Journal of Information Technology Impact
Vol. 1, No. 2, pp. 81-104, 1999

Professional Staff Development: Lessons Learned from Current Usability Studies

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Abstract

One common element of many plans suggested for the improvement of K-12 education in the United States has been the more effective utilization of computer, networking and other technologies. While technology has fundamentally transformed America's offices, factories, and retail establishments, its impact within the nation's classrooms has been quite modest. The Report to the President on the Use of Technology to Strengthen K-12 Education in the United States *(March, 1997) recommends "that a large-scale program of rigorous, systematic research on education in general and educational technology in particular will ultimately prove necessary to ensure both the efficacy and cost-effectiveness of technology use within our nation's schools" (March, 1997, p 9). The same principles that have been explored on the corporate level, (such as GOMS, User Acceptance Information Technology Theories and Models, Cognitively Engineered User Principles, and User Involvement) all have elements that can contribute and add to our understanding and help to develop and design successful pre-service and in-service staff development programs. Such programs would enable educators to effectively, reflectively, and seamlessly integrate technology confidently into existing curricula and guide students to develop problem solving and life learning skills necessary for the new emerging economy.*

A serious commitment to ongoing professional development is a critical component needed to help teachers meet new academic expectations, deepen content knowledge and experiment with new teaching methodologies.

Keywords: Instructional technology; preservice teachers; technology integration; teaching strategies; models for teacher education, technology infusion

Introduction

For more than a decade educational institutions have struggled with the emerging information society and its computer-related technologies. "The fact remains that the question of how best to teach our children remains an empirical question that has not yet been fully answered" (U.S. Report to the President 1997, p. 35). The panel reporting to the President therefore recommended a "large-scale program of rigorous, systematic research on education in general and educational technology in particular" (p. 9).

One common element of many plans suggested for the improvement of K-12 education in the United States has been more effective utilization of computer, networking and other technologies. While technology has fundamentally transformed America's offices, factories, and retail establishments, its impact within the nation's classrooms has been quite modest. Although ETS recently announced increased student achievement in mathematics through the use of technology (Bronner, 1998), there have been few conclusive studies providing empirical evidence demonstrating the benefits of technology use in educational environments. This should come as no surprise since empirical evidence has been long lacking from the corporate sector as well. Corporate America, while encouraging the presence and use of technology internally and externally, has been unable to quantify the benefits of technology (1997 STaR Report). Anecdotal evidence describing numeric measures such as gains in output and lag time between ordering and processing goods is abundant, yet, studies have failed to examine the importance of increased product and service quality or employee satisfaction and motivation.

Though the parameters of corporate and educational efforts to successfully achieve technological integration are different, a commonality for both sectors is the necessity to understand how to utilize technology and the expansive resources it makes available to improve performance and achieve concrete objectives for both students and workers. "It is imperative that ongoing staff development become central to public school's mission of educating children so that school personnel can upgrade their skills to respond to the changing character of education" (Brush, 1994, p. 92). Linda Darling Hammond, executive director of the National commission on Teaching in America's Future, states that "U.S. teacher education has historically been thin, uneven, and poorly financed…Today's schools are organized in ways that support neither learning nor teacher learning well" (1996, p.1). In order for students to become better learners, teachers must have the subject-knowledge skills and teaching skills required to help their students achieve higher academic standards. Professional staff development must become a priority for it has been demonstrated that every dollar spent on more qualified teachers nets greater gains in student performance (Ferguson, as cited in "Teaching quality: What we graded," *Teacher Magazine*, February, 1997).

Recent computer usability studies in the corporate sector may provide insight as to how to work collaboratively with educators, administrators, and library media specialists to develop pre- and in-service professional development programs that will maximize the benefits of information technology. It is the purpose of this paper to review some of the current "corporate" computer usability studies and illustrate how their features and findings might be effortlessly integrated into current educational professional development programs.

Usability studies in the corporate sector provide much insight for universities and educational institutions committed to the effective design and development of successful educational technology programs (Proctor and Van Zandt, 1994). The principles already explored on corporate levels, (such as User Acceptance Information Technology Theories and Models, Diffusion Theory, User Involvement and Activity Theory) have elements that may add to our understanding of how to develop successful professional development programs. Professional development programs must be designed to offer educators; including library media specialists, teachers, parents and administrators, opportunities to make the most effective use of information technology. According to the recommendations of the National Commission on Time and Learning, teachers must have regular school time and support for professional development and collegial planning (Hoyt, 1997).

A Brief Review of Theoretical Approaches to Understanding the Psychology of User

Paramount to any professional development program is an understanding of how and why users either accept or reject new technologies. Staff developers must have a genuine sensitivity to user needs in order to develop effective programs that will enable teachers to successfully integrate and utilize new technologies into their classrooms and curriculum objectives. Understanding why people accept information technology is crucial to the design and planning of educational technology courses and curriculum. An appreciation of theories of information technology acceptance will allow for better methods and standards of professional evaluation and assessment.

Acceptance

Much of the research seeking to understand the dynamics of human decision making in the context of accepting or resisting technology has come from the field of management information systems (MIS). Researchers in the management information systems field seek to predict how users in an organization will react to new technologies (Dillon and Morris, 1996). User acceptance is defined by Dillon and Morris as the willingness within a user group to employ information technology to the tasks it is designed to support.

Lack of user acceptance is of course, an impediment to the success of new information systems. Swanson (1988) found that users are often resistant to using information systems, even if use of such technologies would lead to increased performance. Therefore, user acceptance is viewed as a crucial factor in determining whether an information system project will be successful or not.

1. Theory of Reasoned Action

The theory of reasoned action (TRA) defines relationships among beliefs, attitudes, norms, intentions, and behavior.

> An individual's behavior (e.g., use or rejection of technology) is determined by the person's intention to perform the behavior, and this intention is influenced jointly by the individual's attitude and subjective norm, defined as "the person's perception that most people who are

> important to him [sic] think he should or should not perform the behavior in question (Dillon and Morris 1996, p. 8).

According to the theory of reasoned action, attitudes toward a behavior are determined by beliefs about the consequences of that behavior. Beliefs are defined as the "…individual's subjective probability that performance of a given behavior will result in a given consequence" (Dillon and Morris 1996, p 9). Simply put, if I do A, then B will follow. Administrative institutional culture has a strong influence on the teachers' willingness to accept technological applications. School administrators who openly support their teachers through quality staff development programs will have teachers more willing to take risks and consider alternate pedagogical venues.

