Educational Technology Adoption and Implementation: Learning from Information Systems Research

Karen Lee Jost
Scott L. Schneberger

Abstract: Many educational academics believed that educational technology would play a large part in educational reform. A survey of the literature, however illustrates the low impact that educational technology has had on established education with few implementation successes. These remarks are similar to those heard in the information systems field during the 1980s. A considerable amount of research was done on information systems adoption and implementation. It is proposed that the root problems and issues in Educational Technology adoption are not unique to education and educational technology-but problems faced by proponents of any new technology and, in particular. by those in Information Systems. If the theoretical and practical parallels between Educational Technology and Information Systems adoption hold. Educational Technology can benefit from what Information Systems has learned about adoption. Conceptual and historical similarites between educational technology and information systems are explored IS adoption theory and research is explained. and recommendations for ET adop: tion and implementation are discussed.

Résumé: Un grand nombre d'universitaires experts en éducation ont cru que la technologie éducative jouerait un grand rôle dans la réforme pédagogique. Une étude de la documentation écrite sur le sujet a toutefois révélé qu'elle a eu peu d'impact sur l'éducation traditionnelle et peu de succès dans l'application de ses principes. Ces remarques rappellent d'ailleurs cellesqui ont été faites au cours des années '80 sur les systémes d'information.

La recherche effectuée sur l'adoption et l'application des systèmes d'information est considérable. Nous pensons que les problèmes fondamentaux et les questions portant sur l'adoption de la technologie éducative ne touchent pas seulement l'éducation et la technologie éducative mais sont des problèmes qui confrontent les tenants de toute nouvelle technologie et, en particulier, les tenants des systèmes d'information. Si les parallèles théoriques et pratiques établis entre l'adoption de la technique éducative et des systèmes d'information tiennent, la technique Educative peut bénéficier de ce que les systèmes d'information ont appris à propos de cette adoption,

Les similarités conceptuelles et historiques entre la technologie éducative et les systèmes d'information sont étudiées ici: la théorie de l'adoption et la recherche en systèmes d'information sont expliquees; et, les recommandations pour l'adoption et l'application de la technologie éducative font l'objet de discussion.

Canadian Journal of Educatinal Communication VOL. 23, NO. 3, PAGES 213 - 230. ISSN 07104340

INTRODUCTION

Educational reform is a leading topic in socio-political debate, and was one of the key issues in the latest U.S. presidential election. Many educators envisioned educational technology (ET) becoming a large part of that reform. Heinich (1970), for example, foresaw a major role for educational technology as a tool to support teachers, as a replacement for teachers and a conduit for directly educating students, and/or as a means to forming a partnership with teachers whereby technology delivers routine instruction and teachers focus on planning and educational management. Indeed, interest in educational technology and some practical successes during the last 50 years led educational technology to become a unique academic and professional field. The field has academic departments and courses, professional organizations, journals and conferences, academic professionals who identify themselves as educational technologists, and of particular significance, a considerable amount of scientific research. One could easily assume that with so much interest in educational improvements, with so much potential for educational technology as part of the expanding information age of technology, and with all of the research within the field of educational technology, deep and broad improvements in established education would have resulted.

Many educational technologists, however, lament what they perceive to be few implementation successes and a decidedly low impact of educational technology on established education (Reigeluth, 1989; Winn, 1989; Gentry and Csete, 1991; Heinich, 1991). Educational technology is said to be an applied field, yet its knowledge, based on empirical research, is not applied by practitioners to the degree expected.

Many authors, publishing within the field of educational technology, have analyzed the problem and blamed a wide range of factors. Some view teachers themselves as the culprits; citing the idea that teachers are threatened by perceived professional irrelevance that would cause them to naturally resist educational technology (e.g. Heinich, 1991). Other authors blame simple bureaucratic inertia and lack of educational funding (Gentry and Csete, 1991). While there have been many accusations concerning weak adoption of educational technology in general education, some educational technologists criticize research as a malefactor, it is either too descriptive and not prescriptive enough (Clark, 1989), it is based on too many confusing or conflicting theories (Ross and Morrison, 1989), the research simply lacks external validity to everyday situations (Reigeluth, 1989), or that it fails to take advantage of related research in other fields (Clark, 1989).

The problem of innovation and adoption (and ruminating self-examination) is not, however, unlike what occurred in the information systems (IS) field during the early 1980s before the widespread proliferation of personal computers and readily available commercial software packages. A considerable amount of information systems research and writing has been done on who, what, when, where and why (or why not) information systems are adopted, including research on why some information systems are adopted but then not used. It is unlikely that the problems with the adoption of educational technology innovations are entirely unique to education and educational technology. Instead they include problems commonly faced by proponents of any new technology. As stated by Fullan (1993), “change of all kinds has certain generic properties in complex societies” (p. vii).

