contribute to both internal and external sources for barriers. Certainly, a lack of funding for hardware and software or hiring technical support personnel is a serious external barrier. However, lack of adequate or appropriate funding may be traced to individual choices for allocating funds to certain disciplines, programs, or schools. For example, the choice to fund a computer lab may depend upon a key individual's attitude toward technology, rather than on student needs.

The recitation on the intricacies of barriers and how they interrelate could easily take up the remainder of this article. Anecdotal evidence and justification for avoiding technology adoption is abundant in any teachers' lounge one might visit. Developing a real understanding how internal and external barriers to technology adoption actually impact the daily lives of teachers in P-12 and post-secondary institutions is a matter for serious research. The two studies described below provide a snapshot of the experiences of teachers as they infuse technology into the curriculum. Though short term studies such as surveys and interviews do not provide a desirable on-going report on the shifting patterns of technology adoption in schools, we can begin to gain some insight into how barriers are constructed and what might be done to overcome them by listening to teachers at various stages of adopting newer technologies.

Technology Adoption in K-12 Education

In the first study (Rogers, 1997), one thousand art teachers were randomly selected from a cohort of approximately 10,000 which was defined by years of teaching experience, membership in two professional organizations, and a school address in the United States. Preprimary teachers were not included in the study. Though the data gathered on teaching strategies from a domain-specific group of teachers such as art teachers or mathematicians may be somewhat different from the data from teachers across all disciplines, reports on issues, concerns, and barriers appear to be common to all teachers. Domain-specific barriers, while important, do not seem to add or detract from barriers reported by teachers across all disciplines.

Each teacher selected for this study was sent an extensive survey that gathered both quantitative and qualitative data. The purpose of the survey was to (a) ascertain the current levels of technology adoption among art teachers, (b) characterize the teaching strategies used for learning in computer-based technology art classrooms, (c) identify barriers to computer-based technology adoption, and (d) propose an instructional model, based on current practices in art education with computer-based technology and on Disciplined Based Art Education (DBAE). Data from 507 eligible respondents are included in the results of this study.

Survey data are typically analyzed in terms of frequencies and percentages, however, this study included a triangulated methodology that allowed more in-depth analyses. Data from the respondents were first analyzed using descriptive methods, cross-tabulations, and regressions. Each respondent's level of technology adoption was determined and validated by a regression method. Tables of frequencies were made for certain questions and cross-tabulations were made on selected variables (i.e., age and level of technology adoption). Answers to open-ended questions and spontaneous comments were key-word coded and categorized (Lundy-Dobbert, Eisikovits, & Pitman, 1994), then combined with the quantitative survey data (Miles & Huberman, 1994). Next, quantitative and qualitative data were organized into factors: demographic factors, environmental factors, attitude factors, exposure and use factors, and reported practice factors. Categories of key words and questions in the survey were analyzed as a set to determine the particular factor's influence on teachers' levels of technology adoption. For purposes of this article, only those sets of data concerned with barriers to technology adoption are presented.

Discussion. Table 2 illustrates the key findings with respect to barriers faced by teachers in this study. Note that the number of respondents at each level follows the distribution of innovators to laggards discussed by Scheiman and Fiordo (1990). Thus, respondents in this study are a good representation of teachers facing newer technology challenges.

Previous studies (Appalachia Educational Lab and Tennessee Education Association, 1991; Byers, 1996; Harvey & Purnell, 1995; Hope, 1995; Quality Education Data Inc. Malarkey-Taylor Associates, 1995; Ray, 1991; Schieman & Fiordo, 1990, July; Spotts & Bowman, 1993) have identified barriers to technology adoption and have suggested some interactions between them. The need for technical support, funding, staff development, more time in the day, and a host of other complaints are often cited as the major causes for the lack of computers in a school or office. From these observations and from the responses from teachers in this study, several conclusions may be made:

1. Responses that fall in external categories of Availability and Accessibility, Technical and Institutional Support, and Stakeholder Development were reported mainly by the teachers who were at a familiarization (about twenty eight percent of the total respondents) and utilization level (about sixty six percent) of technology adoption (see Table 2). That is, those with less experience using technology in instruction were more likely to report barriers. Responses from those at the integration and reorganization levels reported fewer barriers, though there were proportionately fewer respondents at these levels.