2. Technology Acceptance Model (TAM)

The technology acceptance model (TAM) is a management information system-specific model from theory of reasoned action (TRA). The technology acceptance model predicts that user acceptance of any technology is determined by two factors:

1. Perceived usefulness (U)
2. Perceived ease of use (EOU)

Perceived usefulness is defined as the degree to which a person believes that use of the system will enhance his or her performance. Perceived ease of use is defined as the degree to which a person believes that the system will be free of effort (Dillon and Morris, 1996).

According to TAM, U and EOU will have a significant impact of a user's attitude toward using the system (A), defined as feelings of favorableness or unfavorableness toward the system. (Thus, attitude is a general construct not tied to any specific beliefs about the technology.) Behavioral intentions to use the system (BI) are modeled as a function of A and U. BI then determines actual use. Research has consistently shown that BI is the strongest predictor of actual use (Davis et al; Taylor and Todd, 1995 as quoted in Dillon and Morris, 1996, p.10).

Teachers' attitudes toward technology must be favorable in order for professional development programs to succeed with any hope of long-lasting effects on the standards of student accomplishment (Becker, 1993). Successful teachers need to be knowledgeable and skilled in the application of new technologies in order to extend teaching effectiveness (Kontos, 1997). Staff developers too, need to exhibit positive attitudes when working with *tech-novices* who may be very apprehensive and anxious when exposed to new technologies. Beliefs educators have regarding technology and the ease or dis-ease of use will color and effect their willingness to acknowledge and consider new technological applications.

3. Theory of Planned Behavior

Theory of planned behavior holds that attitudes, subjective norms, and perceived behavioral control are direct determinants of intentions, which in turn influence behavior. Taylor and Todd (1996) state that the influence of peers and the influence of superiors are antecedents to the subjective norm. Taylor and Todd also view self-efficacy, resource-facilitating conditions, and technology-facilitating conditions as determinants of perceived behavioral control. Technology does not exist in a vacuum and neither do educators. The attitudes of administrators and colleagues can positively or negatively influence the attitudes and behavior of individual educators. School systems are cultures with many different factors contributing toward their growth, development, and unfortunately at times, their inertia.

Alavi and Joachimsthaler (1992) have developed a framework suggesting that individual user factors that are most relevant to acceptance are:

1. Cognitive style - characteristic ways in which individuals process and use information.

2. Personality - the cognitive and affective structures maintained by individuals to facilitate adjustment to events, people, and situation. Personality traits thought to affect IT acceptance include: need for achievement, degree of defensiveness; locus of control, dogmatism, and risk-taking.

3. Demographics – a number of demographic variable, including age and education have been studied and shown to influence users.

4. User-situational variables – variables which include training, experience, and user-involvement, which correlate with acceptance of new technology.

They found that the group of user-situational factors was more important than individual-difference variables. Alvai and Joachminsthaler explain that the manipulation of user-situational variables (involvement, training, and experience) can improve the implementation success rate by as much as 30 percent. Educators are influenced by user-situational variables, and individuals who use computers at home are more likely to utilize technology within their classrooms. As individuals are more exposed to technology the novelty wears off, as does anxiety and fear. People become more comfortable and less anxious and more willing to take new risks and learn new skills (Jay Jacobs, 1998; Kent, 1997).

4. Innovation Diffusion Theory

The primary intent of innovation diffusion theory is to illustrate how any technological innovation moves from invention to widespread use, or non-use (Dillon and Morris, 1996).

Dillon and Morris list five characteristics that affect diffusion:

1. Relative advantage – the extent to which a technology offers improvements over currently available tools.

2. Compatibility – its consistency with social practices and norms among its users

3. Complexity – its ease of use or learning

4. Trialability – the chance to try out an innovation before making a commitment to its use.

5. Observability – the extent to which the technology's outputs and its gains are clear.

Each of these characteristics by itself is not enough to predict the extent or rate of diffusion, but diffusion studies have shown that innovations that offer advantages, compatibility with existing practices and beliefs, low complexity, potential trialability, and observability will have a more widespread and rapid rate of diffusion (Dillon and Morris 1996, p. 6).

Moore and Benbasat's findings suggest that the most important characteristics of an information technology innovation that affect decisions regarding use are: voluntariness of use, image (or the degree to which the use of an innovation is thought to enhance one's image or status in one's social system), relative advantage, compatibility, ease of use, trialability, result demonstrability and visibility (Dillon and Morris, 1996).

Teachers should not be coerced into accepting or utilizing a technology integrated and supported curriculum. Forced participation mandated by administrative directives will surely meet with resistance. Exposure to technologically rich programs in a safe, nurturing, and collaborative environment will be more advantageous to participants and ultimately have positive effects on the students they teach (Jay Jacobs, 1998).

Innovation diffusion theory also suggests that individual user characteristics are very important. Rogers (as quoted in Dillon and Morris, 1996, p. 6) divides technology or innovation adopters into five categories:

1. Innovators
2. Early adopters
3. Early majority
4. Later majority
5. Laggards

Rogers plotted these categories over a normal distribution, with each major category (innovators and early adopters combined into one) representing a standard deviation of dispersion. The mean is the division between early and late majority, with laggards and late adopters constituting 50% of the population. Using this as his basis, Rogers states that early adopters and innovators make up only 16% of the total population. Early adopters have a greater influence over the adoption of any technology, and descriptive studies of these categories reveal a number of personality variables (risk taking, adventure seeking) and socioeconomic factors (wealth, education) that seem to distinguish their members as well (Dillon and Morris, 1996, p. 7).

Using an approach such as Rogers appears to have relevance to studies of IT acceptance in organizations. Educational institutions evaluating technology for use within the organization must be aware of their user base. It is reasonable to assume that a "tool" used throughout the organization will experience a protracted period before all users are "up to speed" on how to use the tool effectively. It is important to understand users who are likely to be "laggards" so that intervention strategies such as extended training, peer teaching, coaching and/or peer modeling are made readily available. Collaboration between peers increases technological integration (Lieberman and Grolnick, 1997).

5. Principles Supporting Usability

Learnability, as described by Dix et al.,1993, is the ease with which new users can begin effective interaction and achieve maximal performance. Learnability is concerned with how the features of an interactive system will allow novice users to understand how to use the system initially and then how to attain a maximal level of performance. Many educators, at least in this generation, will need to be introduced to technology and thus learnability is of great importance in the design of current professional development programs.

Predictability: Predictability is a user-centered concept; it is deterministic behavior from the perspective of the user. The predictability of an interactive system means that the user's knowledge of the interaction history is sufficient to determine the result of his/her future interaction with it. "It is not enough for the behavior of the computer system to be determined completely from its state, as the user must be able to take advantage of the determinism" (Dix et al. 1993, p. 131). Predictability deals with the user's ability to determine the effect of operations on the system (there are many degrees of predictability).