This paper concentrates on the ***how*** problems of educational technology adoption. It presumes the validity of educational technology research on effective and efficient innovations and focuses instead on the adoption and implementation process and its factors. This paper outlines and compares the conceptual definitions of educational technology and information systems and relates the histories of ET and IS adoption. It outlines and explains information systems adoption paradigms, models, and frameworks and suggests similarities and differences between IS adoption/implementation and educational change. Finally, this paper discusses educational change and what can be learned from information systems adoption models.

DEFINITIONS

One of the immediate issues in discussing the educational technology adoption problem is the varying definitions of educational technology. The Association for Educational Communications and Technology (AECT) defines ***educational technology*** as:

> a complex, integrated process involving people, procedures, ideas, devices and organization, for analyzing problems, and devising , implementing, evaluating and managing solutions to those problems, involved in all aspects of human learning. (AECT, 1977, p.59)

Others define educational technology as a methodology or set of techniques (Cleary et al., as cited by Gentry, 1991), a “body of knowledge” (Dieuzeide, 1971, p.1) and as procedures and devices (Silverman, as cited by Gentry, 1991).

Instructional technology (IT), a phrase frequently used interchangeably with educational technology, often carries two connotations, The definition stated by the Presidential Commission on Instructional Technology (1970) includes both the view of instructional technology as:

> the media born of the communications revolution which can be used for instructional purposes along side the teacher, textbook, and blackboard. (p.19)

and as:

> a systematic way ofdesigning, carrying out, and evaluating the total process of learning and teaching in terms of specific objectives, based on research in human learning and communications, and employing a combination of human and non-human resources, to bring about more effective instruction (p.19).

Engler (1972) similarly defines instructional technology within two categories, the first as "hardware- television, motion pictures, audio tapes and discs, textbooks, blackboards, and so on" and secondly as:

> a process by means of which we apply the research findings of the behavioral sciences to the problems of instruction. (p. 59)

One should not view these definitions of educational technology (and instructional technology) as nebulous, contradictory or exclusive definitions, but rather as inclusive definitions to bound the area of interest. By combining the essence of the definitions above (and others cited by Gentry, 1991), this paper defines ***educational technology*** as:

> the application of people, devices, knowledge, and procedures for efficient and effective education.

This definition, resulting from combining the varying ET and IT definitions has a clear correlation with a common textbook definition of ***computer-based information systems (e.g.*** Davis and Olson, 1985; Laudon and Laudon, 1993):

> devices (usually computer hardware and software-based), people, and procedures for organizing, storing, accessing, and maintaining information.

The definitions of educational technology and information systems identically focused on devices, people, knowledge, and process suggest a theoretical linkage between ET and IS application and adoption. The problems and issues associated with adopting information systems appear to have direct bearing on the problems and issues with adopting educational technology. Information systems research on adoption, therefore, would seem to offer rich insight and direction for fruitful educational technology adoption research. If the theoretical and practical parallels between ET and IS adoption hold, what information systems has learned about IS adoption may be what educational technology can benefit from in the future.

EDUCATIONAL CHANGE AND TECHNOLOGY ADOPTION: A SUMMARIZED HISTORY

Fullan (1991) identifies four distinct historical phases in educational change: adoption (1960s), implementation failure (1970-77), implementation success (1978-82), and intensification versus restructuring (1983-90).

Fullan's first phase (adoption) came largely as a result of Soviet success in launching a satellite in 1957 (years before the U.S.). The subsequent "Sputnik crisis" led to large-scale curriculum innovations, technologically-oriented instructional systems, and the advocacy of inquiry-oriented and student-centered instruction. In the rush to meet the crisis, according to Fullan, the emphasis was on how many innovations could be adopted, the more the better as a mark of progress. During this period instructional systems were researched and developed. Significant federal funding for R & D laboratories, mandated evaluation of federally funded educational projects, and the redefinition of audiovisual instruction to include instructional development and technology gave the field of educational technology increased visibility and credibility with educators.

During the 1970s however, innovation got a bad name. According to Fullan, the 1960s' innovations had been adopted haphazardly with little follow-through, leading to pronounced implementation failures. By the end of the 1970s nevertheless, there were some significant, well-documented successes that provided important frameworks and theories for comprehensive educational reforms. The comprehensive reform movements that began in 1983 (as a result of the watershed document *A Nation at Risk* by the National Commission on Excellence in Education) took many approaches, including the use of educational technology.