Limited technical support, staff development opportunities, and hardware and software were reported as barriers as in previous studies, but the qualitative analysis in this study suggested that quality of these services and materials also contributed to barriers. Technicians who have limited training, inadequate staff development activities, and aging hardware and software were reported in the open-ended portions of the survey. If the survey had only asked whether such services and materials were available, our understanding of the reality of what is happening in schools would be biased. How the questions are asked is absolutely critical (Borrell, 1992).

2. As teachers become more comfortable with technology (illustrated by those at higher levels of technology adoption in Table 2), their focus on barriers decreases. Note that the percentage of the responses for "no barrier discussed" increases as the level of technology adoption increases.

3. There appears to be a strong interaction and interdependence among the three external barrier categories (Availability and Accessibility, Technical and Institutional Support, and Stakeholder Development). Teachers report complex relationships among the three major barrier categories. Such connections have been suggested in previous studies (see Table 1), but few have considered the correlation among barriers.

The results of this study suggest that external barriers are most likely to affect those teachers who are at the beginning stages of technology adoption. As staff (stakeholder) development needs become less demanding (as individuals become more comfortable with using the technology), barriers of access and availability and technical support become more critical. Lack of technical support at an advanced level and the need for additional in-depth stakeholder development becomes a barrier for those at the highest level of technology adoption, probably due to their willingness to be innovative.

<u>Technology Adoption in Higher Education</u>

The second study (Rogers, 1998) was designed to gather information from instructional technology coordinators on the impact of a large scale initiative (the Electronic Academy) implemented at two–year and four–year institutions in a Midwestern state post-secondary system. The goals of the Electronic Academy are: (a) to develop and deliver electronically complete technical, associate, bachelor and masters degree programs to students around the state, (b) to enhance existing courses by using multi-media, network and Internet capability, (c) to provide on-line services to students: registration, financial aid, business office, e-mail, and library access, (d) to give students access to leased computers, (e) to partner with private telecommunications firms to pilot new technology and market new educational products, and (f) to evaluate student satisfaction and learning outcomes achieved by the Electronic Academy.

To accomplish the goals of the initiative, the first year of funding included extensive staff development in computer skills and instructional design, as well as large-scale hardware and software purchases. Technology coordinators and their colleagues continue to provide basic and advanced staff development opportunities as more faculty infuse technology into their teaching. While staff development efforts in the Electronic Academy are not focused solely on teacher education programs, we will consider this study in terms of in-service teachers in higher education.

Twenty-eight of the 36 technical coordinators participated in the study, representing 78 percent of the system's institutions (some of which have multiple campuses). The purpose of this study was (a) to examine the impact of the Electronic Academy across the system, (b) to serve as a basis for reports to the state legislature on how the funds were expended, and (c) to learn what the needs and expectations are for future funding from this initiative. Data were gathered from each coordinator through a loosely structured interview conducted on the telephone or in-person. Five questions were sent to each coordinator prior to the interview. This qualitative design provided an overview of the impact of the initiative in the system and a better understanding of barriers to its success. Table 3 summarizes barriers identified by the coordinators.

Discussion. Many of the coordinators gave multiple responses to each question, which made reporting the results difficult (see Table 3). A frequency count is provided for responses that generally fall within the indicated items. Also provided is the percentage of coordinators who included a particular item in their response to a question. For example, in item 1 of Table 3, eleven coordinators from two–year institutions (technical and community colleges) and six from four-year institutions (state universities) included "need technical support staff" in their responses. These response frequencies represent fifty-two percent of two–year coordinators and eighty-six percent of four-year coordinators who participated in the study, and sixty one percent of all participating institutions.

Items 2 and 4 are concerned with additional opportunities for stakeholder development and sharing of best practices among the institutions in the system. Coordinators consider stakeholder development (faculty, staff, and students) to be a continuing primary focus of the Electronic Academy. Items 2 and 3 (lack of time and appropriate funding) may be identified as external barriers, though some coordinators suggested that lack of funding and time (as internal barriers) could be relieved by changing the attitude of key administrators at individual institutions.