Synthesizability: Synthesis is the ability of the user to assess the effect of past operations on the current state (Dix et al., 1993). The user must be able to assess the consequences of previous interactions in order to formulate a model of the behavior of the system. As people gain technological experience they are able to predict and determine with greater accuracy how systems will operate based upon previous use and knowledge.

Familiarity: Participants new to a system bring along with them a wealth of experience across a wide number of application domains. This experience has been obtained through interacting in the real world and also through interacting with other computer systems. For a new user, "the familiarity of an interactive system measures the correlation between the user's existing knowledge and the knowledge required for effective interaction" (Dix et al., 1993, p. 134). Familiarity, as Dix states, has to do with a user's first impression of the system. Researchers are interested in how the system is first perceived and whether the user can determine how to initiate any interaction.

Generalizability: The generalizability of an interactive system supports the extent to which users try to extend their knowledge of specific interaction behavior to situations which are similar but never experienced before. Generalizability can be seen as a form of consistency. It has often been suggested that the best way to introduce a new computer system is to draw an analogy between the computer and some similar situation that is familiar to the user (Waern, 1993). Software giants such as Microsoft capitalize on this concept by introducing features with names that are familiar to users, such as "desktops", "file managers" or "address books".__ Educators need to view technology not as an add on but rather as a enhancement of teaching that is already taking place. The use of technology that is seamlessly integrated into existing curriculum will allow teachers and students to explore alternate means of examining subject matter.

Consistency: Consistency relates to the likelihood of behavior arising from similar situations or similar task objectives (Dix et al., 1993). Prior exposure to technology will predispose some individuals to harbor negative or positive attitudes toward technology.

Customizability: Customizability is the modifiability of the user interface by the user or the system (Dix et al., 1993). As educators learn to customize software and applications their sense of empowerment will grow.

Flexibility: Flexibility encompasses the multiplicity of ways in which the user and system exchange information (Dix et al., 1993). Teachers more comfortable with a variety of systems and programs are more fluid in their application.

Robustness: Robustness is the level of support provided the user in determining successful achievement and assessment of goals (Dix et al., 1993). In an educational environment this would include technical, administrative, societal, peer and professional support. Many times this support is overlooked, however, it is a crucial element in order to create and implement technology successfully within the curricula.

6. Learning and User Characteristics

Learning is probably one of the most researched subjects in the history of psychology, and now this topic is being revitalized through the introduction of computers. Learning in computer situations is not uniform, but takes many forms (Waern, 1993).

1. Mental Model

The term *mental model* has been frequently used to describe a user's conception of a computer system. According to Waern, the mental model can be regarded as a construct, attributed to the user by the researchers, based on observations of how the user interacts with and talks about the system. Waern is not proposing however, that the mental model represents an entity of which the user is aware (p. 327). A mental model serves important functions by providing the user with efficient procedures. Craik's 1943 description of the functioning of mental model is still applicable:

> If the organism carries a "small-scale model" of external reality and of its own possible actions within its head, it is able to try out various alternatives, conclude which is the best of them, react to future situations before they arise, utilize the knowledge of past events in dealing with the present and future, and in every way to react in a much fuller, safer, and more competent manner to the emergencies which face it. (as cited in Waern, 1993, p. 327).

The function of the mental model during learning is to make sense of observations and reduce the complexity of the individual observations. According to Waern (1993) the development of a mental model may be regarded as a more or less explicit hypothesis-testing procedure. The mental model can be regarded as the generator of hypotheses that concern the characteristics of objects and operations in the system. Thus, the model is dynamically changed when these hypotheses fail. In order to infer mental models a think-aloud method must be utilized (Waern, 1993). The use of good reflective practice helps pre and in-service teachers develop effective mental models (Waern, 1993, Kent, 1997).

Artifacts

Carey and Rusli (1995) state that we cannot simply observe people, we must know what the user is thinking. Humans control their behavior not from the inside (because of biological urges) but from the outside, through their creation and use of artifacts (Kuuti, 1996). This perspective according to Kuuti, is an optimistic view of human determinism and an "…invitation to serious study of artifacts as integral and inseparable components of human functioning" (Engestrõm, 1991, in Nardi, 1996, Activity Theory and Human Consciousness, p. 27).

Bannon & Bodker (1991) share a fundamental belief that design is a learning and change process for *all* the involved parties, both designers and users.

> Our quest is to design more usable computer artifacts, then a better knowledge of the "users" is required as a part of our analysis – one that sees people acting in a situation, with motives, and intentions, in interaction with others and the environment. We subscribe to the idea that good design comes from an empathy with the work process itself, with possibilities for individual and societal growth. As scientists and researchers we are not removed from, but are ourselves a part of the process (p. 249).

Quality educational technology programs require total commitment on the part of the participants and the program administrators in order to be successful.

Teachers and students learn best when they actively develop their own structure of knowledge through discussion, research, and reflection. Quality professional development ensures that there is sufficient time allotted for teacher collaboration and reflection (Kent, 1997).

7. Learning Styles

Ayersman (1996) found that learning styles groups differentially possessed degrees of computer anxiety after an extended computer-based treatment.

1. Kolb's Learning Styles Inventory can be used to determine individual learning styles. Four types of learning styles are possible using this instrument:

- Accommodator – more of a risk taker, relies on intuitive trial-and-error approaches to problem solving, and is highly adaptive to new situations.

- Assimilator - portrayed as a thinker who specializes at inductive reasoning and the formulation of theories.

- Diverger – adapted to viewing a situation from multiple perspectives, has broad cultural interests, and excels in areas, which require imagination and the generation of ideas through methods such as brainstorming.

- Converger – relies on common sense, is better suited to the practical application of ideas, and is viewed as a pragmatist (Jonassen, Grabowski 1993, p. 249).

Divergers maintain higher levels of computer anxiety (CANX). Convergers have the lowest levels of CANX. Convergers enter the instruction with the lowest levels of CANX and further reduce their anxiety so that by the end of instruction they experience significantly lower levels of CANX than the other three learning style groups. Ayersman found that virtually any type of prior computer experience is related to lower levels of computer anxiety. The fact that learning style groups differentially possess degrees of CANX after an extended computer-based treatment implies that these variables should be more closely examined to gain an understanding that will allow all learners to effectively and equitably succeed in computer-based learning environments.

2. User characteristics that may affect user performance and preferences in interacting with computers may include but are certainly not restricted to:

- Level of experience (Perceived or otherwise)

- Personality traits (Jungian personality types, Field dependence/independence, Locus of control, Imagery, Spatial ability, Type A/Type B behavior, Ambiguity tolerance, Self-efficacy, etc.)