The advent of microcomputers in the 1980s appeared to offer the dawn of a new era with computer-based instructional systems. The wide availability of relatively inexpensive desktop computers, the capabilities of computer-driven media, and the inherent ease of developing, using, and improving software, provided a ready vehicle for applying educational technology. By 1989, 76,395 of the 79,693 U.S. public schools had two or more microcomputers, averaging about 20 per school (Quality Education Data, 1989). Their use, however, was primarily for administrative and clerical applications and not for the process of teaching and learning. The most common educational use of microcomputers was limited to teaching computer literacy (Ely, 1991). Higher education was not reported as any better; the average U.S. university, in terms of its use of information technology in teaching, was substantially behind the typical elementary and secondary school (Newman, 1989 as cited by Ely 1991).

THE INFORMATION SYSTEMS ADOPTION PROBLEM A BRIEF HISTORY AND COMPARISON TO THE ADOPTION OF EDUCATIONAL TECHNOLOGY WITHIN EDUCATION

Although electronic computers were used for military purposes in the 1940s the public application of computers for information processing began in 1954 when one of the first computers was installed to process payroll at a large U.S. corporation (Davis and Olson, 1985). There have been three generally recognized eras in Information Systems adoption.

The first era was from 1954 to about 1964 when computers were used for accounting and clerical applications in major organizations. Information systems were expensive and very difficult to use. Few people understood how they worked, even fewer knew what to do with them. There was a wealth of research and theory that predicted enormous benefits from computers in everyday business and personal life, but potential users and those in management positions could only wonder at the futuristic predictions while continuing traditional work habits. With considerable simplification, this era roughly equates to the adoption of educational technology innovations in education prior to 1983.

During the second era, from around 1965-1980, the breadth of applications expanded due to improved general purpose programming languages. Major businesses saw computers as a strategic weapon, or at least an image maker, and management began to see the potential ***efficiency*** benefits from computers. There were large investments in computers and one-of-a-kind application software. Computers were ensconced within glass "throne rooms" tended to by computer specialists who were intermediaries to users of computed data. Users still did not understand computers or their potential, but they began to be exposed to the effects of computing. People were mostly forced to adapt to computers and, increasingly, to depend on them for record keeping as well as finance and accounting. These systems were designed by computer specialists who tended to oversell capabilities, had little understanding of user needs, and increasingly built systems that either did not work, went way over budget, or users would not use. Management perceived the importance of computers, but not how to apply them. As the chief strategist for a major U.S. bank said:

> [Computer] technology is our top strategic concern, not because it outweighs everything else, but because we are unsure what to do with it. Although we have a strategy for the marketplace, the technology issues seem to be eluding us. We can't seem to grasp the bigger picture (Parsons, 1983).

Information systems academics and professionals bemoaned the dirth of effective IS applications taking advantage of empirical research, while management complained that IS research was not practical enough or relevant.

This second IS era seems to correlate with the present state ofeducational technology research, development, and adoption. During the 1980s educational technologists also foresaw the importance of the use of technology in education. Educational software increased in availability and became more "user-friendly." Innovators have, however, made mistakes similar to IS designers. Educational programs and products have often been designed by specialists who do notunderstand the user (teacher) or the classroom learning environment. These innovations, therefore, are not implemented as the designers intended. Thus, while the use of technology has grown, it has not dramatically impacted on educational practice in general. Most educators like their IS counterparts in the second IS era, still do not seem quite sure of what to do with the technology.

The third era began with the advent of microcomputers around 1980. The entire mindset of users adapting to computers was reversed as powerful applications that ***adapted to users*** were mass-produced and were made commercially available. Moreover, non-procedural programming languages allowed non-programmers to write software specifically tailored to their needs, conditions, and location. Simultaneous communication innovations that digitally tied computers together allowed the full potential (widely predicted by researchers in the 1940s) of computers and IS to overcome time and distance. For most industries, information systems was no longer a service, or simply a medium for information; it had become the core impetus for an entire ***r-e-engineering*** of organizational processes. The second era issues about ***what*** can be done with information systems became third era ***how*** issues as new, practical applications spread. Information systems researchers began to struggle just to keep up with IS practice, let alone perform research that was not obsolete before it was published.

This third IS era parallels current trends in educational technology in the 90s. The third ET era exists in the literature and in isolated settings. The full potential of computer and communications technologies has yet to be utilized within the educational system as a whole. True organizational change has occurred in a limited number of specific school settings.

Given the theoretical and practical parallels between educational technology and information systems, educational technology should explore information systems research on adoption and implementation for insights and guidance.