Understanding Barriers to Technology Adoption

The results of both studies suggest that barriers to technology adoption in schools is a complex balance and counter-balance of several components. Attitudes toward technology and its uses in education as well as attitudes toward the level of institutional support available plays a substantial role in determining what will and will not be considered. Attitudes and perceptions of key individuals may become the major barrier to adopting any technology. Once past this component, potential barriers cluster within three major categories: availability and accessibility of hardware and software, appropriate stakeholder development opportunities for teachers at all levels of technology adoption, and appropriate and adequate technical and institutional support to initiate and maintain technology adoption in teaching and learning.

Figure 1 suggests how barriers to adopting emerging technologies are dependent upon a variety of circumstances and relationships. For example, many schools purchased a computer for every classroom in the late 1980's but did not provide technical support or staff development opportunities (Borrell, 1992; Piller, 1992). Computers were available and accessible, but useless to teachers because of a lack of technical support and training. Or consider how issues of funding may cross all categories of the identified barriers.

Without institutional, community, and legislative support, schools are unable to purchase hardware, software, technical services, or create release time for staff development.

Recent exchanges on a listserv devoted to staff development clearly illustrates that teachers and staff development professionals sense the interdependence and complexity of barriers to technology adoption suggested by Figure 1. One message effectively tells the story of how this complexity manifests in a school setting:

> Yes, schools now have access to the Internet. But no, it has not produced increased use. Why? because [sic] staff have not been adequately trained and supported in their use of technology [italics added]. Most districts have spent all of their money on the technology and not the people using it. Districts believe that they make a one time purchase, connect the school, give a brief, if any inservice to teachers and expect them to use it. What is the result? A handful of innovative teachers see this as exciting and want to jump in and use it. They are willing to spend their free time to learn how to incorporate technology use into their curriculum. The end result is that the equipment is used to its potential by a few people. Parents and administrators say why should we spend more money on technology used by so few people.
>
> Another reason for the lack of use is the availability issue [italics added]. For example, in our elementary school of 840 students, we have one 50 minute period scheduled in our computer lab every six days. We also have only one networked computer in our classrooms. This really makes it difficult to complete any project in a reasonable period of time. Our high schools have 3 labs, but 2500 students. Scheduling time is a headache. So teachers often don't even attempt it.
>
> My biggest concern is the lack of commitment to professional development [italics added] in this area. The districts with the most success with technology are the ones who knew they had to save money to spend on the professional development piece of the equation. Without commitment to this need, districts might as well not spend their money on hardware and software. It would be better spent elsewhere. (Menas, 1998, December)

Coordinators in the Electronic Academy study identify barriers in a similar fashion:

> [A barrier is the] timeline that I have. Tech support is a major issue. Training and staff development. Need more funds to get classes and teachers set up to do the training. Electronic Academy is a great incentive to DO this: it gets faculty paid to do the extra work. Three major areas of need in future: technical staff, more [system]-based training classes, and [system]-wide contracts for hardware/software. We really need more hands-on training, someone who relates to faculty and staff. [consider] release time for the trainers [italics added]. (D. Knutson in Rogers, 1998)

Notice how barriers are reported as overlapping issues and needs. Personnel needs are tied to staff development needs that are in turn dependent upon available time and equipment. The almost circular conversations among teachers, technology coordinators, and staff development professionals provide strong evidence for the inter-relatedness of barriers. It is no accident that the model of barriers (Figure 1) suggests a circular motion.

As designers and developers at elementary, secondary, and post-secondary institutions begin to infuse technology into the curriculum, planning for technology becomes increasingly necessary. The most successful technology plans include input from all stakeholders concerned as well as those who may be hired specifically to develop technology plans. Graphic representations such as the model presented in this article, help designers and developers visualize the components of technology plans and focus on what is needed for success.