- Demographic Characteristics (Age, sex) (Aykin, 1989, p. 615).

8. User Involvement - Iterative Design

The willingness to involve users in the design process of systems has been an ongoing process which has led to iterative design (Kuuti, 1996). According to Kuuti when problems in system use arose during the eighties, the term "user-centered" arose to indicate that designers should study user populations more carefully than they had in the past. But Kuuti stresses that studying users from the "outside" is not enough and recommends that users become involved in the design process itself. So too, it follows that teachers must be actively involved in their learning process(es). Teachers should be actively involved in the planning of professional development programs. The integration of technology into existing curricula should be a dynamic experience marked with an interactive blend of sharing, mentoring, consulting, and an openness to much needed venting.

Amoako-Gyampah (1997) concludes that a user's overall satisfaction with the computer information system (CIS) function within the organization significantly affects his/her desire to be involved in system development. Jointly planned projects are likely to affect the desire of users to be involved in development activities. Srinivasan and Davis (1987) state that a user's past experience with computer systems and their expectations about the benefits that may be derived from computer systems determine their behavior in system development environments.

Research on computers as attitude objects have concluded that doing well at a task leads to liking for or positive attitudes toward the task (Whitley Jr., 1996). People with an aptitude for a task should expect to do well at it, and also should have more positive attitudes toward it and hence positive attitudes should result in greater computer usage and involvment.

9. Learning by Doing

Soloway et al., (1994) feel that the way in which computers are being used in the corporate world provides the ideal conditions under which learning should take place, that is to say learning in the content of doing. Learning by doing is the equivalent of learning in a problem-solving situation (Waern, 1993). Problem solving can be described as a search in a problem space. This means that learning by doing involves learning the characteristics or nature of the problem space as well as learning how to search efficiently within it (Waern 1993, p. 334). Waern concludes that four stages must be passed through in order to create a new efficient problem space for a particular task:

1. The users have to perform activities that allow them to detect new aspects of the system's functioning. This means the user must be allowed to "play around" with the system.

2. The users have to attend to unexpected outcomes of their actions.

3. The user must reflect upon the observations made. The discovery of new possibilities is not enough. Reflection allows for the possibility of the construction of richer problem space. (Waern found in her studies, that most users were too impatient to allow themselves this important reflection time).

4. The user must create a mental model of the system that can be used for several tasks. This may be referred to as a "generative" model (Waern, 1993, p. 334).

The premise that people remember more of what they do than what they hear or see should drive the methodology of professional development models (Hoyt, 1997).

10. Playfulness

Anderson (1996) describes *playfulness* as one of the most important aspects of human-computer interaction. Webster and Martocchio (1992) determined that there was an inverse relationship between computer anxiety and playfulness. They emphasized the importance of playfulness as a character trait that fosters "a greater degree of cognitive spontaneity, inquisitiveness and creativity with computers" (Webster and Martocchio, 1992, p. 202). Webster and Martocchio also characterized playfulness as a state. A person who may not be playful by nature may become "playful" with a computer, especially when using software which is very user friendly (Webster and Martocchio, 1992, p. 204).

To encourage users to "search the problem space" (choose efficient ways of solving each particular task) the following conditions need to be fulfilled:

1. People must know the problem space within which the search is performed

2. People must get feedback as to the result of their actions

3. People must remember both their own actions (in detail) and the outcomes of them.

Efficiency cannot be measured simply in terms of the number of commands or keystrokes used, as was suggested by the GOMS model (Card et al., 1983, proposed that the psychology of human computer interaction could be reduced to measuring a set of "goals", a set of "operators", a set of "methods" for achieving the goals, and a set of "selection" rules for choosing among competing methods for goals, p. 140). Efficiency must also be measured in terms of perceived effort (Waern, 1996).

11. Attitudes towards Computers

Martocchio (1994) found that creating a context in which trainees believed they could build on their present abilities was associated with a significant decline in computer anxiety. Martocchio concludes that people who believe that their ability is malleable may view training as an opportunity or positive challenge and people who believe that their ability is fixed may view training as a threat. Dyck and Smither (1996) examined the relationship between computer attitudes and computer experience. They found more positive attitudes towards computers was associated with a higher level of computer experience. They also found that females had a less positive attitude towards computers than males. Anderson (1996) found that perceived knowledge rather than experience is a predictor of microcomputer anxiety. According to Anderson, computer anxiety affects the ability of individuals to use computers. He recommends that managers and educators should use "simple" methods to assess whether or not a person is anxious about using a microcomputer. Anderson recommends the CARS scale, a self-report inventory consisting of 10 statements designed to measure computer anxiety. The scale comprises a mix of anxiety-specific statements and positive statements (Anderson, 1996, p. 66).

A modest amount of research has identified factors that might account for gender-specific differences in the appeal and effectiveness of programs, environments, and contexts for computer use (Report to the President, 1997). But there remain many issues pertaining to computer instruction that are unresolved. Maurer and Simonson (1993-94) found that it probably takes more than a few weeks of instruction to positively impact computer anxiety. Their findings suggest that if several weeks of instruction are necessary to significantly reduce computer anxiety, "then computer short courses and condensed course (e.g., summer course) would be either less effective, ineffective, or even harmful to the goal of reducing computer anxiety" (p. 214). This information is crucial for universities and institutions designing and developing professional development courses and programs. There is no fast and easy method of infusing professional staff development, it takes time, money, and a commitment on the part of administrators, teachers, and those who facilitate such programs. Districts and teachers need to be creative and flexible in providing time within the school day and year to support staff development and realize that it is a continuing and ongoing serious financial commitment (Kent, 1997).

12. Sociotechnical System Design – Artifacts and Social Environments

Sociotechnical system design (STS) began after World War II at the Tavistock Institute, which included a group of psychologists and organizational theorists based in London who applied their skills to Britain's difficult labor-management relations (Agre, as quoted in Thomas, 1995). STS research has investigated the interactions between the social technical subsystems. Sociotechnical systems design introduced the idea that the designed artifact consists of both the technical artifacts and the social arrangements that surround them, including the actual process of implementation and use. Resistance is described as a system failure. Agre argues that the

> Acceleration of technical and organizational change must be met with an accelerating reaffirmation of human values. The resources for such a project derive not from the rejection of technical and managerial practices but from their transformation: from a unilateral to a participatory technical practice (Argre, as quoted in Thomas, 1995, pp. 101-102).