INFORMATION SYSTEMS ADOPTION THEORY AND RESEARCH

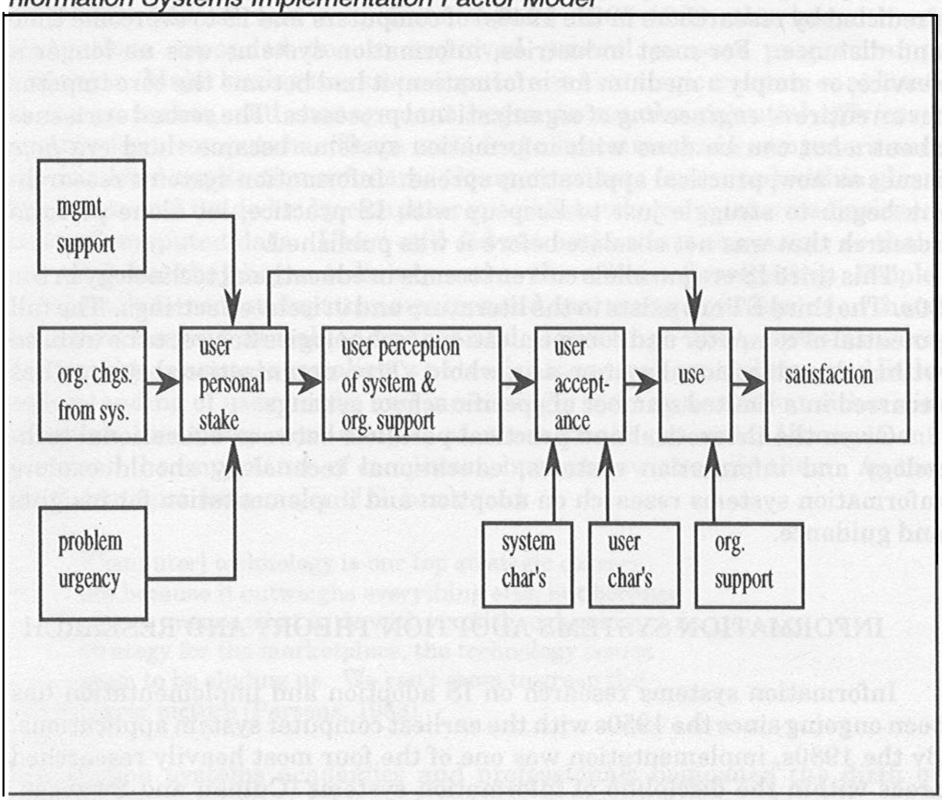
Information systems research on IS adoption and implementation has been ongoing since the 1950s with the earliest computer system applications. By the 1980s implementation was one of the four most heavily researched areas within the discipline of information systems (Culnan and Swanson, 1986). Two basic adoption paradigms were used for research: factors and process.

Factor Paradigm. The factor paradigm, the dominant paradigm in information systems implementation research, sought to identify and relate the many factors involved in IS implementation success, the what behind successful adoption. Six key variables have been identified from scores of empirical research and analysis efforts:

1) organizational need and support
2) user personal stake in success
3) user assessment of system and organizational support for it
4) user acceptance of system
5) use of system
6) satisfaction (Lucas, Ginsberg and Schultz, 1990).

These factors are linked into a generic model for IS implementation as shown in Figure 1.

Figure 1.
Information Systems Implementation Factor Model



In this model, management support for a system, organizational changes required as a result of the system, and the urgency of the problem the system is supposed to address combine to affect the user's perceived stake in the system's adoption. User stake, in turn, influences user perception about the system (how efficiently and effectively it works toward the user's goals) as well as the organizational support behind the system (e.g., corrective maintenance, improvement, supplies). The user's perception of the system and its organizational support in turn directly affects the user's acceptance of the system, in addition to the technical characteristics of the system and the characteristics of the user. User acceptance, overt organizational support, and the user's personal stake in the system then determine how (or whether) the system is used. Experience using the system then directly determines satisfaction with the system from a user and organizational standpoint. Also generally believed to be important factors (but not empirically confirmed with strong data or consistently among researchers) are: user knowledge of the system purpose, user decision making style, user job characteristics, user/designerjoint system development, and user knowledge of the system (Lucas, Ginzberg and Schultz, 1990). Underlying the entire model is the assumption that user acceptance and use are voluntary; the model changes considerably when system use is mandatory.