Several recommendations for technology planning can be made from this examination of barriers to technology adoption. This list is by no means exhaustive, considering how many different components and delicate contingencies are represented by the model. However, some major ideas can be listed to aid in the development of electronically enhanced curriculum development:

1. Determine the goals of teaching and learning first. No technology plan should be developed without a clear understanding of the mission of the school, the needs of its learners, and some consideration of the institution's future. Technology plans that center on technology rather than teaching and learning create more barriers than they prevent.

2. Assess the level of technology adoption of the stakeholders, particularly the faculty and staff. An understanding of where each faculty member stands in terms of the adoption of technology will guide the selection of technical support and sophistication of equipment needed. Those at lower levels of technology adoption require more staff development time and basic technical support (e.g., someone to call when the computer "freezes"). Those at higher levels, particularly those innovators who reach a reorientation stage, require more sophisticated technical support and staff development opportunities (e.g., attending Authorware courses and creating CD-ROMs). Technology plans in P-12 and higher education should consider designing phases of both stakeholder development and technical support. Basic courses and in-services could be handled in a large group setting, while more difficult or detailed courses could be handled in small group or one-on-one situations. Technical support for basic needs might best be handled by talented students and more difficult problems handled by a media specialist. Use focus groups, anonymous surveys, or individual interviews with key stakeholders to ascertain levels of technology adoption.

3. Assess the attitudes of stakeholders toward technology in education. Individual and institutional attitudes and perceptions are critical considerations when confronting barriers. Technology planning should include some strategies for changing attitudes and addressing the "fear factor." Use focus groups, anonymous surveys, or individual interviews with key stakeholders to ascertain attitudes toward technology.

4. Consider three categories of barriers to technology adoption (availability and accessibility, institutional and technical support, and stakeholder development) simultaneously. It is of little use to purchase high end computers without also providing technical support and appropriate stakeholder development opportunities. Providing in-depth classes on video conferencing for teachers who do not have basic computer equipment is a waste of valuable time and funding. Technicians who have appropriate

skills in maintaining such high end equipment and who can answer detailed questions must be available and accessible to teachers.

5. Technology plans must include a consideration of time and funding issues. Teachers need time to develop new course materials, time to learn new skills, and time to adjust their attitude toward the role technology holds in teaching and learning. Teachers at lower levels of the technology adoption hierarchy need more time than do teachers who are at higher levels of technology adoption. Technology plans must accommodate such differences in teachers' needs if the plan is to be successful for all concerned.

Funding is often the major focus of technology planning. Again, consider the needs of the institution in terms of teaching and learning first, then determine what technologies can support those educational goals. Funding that is inappropriately allocated (e.g., that is used only for hardware purchases and not for personnel or training) is wasted. Such waste contributes to negative attitudes toward technology, which ultimately is represented as the first major barrier to technology adoption.

And so the vicious cycle goes.

Table 1

A Summary of Research on Barriers to Technology Adoption

| BARRIER CATEGORY ITEMS | Appalacia Educational Lab (1991) | Byers (1996) | Harvey (1995) | Hope (1995) | Quality Education Data, Inc. (1995) | Ray (1991) | Schieman (1990) | Spotts (1993) |
|---|---|---|---|---|---|---|---|---|
| 1. Availability and quality of hardware/software | X | | X | X | X | X | X | X |
| 2. Faculty role models (early adapters) | | | X | X | X | | | X |
| 3. Funding | X | X | X | | X | | | X |
| 4. Institutional support | X | | X | X | X | X | X | X |
| 5. Models for using technology in instruction | | | X | | X | | | |
| 6. Staff development | X | X | X | X | X | | | X |
| 7. Student learning | | | | | X | | | X |
| 8. Teacher attitudes | X | X | X | X | X | X | X | X |
| 9. Technical support | X | X | X | | | X | | X |
| 10. Time to learn to use technology (personal or release time) | X | | X | X | X | | | X |