According to sociotechnical theorists, working group autonomy should be encouraged since it is thought to increase satisfaction and long-term performance. Some of the control issues raised with respect to technology design are access, reliability, confidentiality, monitoring, pacing, stress, and social contact. The low or high presence of certain factors (for example low reliability and high pacing) with the introduction of a new technology is likely to reduce the users' perception of control and increase the risk of resistance (Dillon and Morris, 1996). By stressing autonomy, growth, and job satisfaction as important values, emphasis is placed on user participation in the design process through task analysis, usability evaluation, and planned introduction. Educational technology programs should be carefully designed and developed with the full participation of teachers both as "users" and as "learners."

13. Activity Theory and Its Role in Professional Development

Activity theory has a rich philosophical and scientific background and has much to offer when considering the pedagogical issues of technological instruction. It is an evolving descriptive theory and much research in this field is currently taking place in Russia, Europe, North America, and Australia. Activity theory stems from the work of Lev Semenovich Vygotsky and his cultural-historical approach to the origins and development of higher mental functions and consciousness (Wertsch 1985). The main concerns of activity theory are consciousness, the asymmetrical relation between people and things, and the role of artifacts in everyday life (Nardi, 1995). Activity theory has a simple hierarchy for describing activity that resembles GOMS, but is different in that it describes "dynamic movement between levels of activity rather than assuming stasis." (Nardi, 1996, p. 10). GOMS sought to supplement or replace user involvement through user descriptions, and, in many empirical approaches to user-center design users are described as records, subjects, or cases, but not as full participants (Nardi, 1995).

Vygotsky argued that tools mediate thought, and that the mind develops through interaction with the environment. Artifacts, including signs, procedures, laws, machines, methods, forms of work organization, and accepted practices affect the kinds of mental processes that develop (Bellamy, 1996). As a result, humans control their own behavior through the use and creation of artifacts. Therefore, any artifact, technological or otherwise, has the potential to change activity. The nature of any artifact can only be understood within the context of human activity—by identifying the ways people use the artifact, the needs it serves, and the history of its development (Kaptelinin, 1996).

The artifacts we work with are under a constant state of flux, due to conflicts in the way they are applied. Change is seen as a collective learning process where two principles are fundamental: the application of a methodological cycle and the notion of the zone of proximal development (Bodker, 1996).

> *The methodological cycle* is the movement from an analysis of the activity and the surrounding activities to the creation of instruments by which the practitioners can transcend their own praxis - thus creating a vision of change - to an implementation of a final new instrument into the organization (Bodker, 1996, p. 231).

In other words, as we try and predict how the praxis will change, the artifacts are used in different ways from the original intentions, with new contradictions constantly being introduced, causing the need for new artifacts to emerge.

The zone of proximal development, according to Vygotsky, is a notion to understand the lines along which learning can take place (Wertsch, 1985). Apart from a person's present skills and understanding, there is a zone within which the person is capable of learning and is motivated to learn. Vygotsky believed that there is no learning if it does not result in the development of the human being. The zone of proximal development is the distance or path between what a group can do at present, and what it comes to understand as possible new ways of acting (Bodker, 1996). Activity theory itself is described by Kapetelinin as a special kind of artifact (1996, p. 46). Cole and Engestrom (1991) suggest that to understand an activity, "one must understand how artifacts mediate the activity within the cultural context in which the activity is situated" (p. 124). Cole and Engestrom show that in any activity, artifacts whether they are tools or symbols mediate between the individual (the subject of the activity) and the individual's purpose (the object of the activity). They also explain that individuals are not isolated but are part of a community and thus the activity will be affected by the individual's participation within the community.

> Additionally, the subject's relationship to the community is mediated by rules and the community's full collection of tools. And, in turn, the community's relationship to the object of the activity is distributed among the members of the community, that is, the role each individual in the community play in the activity, the power each wields, and the tasks each is held responsible for. This last relationship occurs because in order for a community to achieve a common objective, the activities of the individuals in it must be organized, and the paths of communication coordinated, so that together they form the set of actions that will achieve the common objective (Nardi, 1996, p. 124).

The proposal of activity theorists that artifacts mediate human activity, and Cole and Engestrom's description that the introduction of new artifacts to an activity affects the kinds of processes, social and individual that develop, provide a framework to understand how new technologies can affect educational change. Cole and Engestrom's analysis can therefore, according to Bellamy (1996) be used as a framework for describing the activity of K-12 education and their analysis suggests that when considering whether technology is the catalyst for educational change, it is not enough to consider individual artifacts. Analysis must consider all the complex relationships of educational activity. "The effect of a new technology on education will be as much determined by individuals' mediating their objectives through the technology as it will be determined by the existing tools and community structures" (Bellamy, 1996, p.127).

Professional development and/or educational technology programs need to be designed by carefully analyzing and understanding the interplay of community, individuals, and rules and divisions of labor. The entire environment and culture must be holistically considered. It is not just the technology that is of importance, nor are the issues of usability and usefulness. Effective professional development programs must take into account the context, environment, culture and background and attitudes of participants. Researchers, library media specialists, teachers, students, parents, and administrators should all be viewed as partners engaged in a collaborative continuous spiraling learning process. Teachers need to become familiar with the technology first, to give them an understanding of technology from a learner's perspective before thinking about it from a teacher's perspective. Involving teachers in the design of technology helps them to feel ownership and develop the associated curriculum supplemental materials that are crucial to the creative and effective use of technology (Bellamy, 1996).

Bellamy (1996) Yocam, Wilmore, and Dwyer (1994) have been investigating how to support teachers in changing their educational practices with approaches that include the principles of authentic activities, construction, and collaboration. They have created a number of teacher development centers (TDCs) for teachers to attend. Teachers attending classes in these centers take part in classroom activities that model particular teaching practices. It is hoped that teachers, working in collaboration with a coordinator and teachers leading the model classroom, will develop ideas that they can take back and implement within their own classrooms.

Yocam (1994) has discovered some problems with this approach, the largest being that many teachers cannot implement the new skills that they have learned when they return to their educational communities. They are unable to put into practice their new skills because the structure, rules, and division of labor in their own school community does not readily allow for the use of such advances. Bellamy (1996) is currently engaged in the design of tools and processes that seek to overcome these problems.

Activity theory postulates that activity cannot be understood unless the artifacts of everyday existence are also understood (Nardi, 1996). Activity theory is concerned with *practice,* that is, *doing* and *activity*, which significantly involve "the mastery of…external devices and tools of labor activity" (Zinchenko, 1986). And, what is especially important is how these artifacts are integrated into social practice. Social practice is defined as doing and activity. This makes activity theory, which looks at ongoing human interaction with the world, and includes relations with others, and the social processes of learning and development, an attractive framework in the effort to develop quality professional development models (Bannon and Bodker, 1991).