Under the IS factor implementation model, adoption and successful implementation largely depend on:

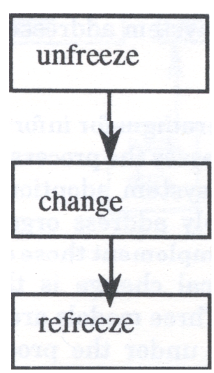
1) gaining support and commitment from the user's management (e.g., funding, job re-design, organizational changes, rewards and incentives, operational support and training);
2) seeking out potential users as early adopters who have a significant personal stake in the problem the system is designed to address, directly involving them in the design process, designing the system to target their technical needs as well as personal characteristics, and focusing attention on their adoption and early use; and
3) ensuring that the system addresses user personal stakes in system use.

Process Paradigm. This paradigm for information systems adoption and implementation research addresses the process of organizational change and management support behind system adoption. This paradigm takes the standpoint that systems simply address organizational and user change needs and provide a vehicle to implement those change needs. Therefore, ***how*** one implements a technological change is the key in this paradigm to successful adoption and use. Three models are prevalent in the IS adoption and implementation research under the process paradigm: ***technological imperative, organizational imperative, and emergentperspective*** (Keil, 1991).

The ***technological imperative model*** is based on the sociological assumption that external forces (the environment) cause internal changes, namely technological changes, to user behavior. In consonance with innovation theories, this model revolves around two change process factors: the technological advantage the system provides a user in performing his or her functions, and the system's ease of use. Together, these process factors determine system use. To promote adoption, management ensures that the system provides technological advantages (or at least that the benefits outweigh the detriments) and that the system is technologically easy to use, Management's agents to this end are IS specialists who are trained in systems, the organization, how to elicit requirements, and how to appropriately design systems for the users. This model is consistent under voluntary or mandatory use situations.

The organizational imperative model assumes that people are causative decision makers in anticipation or in response to environmental changes. Successful adoption and implementation therefore depend on successfully managing the decision making and implementation processes. This model, primarily based on the change and innovation work of Lewin (1947), consists of three phases. According to this model, successful change depends on ***unfreezing*** a situation by creating a climate or motivation for change. The second phase consists of the actual ***change*** based on analysis, design, development, implementation and training for a system and the organizational changes that must accompany the system. The final phase requires ***refreezing*** by institutionalizing the new system (with resulting organizational stability). This model (as shown in Figure 2) emphasizes that an organization with stable political, personal, and social coalitions must first be disturbed before change can be accepted. Although there are many roles (e.g., the user, management, IS developers), management plays the key organizational role in directing the change process.

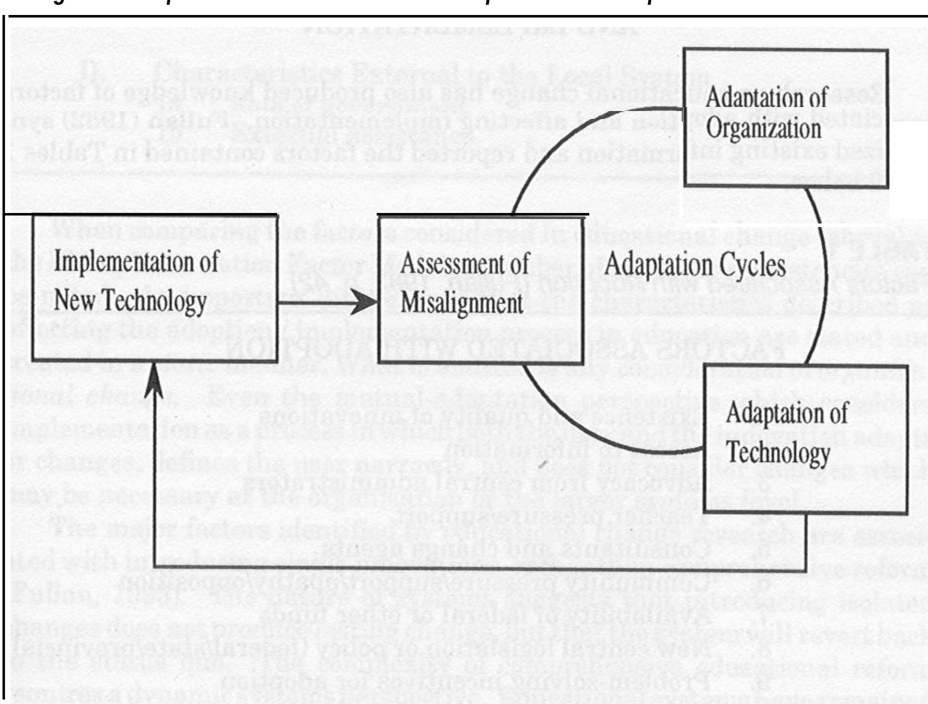
Figure 2.
Organizational Imperative Model for IS Adoption and Implementation



The key to adoption according to this model, therefore, is management awareness of the need for change, awareness and support for a change vehicle (the system with attendant personnel, data, process and organizational structure changes), determination and follow-through on changes, and institutionalization of the changes. While this model is associated more with mandatory than voluntary IS adoption, it can apply equally to both situations. Based on the managerial approach to implementing the change, management can serve as a catalyst to user change as well as an orchestrator.