Table 2
Barriers to Technology Adoption at the Elementary and Secondary Level

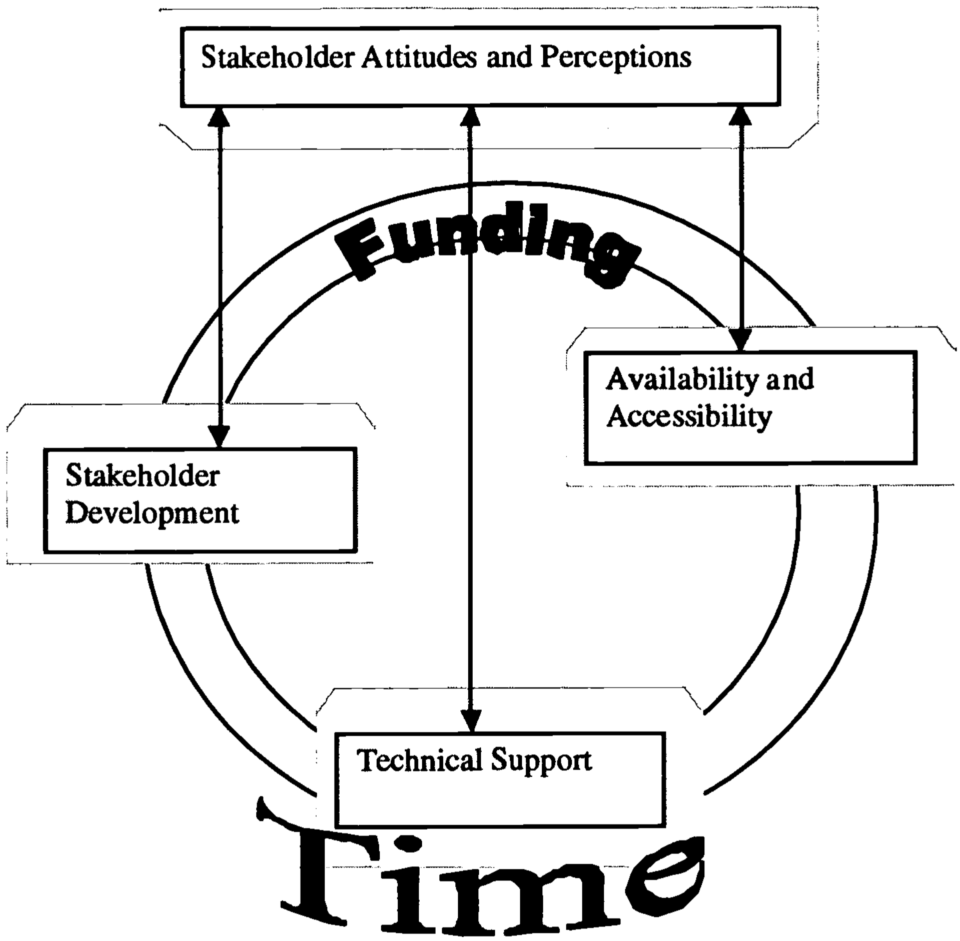
| | Technology adoption levels | | | |
|---|---|---|---|---|
| BARRIER CATEGORY | Familiarization (%) | Utilization (%) | Integration (%) | Reorganization (%) |
| Availability and accessibility | 24.08 | 18.26 | 2.17 | 0.00 |
| Technical and institutional support | 22.86 | 14.81 | 6.52 | 16.66 |
| Stakeholder development | 27.76 | 11.55 | 6.52 | 16.66 |
| no barrier discussed | 25.30 | 55.38 | 84.78 | 66.66 |
| Percent of total responses at each level | 27.84 | 66.25 | 5.23 | 0.68 |

Table 3

Barriers to Technology Adoption at the Post-secondary Level

| Interviews Completed: | Technical and Community Colleges | State Universities | Total |
|---|---|---|---|
| 28 | (21) | (7) | 28 |
| 1. Need technical support staff | 11<br>52% | 6<br>86% | 17<br>61% |
| 2. Need release time and time for training faculty and staff | 11<br>52% | 3<br>43% | 14<br>50% |
| 3. Funds not specified for technology-related needs | 13<br>62% | 6<br>86% | 19<br>68% |
| 4. Lack of sharing best practices across system | 14<br>67% | 3<br>43% | 17<br>61% |

Figure 1. The relationship among internal and external sources of barriers to technology adoption.



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