14. Human Actors

Liam Bannon (1991) describes a new vision of human beings as active actors and not only as collections of attributes of cognitive processors*:*

> Individual motivation, membership in a community of workers, and the importance of the setting in determining human action are just a few of the issues that are neglected. By using the

term *human actors* emphasis is placed on the person as an autonomous agent that has the capacity to regulate and coordinate his or her behavior, rather than being simply a passive element in a human-machine system (Bannon, 1991, pp. 27-29).

Professional staff development programs should be carefully outlined by directing vigilant attention to the importance of individuality, motivation, social membership, and environment. When designing such programs it is prudent to recall Bannon's advice that the use of systems is a long-term process that cannot be adequately understood by only studying the preliminary steps of usage. In real life people develop their skills over time, and such skill-achieving dynamics have not, according to Bannon, received the proper amount of attention in research. This lack of research is true in both corporate and academic sectors.

15. Participatory Design

Carroll (1996) refers to Participatory design (PD) as an approach to user-centered design (UCD), whereby users are directly consulted throughout the system development process. Susanne Bodker (1996) and her colleagues at Aarhus University were among the first proponents of PD when it arrived from Europe in North America ten years ago. She describes recent work in which she explores new roles for PD action researchers. In her new work (AT project, a cooperative project between Aarhus University and the local branch of the Danish National Labor Inspection Service (NLS)) researchers are both consultants and trainers. They work closely with both management and labor. In short, Bodker's approach involves facilitating an autonomous learning community in the workplace (1996). This approach is an action-oriented approach to studying learning and change in work. Participatory design argues a humane, socially responsible practice (Kyng, 1991; Muller and Kuhn, 1993).

Like Bodker, Blomberg, Suchman and Trigg (1996) are exploring new roles for PD action researchers. They describe a "technology-driven" PD, in which researchers play the role of what could be called "mediators." Karlheinz Kautz (1996) states that PD should be incorporated into the curricula for computer science and other computing disciplines. In order to acquire the skills, attitudes, and knowledge needed to assist students learn higher standards, teachers need to be actively involved in their own learning, just as their students should be (Darling-Hammond and Berry, 1998).

New Challenges

Lewis J. Perelman, former director of Project Learning 2000 and a Senior Fellow of the Discovery Institute states that:

> Technology is the most purely human of humanity's features, and it is the driving force of human society. The defining benchmarks of the epochs of human history are the dominant technologies: the stone age, the bronze age, the iron age, the industrial age (1992, p. 25).

And Barker, 1994-5 predicts:

> The unrelenting pace of technological revolution in telecommunications has profound

> implications for the future of higher education. This trend will eventually alter almost entirely who, what, and how we teach. As the availability and quality of telecommunications improves, we will begin to educate a more diverse and geographically dispersed student population (p. 158).

Business, government, and educational organizations and institutions are part of a technologically driven information society in which the ability to find, interpret, and use appropriate information is critical. Drucker (1992) calls this society the “knowledge society”.

The rate of technological change has been nothing short of astounding. In fact, Toong and Gupta claim that “if [aircraft technology] had evolved as spectacularly as the computer industry over the last 25 years, a Boeing 767 would cost $500 today and it would circle the globe in 20 minutes on 5 gallons of fuel.”(as cited in Wright, 1993, p. 2). In our *information knowledge* society the major issue we need to address is the management of rapid change. Change is the most persuasive characteristic of life in the twentieth century (Wright, 1993). New equipment, new processes and methods, new relationships, and new work assignments are rapidly introduced into our society. As the use of computer-related technologies changes the way society operates there are new demands on the people in the work force who must learn to adapt to these changes. Through participation people change and in the process become prepared to engage in subsequent similar activities. By engaging in an activity, and participating in its meaning, people make ongoing contributions, thus the *process is the product* (Wertsch and Stone, 1979 as quoted in Rogoff, 1995). Or in John Dewey’s words:

> The living creature is a part of the world, sharing its vicissitudes and fortunes, and making itself secure in its precarious dependence only as it intellectually identifies itself with the changes about it, and, forecasting the future consequences of what is going on, shapes its own activities accordingly. If the living, experiencing being is an intimate participant in the activities of the world to which it belongs, then knowledge is a mode of participation, valuable in the degree in which it is effective. It cannot be the idle view of an unconcerned spectator (1916, p. 393).

Teachers need to be actively involved in the design, creation, and implementation of professional staff development programs. “Changes will not work if they are done to teachers; they must be done by teachers” (Kent, 1997, p.3).

Conclusion

Information technologies such as computer-mediated communications, electronic publishing, intelligent tutoring systems, groupware, multimedia, intelligent agents, videoconferencing, video-on-demand, and virtual reality are growing and maturing to produce “intelligent multimedia virtual classrooms” (Barker, 1994-95, p. 166). These cyber-educational links will enable students and faculties to work together, share knowledge, and instantly access vast amounts of information.

The real promise of integrating technology in education lies in its potential to facilitate fundamental, qualitative and global changes in the nature of teaching and learning. Computers, digital media, and telecommunications should support human knowledge processes. The impact of these relatively new technologies can only be understood in terms of their human factors, …their *utility* in supporting scholarship, their usability in making this support simply available, and their *likeability* in making it an attractive task (Gaines, Chen, and Shaw, 1997 p. 1001).

Life-long learning has become a pre-requisite for survival. Professionals should be constantly learning. Businesses, corporate or academic, know at some level at least that investing in the growth and development of "their" people is good business. The value of any company is directly related to the depth of understanding its employees have of the business, and how effective the business can compete in today's marketplace (Soloway, Guzdial and Hay, 1994). I propose using Bodker's Participatory Design approach as a working model to educate teachers and library medial specialists, as a prerequisite to integrate technology efficiently and effectively within our nation's school systems.

Participatory Design could easily be incorporated into a community-initiated educational process, with researchers playing the roles of consultants and trainers. They should interact with the educators, administration, parents and the student body. This would become, as Bodker (1996) describes, an autonomous learning community in the workplace.

A Dynamic Participatory Design Approach (my terminology) could be and should be designed to guide educators in the creative use of technology. Professional staff development programs should be adaptive to incorporate individual differences such as level of knowledge, cognitive characteristics, learning style, and user characteristics.

From the results of Amoako-Gyampah's study, it is this author's recommendation that professional staff development programs aim at including administrators as well as teachers in the development and design of their school's technology planning from the very start. User involvement leads to user satisfaction and ownership. Teachers and administrators need to become stakeholders in these programs (Kent, 1997). Teachers who are adept at integrating technology and curriculum practice in teaching environments are characterized by a great deal of support for instructional change (Becker, 1994). User involvement leads to user satisfaction insuring that projects that are jointly planned and developed by administrators and teachers stand a better chance of succeeding, than programs which are dictated solely by administrative powers (Amoako-Gyampah, 1997).