The final model under the process paradigm is the ***emergent perspective model*** that assumes people and technologies interact in unpredictable ways. What is important is perpetually adjusting that interaction in response to uncovered barriers to success, as shown in Figure 3 (Leonard-Barton, 1988). The important point of this model is that there must be mutual adaptation of technological systems and the organization (including the organizational structure, its management, support, and the users). Change is assumed to be the norm, whether from internal or external environmental forces. No technological system, the model presumes, can ever satisfy all organizational needs forever and will therefore require continual, incremental changes. Likewise, no organization can remain static in light of technological changes or opportunities provided by systems.

Figure 3.
Emergent Perspective Model for IS Adoption and Implementation



The key to adoption in this model is the initial deployment of a new technology, followed by orchestrated monitoring and adaptation. Management and users must be willing to innovate and to take risks on the initial adoption and implementation with the understanding that problems will occur. Management and users must also be willing to invest resources (e.g., time, personnel, budgets) to identify and analyze implementation problems. Most importantly, they must be willing to continually implement technological and organizational changes in a perpetual cycle of change, analysis, and correction. Leonard-Barton (1988) views the initial implementation of a new technology as an extension of the invention process and the mutual adaptation process as occurring at multiple levels within the organization. She argues that "the successful management of technology transfer from developers to users requires that managers recognize and assume responsibility for both technical and organizational change" (p. 253). In organizational terms, this is conflict management, an essential feature of organizational management that entails managerial processes, structure, and content.

These information systems adoption and implementation paradigms, models, factors and processes provide ample suggestions for how to increase and improve successful educational technology implementation in education, as well as provide plentiful opportunities for research.

EDUCATIONAL CHANGE THEORY AND RECOMMENDATIONS TO EDUCATIONAL TECHNOLOGY ADOPTION AND IMPLEMENTATION

Research on educational change has also produced knowledge of factors associated with adoption and affecting implementation. Fullan (1982) synthesized existing information and reported the factors contained in Tables 1 and 2 below.

TABLE 1
Factors Associated with Adoption (Fullan, 1982, p. 42)

FACTORS ASSOCIATED WITH ADOPTION

1. Existence and quality of innovations
2. Access to information
3. Advocacy from central administrators
4. Teacher pressure/support
5. Consultants and change agents
6. Community pressure/support/apathy/opposition
7. Availability of federal or other funds
8. New central legislation or policy (federal/state/provincial)
9. Problem-solving incentives for adoption
10. Bureaucratic incentives for adoption

TABLE 2
Factors Affecting implementation (Fullan, 1982, p. 56)

FACTORS AFFECTING IMPLEMENTATION

A. Characteristics of the Change
1. Need and relevance of the change
2. Clarity
3. Complexity
4. Quality and practicality of program (materials, etc.)

B. Characteristics at the School District Level
5. The history of innovative attempts
6. The adoption process
7. Central administrative support and involvement
8. Staff development (in-service) and participation
9. Time-line and information system (evaluation)
10. Board and community characteristics

C. Characteristics at the School Level
11. The principal
12. Teacher-teacher relations
13. Teacher characteristics and orientations

D. Characteristics External to the Local System
14. Bole of government
15. External assistance

When comparing the factors considered in educational change (above) to the IS Implementation Factor Model, a number of apparent consistencies can be noted. An important difference is that the characteristics described as affecting the adoption / implementation process in education are stated and treated in a static manner. What is omitted is any consideration of ***organizational change.*** Even the mutual-adaptation perspective which considers implementation as a process in which both the user and the innovation adapts or changes, defines the user narrowly, and does not consider changes which may be necessary at the organization or the larger systems level.

The major factors identified by educational change research are associated with introducing single innovations, rather than comprehensive reform (Fullan, 1993). The nature of systems suggests that introducing isolated changes does not produce lasting change, but that the system will revert back to the status quo. The complexity of comprehensive educational reform requires a dynamic systems perspective. Educational systems have remained as relatively closed systems. Too much isolation exists both within schools and between schools and their environment. This isolation is an additional barrier to educational change.