Schools need administrators, teachers, and library media specialists to structure effective learning environments and who are flexible in the roles they play with colleagues and with students (Wright,1993). Computer-related technologies do not exist in isolation; they are part of the whole larger social and community network. How schools and school districts respond to and incorporate emerging computer technologies will depend on what model of the educational process a particular school uses (Wright, 1993). Teachers need ready access to information about new teaching practices and innovations so that they can carry out their jobs more effectively and ready students for new demands of the community and corporate world (Brush et.al., 1994).

There are many lessons to be learned from the corporate sector that are applicable to educators as they cope with the challenge of technology integration. Teachers need to learn how to deepen their content knowledge and learn new methods of teaching. They need more time to work with colleagues, to critically examine the new standards being proposed, and to revise curriculum. They need opportunities to develop, master and reflect on new approaches to working with children. New curriculum, standards, assessments, methodologies, technology and reforms will not have much of an impact unless teachers have the appropriate access, knowledge, support and skills; all of these activities fall under the general heading of professional development (Corcoran, 1995).

References

Alavi, M. and Joachimsthaler, E. (1992). Revisiting DSS implementation research: A meta-analysis of the literature and suggestions for researchers. *MIS Quarterly*. 16(1):95-116.

Alter, M. (1998). A professional development model that works. National Teacher Policy Institute Impact II Project [online]. Available: http://www.teachnet.org/ntpi

Amoako-Gyampah. (1997). *Exploring users' desire to be involved in computer systems development: An exploratory study.* Computers in Human Behavior. 13(1):65-81.

Appleborne, P. (1996). Computer idea gets mixed response: Questions about cost and the best strategies for education," *New York Times.* January 25th, 1996.

Anderson, A.A. (1996). Predictors of computer anxiety and performance in information systems. *Computers in Education.* 12(1) 33:61-77.

Ayersman, D.J. (1996). Effects of computer instruction, learning style, gender, and experience on computer anxiety. *Computers in the Schools* 12(4):15-30.

Ayersman, D.J. (1995). Individual differences, computers, and instruction. *Computers in Human Behavior* 11(3-4):371-390.

Aykin, N.M. (1989). Individual differences in human computer interaction. *Computers and Industrial Engineering* 17(40):614-619.

Bannon, , L., and Bodler, S. (1991). Beyond the interface: Encountering artifacts in use. In J. Carroll (Ed.). (1991). *Designing Interaction: Psychology at the Human Computer Interface.* Cambridge: Cambridge University Press.

Barker, D.I., (1994-5). A technological revolution in higher education. *Educational Technology Systems* 23(2):155-168.

Barker, K. 1997. Smoothing the transition to a new paradigm of professional development. National Teacher Policy Institute Impact II Project [Online]. Available: http:// www.teachnet.org/ntpi.

Becker, H.J. (1994). How our best computer-using teachers differ from other teachers: Implications for realizing the potential of computers in schools. *Journal of Research on Computing in Education* 26 (3).

Becker, H.J. (1993). How much will a truly empowering technology-rich education cost? *Educational IRM Quarterly* 3(1): 31-35.

Becker, J.M. (1997). Peer coaching for the improvement of teaching and learning. National Teacher Policy Institute Impact II Project [Online]. Available: http://www.teachnet.org/ntpi

Bellamy, R.K.E., (1996). Designing educational technology: Computer-mediated change. In Nardi, B. (Ed.). (1996) *Activity Theory and Human-Computer Interaction* (pp. 123-146). The MIT Press: Cambridge, Massachusetts.

Bodker, S. (1996). Creating conditions for participation: Conflicts and resources in systems development. *Human-Computer Interaction,* 11: 215-236.

Bodker, S. (1996). Applying activity theory to video analysis: How to make sense of video data in HCI. In Nardi, B. (1996) Ed. *Activity Theory and Human-Computer Interaction.* (pp.147-174). The MIT Press: Cambridge, Massachusetts.

Bronner, E. (1998,, October). Computers help math learning, study finds. *The New York Times*.

Brush, T., D. Knapczyk, L. Hubbard, 1994. Incorporating technology in the field-based preparation of teachers. *Journal of Technology and Teacher Education* 2(1) : 91-102.

Card S.K., Moran T.P. and Newell A. (1983). *The Psychology of Human Computer Interaction.* Hillsdale, NJ: Lawrence Erlbaum Associates.

Carey, T., and Rusli, M. (1995). Usage representations for re-use of design insights: A case study of access to on-line books. In J. Carroll, ed., *Scenario-based Design for Human Computer Interaction.* New York: Wiley.

Carrol, J.M. (1996). Encountering others: Reciprocal openings in participatory design and user-centered design. *Human-Computer Interaction* 11: 285-290.

Cole, M., and Engestrom, Y. (1991). A cultural-historical approach to distributed cognition. In G. Salomon, Ed., *Distributed Cognition* (pp. 1-47). Cambridge: Cambridge University Press.

Corcoran, T. 1995. *Transforming professional development for teachers: A Guide for state policymakers.* Washington, DC: National Governors' Association.

de Mul, Sjaak, and van Oostendorp, H. (1996). Learning user interfaces by exploration. *Acta Psychologica* 91(3):325-344.

Dewey, J. (1916). *Democracy and Education: An Introduction to the Philosophy of Education.* New York: Macmillan.

Dillon, A., and Morris, M.G. (1996). User acceptance of information technology: Theories and models. *Annual Review of Information Science and Technology* 31:3-32.

Dix, A. Finlay, J., Abowd, G., and Beale, R. (1993). *Human Computer Interaction.* Prentice Hall International (UK).

Drucker, P.F. (1992). *Managing for the future: The 1900s and beyond.* New York: Dutton Truman Talley Books.

Dyck, J.L., Smither, J.A. (1995). Older adults' acquisition of word processing: The contribution of cognitive abilities and computer anxiety. *Computers in Human Behavior* 12(1):107-199.

Engestrõm, Y. (1991). Activity theory and individual and social transformation. *Multi-disciplinary Newsletter for Activity Theory* (7/8): 6-17

Gaines, B.R.; Lee Li-Jen Chen, and Mildren L.G. Shaw. (1997). Modeling the human factors of scholarly communities supported through the Internet and World Wide Web. *Journal of the American Society for Information Science.* 48(11):987-1003.

Goals 2000: Reforming Education to Improve Student Achievement. April 30, 1998. [Online]. Available: http://www.ed.gov/pubs/G2Kreforming/g2exec.html

Hoyt, M. 1997. "Time on our side": Flexible school scheduling on the secondary level with implications for professional development. National Teacher Policy Institute Impact II Project [Online]. Available: http://www.teachnet.org/ntpi.

Jay Jacobs, H. 1998. Professional Staff Development and Technology Training Session. BOCES, Salisbury, New York. November 13, 1998.

Kaptelinin, V. (1996). Activity theory: Implications for human-computer interaction. In Nardi, B. 1996 ed. *Activity Theory and Human-Computer Interaction.* (pp.45-68). The MIT Press: Cambridge, Massachusetts.

Kautz, K. (1996). User participation and participatory design: Topics in computing education. *Human-Computer Interaction* 11: 267-284.

Kent, J.M. (1997). Teachers: A significant and vital long-term investment. . National Teacher Policy Institute Impact II Project [Online]. Available: http://www.teachnet.org/ntpi.

Kontos, G. and A.P. Mizell, 1997. Global village classroom: The changing roles of teachers and students through technology. *TechTrends* 43(5) : 17-22.

Kuutti, K. (1996). Activity theory as a potential framework for human-computer interaction research. In Nardi, B. (Ed.). (1996). *Activity Theory and Human-Computer Interaction.* (pp.17-44). The MIT Press: Cambridge, Massachusetts.

Kyng, M. (1991). Designing for cooperation—cooperating in design. *Communications of the* ACM 34(12):64-73.

Lieberman, A. and M. Grolnick. (in publication) *Networks and Reform in American Education.* Teachers College Press.

Martocchio, J.J. (1994). Effects of conceptions of ability on anxiety, self-efficacy, and learning in training. *Journal of Applied Psychology* 79(6):819-825.

Maurer, M.M., and Simonson, M.R. (1993-94). The reduction of computer anxiety: Its relation to relaxation training, previous computer coursework, achievement, and need for cognition. *Journal of Research on Computing in Education* 26(2): 205-219.

McGill, L. (1997). Professional development in technology: Where are the teachers being trained? National Teacher Policy Institute Impact II Project [Online]. Available: http://www.teachnet.org/ntpi

Muller, M., and Kuhn, S. (1993). Introduction to special issue on participatory design. *Communications of the ACM* 36: 24-28.

Nardi, B. (Ed.). (1996). *Activity Theory and Human-Computer Interaction.* The MIT Press: Cambridge, Massachusetts.

Perelman, L.J. (1994-95). A technological revolution in higher education. *Journal of Educational Technology Systems* 23(2):155-168.

Proctor, R.W., and Van Zandt, T. (1994). *Human factors in simple and complex systems.* Allyn and Bacon: Massachusetts.

Rafter, J. (1997). The development of power: A tale of the need for teacher development. National Teacher Policy Institute Impact II Project [Online]. Available: http://www.teachnet.org/ntpi.

Ramos de Oliveira, Z. and Rossetti-Ferreira, M. (1996). Understanding the co-constructive nature of human development: Role coordination in early peer interaction. In Valsiner, J. and Voss, H. (1996). *The Structure of Learning Processes. (*pp. 177-204). Ablex Publishing Corporation, New Jersey.

Ringstaff, C., Kelley, L., and Dwyer, D. (1993). Breaking the mold of instruction with technology: Formative case studies of the unit of study process. *ACOT Report* (August).

Rogoff, B. (1995). Sociocultural activity on three planes. In Wertsch, J.V.; Del Rio, P., and Alvarez, Amelia, (Eds.). (1995). *Sociocultural Studies of Mind.*. (pp.139-164). Cambridge University Press, New York, NY.

Rosenberg, R. (1992). *The Social Impact of Computers.* Academic Press, Inc., San Diego, CA.

Shneiderman, B. (Ed.). (1993). *Sparks of Innovation In Human-Computer Interaction.* Ablex Publishing Corporation, New Jersey.

Soloway, E., Guzdial, M., and Hay, K.E. (1994). Learning-centered design: The challenge for HCI in the 21st century. *Interactions* 1(2):36-48.

Swanson, B. (1988). Information system implementation: Bridging the gap between design and utilization. Burr Ridge, IL: Richard D Irwin Inc.

Taylor, S., and Todd, P.A. (1996). Assessing IT usage: The role of prior evidence. In Dillon, A., and Morris, M.G. (1996). User acceptance of information technology: Theories and models. *Annual Review of Information Science and Technology* 31:3-32.

Teaching Quality: What we graded. (1997, February). *Teacher Magazine.*

Trotter, A. (1998). A question of effectiveness. *Education Week on the Web* [Online]. Available: http://www.edweek.org/sreport/tc98/intro.htm.

CEO Forum, The 1997 STaR Report [Online]. Available: http://www.ceoforum.org/report97/ nationalstar.html

Thomas, P.J. (Ed.). (1995). *The Social and Interactional Dimensions of Human-Computer Interfaces.* Cambridge University Press: New York.

U.S., Executive Office of the President. (1997). *Report to the President on the Use of Technology to Strengthen K-12 Education in the United States.* President's Committee of Advisors on Science and Technology, Panel on Educational Technology. March, 1997.

Valsiner, J. and Voss, H. (1996). *The Structure of Learning Processes.* Ablex Publishing Corporation, New Jersey.

Waern, Y. (1993). Varieties of learning to use computer tools. Special Issue: *Swedish Research on Learning and Instruction with Computers.* 9(2-3):323-339.

Webster J., and Martocchio, J.J. (1992). Microcomputer playfulness: Development of a measure with workplace implications. *MIS Quarterly.* 16, June 201-226.

Wertsch, J.V. (1985). *Vygotsky and the Social Formation of Mind.* Harvard University Press: Cambridge, Massachusetts.

Whitley, B.E. (1996). The relationship of psychological type to computer aptitude, attitudes and behavior. *Computers in Human Behavior* 12(3):389-406.

Wright, K. (1993). *The Challenge of Technology: Action Strategies for the School Library Media Specialist.* American Library Association/Chicago and London.

Yocam, K. Wilmore, F., and Dwyer, D. (1994). Situated teacher development: ACOT's two-year pilot project. *Apple Classrooms of Tomorrow Report.*

Zinchenko, V.P. (1996). Developing activity theory: The zone of proximal development and beyond. In Nardi, B. (Ed.). (1996) *Activity Theory and Human-Computer Interaction.* (pp.283-324). The MIT Press: Cambridge, Massachusetts.

Zinchenko, V.P. (1986). Ergonomics and informatics. *Problems in Philosophy* 7: 53-64.

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