Successful corporations, such as the Hanover Insurance Company (Hampden-Turner, 1992), and schools that have been successful in achieving major reform (Louis and Miles, 1990; Rosenholtz, 1989) are systems which learn from their environments. Successful organizations are continually changing and adapting, The vast majority of schools, however, have attempted to adopt isolated innovations into a conservative system that remains the same.

Schools that will be successful at serving a diverse and changing student body, must interact with and learn from their environment through collaborations and partnerships (Fullan, 1993). From past research we have learned that comprehensive change is a complex process that cannot be totally preplanned. Each change causes numerous consequences, including many which can not be anticipated. We can again learn from studies of other types of organizations. In a study of business computing, Attewell (1992) reconceptualizes the diffusion of technology in terms of organizational learning, skill development, and knowledge barriers. He notes important differences when dealing with complex technologies which can inform the diffusion of technology in education.

Despite similarities to information systems, educational technology adoption research and practice should also bear in mind that educational systems have a characteristic rarely seen in general organizations used in information systems research. Educational systems are professional bureaucracies with a unique organizational structure, unique coordinating and controlling apparati, user roles and culture, communication channels, flow of decision making and authority, and situational factors. For example, information systems factor research consistently reveals management support as the most important, overriding factor in IS adoption and implementation success, but the role of management in a professional bureaucracy is small, existing mainly to provide resources to the professionals (i.e., educators), resolve conflicts among the professionals, and liaise with the external environment. In a professional bureaucracy, a successful decision to adopt an innovation will not be made by the administration alone, it will be made and carried out by individual professional educators. This characteristic, however, does not negate ET application of IS adoption models, it only suggests that the factors and processes for successful educational technology adoption will likely have different relative weights than the factors and processes in successful information systems adoption.

Educational systems are also social systems. As such there exists a variety of stakeholders insisting on having a voice in organizational change and/or instructional changes. The challenge is in learning from the different perspectives and working together rather than polarizing and working separately on opposing goals.

There also exists an important difference between the use of new information systems and the implementation of new programs, products, or technologies in education, at the level of the teacher. The way that a teacher implements and adapts an instructional innovation is affected by his or her personal constructs concerning learning and instruction (Jost, 1992). In addition, classroom instruction includes social interactions and constructions that influence both teachers' thought processes and actions.

User acceptance and use has consistently been identified as essential to information systems adoption. Given the professional bureaucracy structure of the educational system, professional educators rightly have the authority and discretion to adopt or not adopt innovations for teaching; they are hired because of their expertise in education. An important way to improve success should be adopted from the IS factor model: directly involving users in the design process and designing systems that target their needs and characteristics. Without consideration of the user, support and incentives, widespread user acceptance by existing educational professionals is unlikely to occur. In professional bureaucracies, attrition or replacement is the most common means of organizational changes, in addition to changing the standards of who can newly enter the profession, changing what individuals learn in training for the profession, and re-educating those professionals who are willing to be re-educated (Mintzberg, 1993).

Be-educating must take into consideration the issues of conceptual change and role changes as well as technical and curricular competencies. Leonard-Barton (1988), in case studies concerning the introduction of technology into the operations of large corporations, found that extensive investment was sometimes made in supporting hardware but not enough in training, or in training but not in education. "Training did not equate with education and people needed 'know-why' as well as 'know-how'" (p. 262). Research on educational change parallels these findings. When teachers learn the outward appearances of an innovation (procedures) without understanding the underlying philosophy, no real change occurs because the intended innovation has not been implemented.

Education systems and educational change involve complex and dynamic interrelationships. We must expand our understanding of mutual adaptation to include changes in the innovation, the teacher, the organization and the system. Successful change, particularly change involving sophisticated and pervasive uses of technology, requires both bottom-up and top-down involvement and support. Education systems must become learning organizations composed of inquiry-oriented individuals and environments that support collaboration and problem-solving.

REFERENCES

Association for Educational Communications and Technology (1977). ***The definition of educational technology.*** Washington, DC: AECT.

Attewell, P. (1992). Technology diffusion and organizational learning: The case of business computing. ***Organizational Science, 3*** (1), 1-19.

Clark, R.E. (1989). Current progress and future directions for research in instructional technology. ***Educational Technology Research & Develo ment,*** 37(l), 57-66.

Cleary, A et al. (1976). ***Educational technology: Implications for early and special education.*** New York: John Wiley and Sons.

Commission on Instructional Technology (1970). ***To improve learning. A report to the President and the Congressof the United States.*** Washington, DC: Commission on Instructional Technology.

Culnan, M.J., & Swanson, E.B. (1986). Research in management information systems, 1980-84. ***MIS Quarterly, 10(3),*** 289-301.

Davis, G.B., & Olson, M.H. (1985). ***Management information systems*** (2nd ed.). New York McGraw-Hill.

Dieuzeide, H. (1971). ***Educational technology: Sophisticated, adapted and rational technology. Series B: Opinions*** (No. 30). Paris: International Commission on the Development of Education, UNESCO.

Ely, D.P. (1990). Trends and issues in educational technology, 1989. In G. Anglin (Ed.), ***Instructional technology.*** (pp. 34-58). Englewood, CO: Libraries Unlimited.

Engler, D. (1972). Instructional technology and the curriculum. In F.J. Pula and R.J. Goff (Eds.), ***Technology in education: Challenge and change.*** Worthington, OH: Charles A Jones.

Fullan, M. (1993). ***Change forces: Probing the depths of educational reform.*** New York: The Falmer Press.

Fullan, Michael (1991). ***The new meaning of educational change*** (2nd ed.). New York: Teachers College Press.

Fullan, Michael (1982). ***The meaning of educational change. New*** York: Teachers College Press.

Gentry, C.G. (1991). Educational technology: A question of meaning. In G. Anglin (Ed.), ***Instructional technology.*** (pp. l-10). Englewood, CO: Libraries Unlimited.

Gentry, C.G., & Csete, J. (1991). Educational technology in the 1990s. In G. Anglin (Ed.), ***Instructional technology.*** (pp. 20-33). Englewood, CO: Libraries Unlimited.

Hampden-Turner, C. (1992). Charting the dilemmas of Hanover Insurance. ***Planning Review,*** January-February, 22-28.

Heinich, R. (1970). ***Technology and the management of instruction.*** Washington, DC: Association for Educational Communications and Technology.

Heinich, R. (1991). The proper study of instructional technology. In G. Angl (Ed.), ***Instructional*** technology. (pp. 59-81). Englewood, CO: Libraries Unlimited.

Jost, KL. (1992). The implementation of technology in the calculus classroom: An examination of teacher beliefs, practice and curriculum change. (Doctoral dissertation, Syracuse University). Dissertation Abstracts International, Order no. 9229677.

Keil, M.J. (1991). Managing MIS implementation. Unpublished doctoral dissertation, Harvard University Graduate School of Business Administration.

Laudon, KC. and Laudon, J.P. (1993). Business information ***systems*** (2nd ed.). New York: Dryden Press.

Leonard-Barton, D. (1988). Implementation as mutual adaptation of technology and organization. ***Research Policy, 17,251-267.***

Lewin, K. (1947). Frontiers in group dynamics. ***Human Relations, 1,541.***

Louis, K, &Miles, M.B. (1990). ***Improving the urban high school: What works and why.*** New York: Teachers College Press.

Lucas, H.C., Ginzberg, M.J., and Schultz, R.L. (1990). ***Information systems implementation.*** Nor-wood, NJ.: Ablex Publishing.

Mintzberg, H. (1993). ***Structure in fives: Designing effective organizations.*** Englewood Cliffs, NJ: Prentice Hall.

National Commission on Excellence in Education (1983). ***A nation at risk: The imperative for educational reform.*** Washington, D.C.: U.S. Dept. of Education.

Newman, F. (1989). ***Uneven marriage: The university and the management of information technology.*** Keynote address presented at the CAUSE National Conference on Managing Information Technologies: Facing Issues, San Diego, CA.

Parsons, G.L. (1983). Information technology: Anew competitive weapon. In P. Gray, et al. (Eds.) ***The management of information systems.*** (pp. 473-502). Chicago: The Dryden Press.

Quality Education Data (1989). ***1989-90 Catalog of educational mailing lists and marketing services.*** Denver, CO: Quality Education Data.

Reigeluth, C.M. (1989). Educational technology at the crossroads: New mindsets and new directions. ***Educational Technology Research & Development,*** 37(l), 67-80.

Rosenholtz, S. (1989). ***Teuchers'workplace: The social organization ofschools.*** New York: Longman.

Ross, S.M., & Morrison, G.R. (1989). In search of a happy medium in instructional technology research. ***Educational Technology Research & Development,*** 37(l), 19-33.

Silverman, R.E. (1969). Two kinds of technology. ***Educational Technology,*** January, 3.

Winn, W. (1989). Toward a rationale and theoretical basis for educational technology. ***Educational Technology Research & Development,*** 37(l), 35-***46.***

AUTHORS

Karen Lee Jost is Assistant Professor, Instructional Technology at Georgia State University, Atlanta, GA 30303.

Scott L. Schneberger is a Doctoral Candidate in Computer Information Systems, Georgia State University, Atlanta, GA 30303.