The Use of Information Technology to Enhance Management School Education: A Theoretical View

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Abstract

To use information technology to improve learning processes, the pedagogical assumptions underlying the design of information technology for educational purposes must be understood. This paper reviews different models of learning, surfaces assumptions of electronic teaching technology, and relates those assumptions to the differing models of learning. Our analysis suggests that initial attempts to bring information technology to management education follow a classic story of automating rather than transforming. IT is primarily used to automate the information delivery function in classrooms. In the absence of fundamental changes to the teaching and learning process, such classrooms may do little but speed up ineffective processes and methods of teaching. Our mapping of technologies to learning models identifies sets of technologies in which management schools should invest in order to informate up and down and ultimately transform the educational environment and processes. For researchers interested in the use of information technology to improve learning processes, the paper provides a theoretical foundation for future work.

Keywords Educational technology, classroom technology, electronic classrooms, learning, instruction

ISRL Categories: AA06, HB08

Introduction

Although universities create and acquire knowledge, they are seldom successful in applying that knowledge to their own activities (Garvin, 1993). In fact, academic institutions typically lag businesses by roughly a decade in the adoption of new technologies (U.S. Congress, 1988). This is certainly true in terms of the application of information technology (IT) into the learning process: the blackboard and chalk remain the primary teaching technologies in many business schools even while the merits of information technology to improve communication, efficiency, and decision making in organizations are recognized and inculcated by IS researchers. However, as business schools experience increased competitive pressures, information technology is one area that schools might use to differentiate or compete with or, more importantly, to use as a catalyst for transforming educational processes. IT is not heralded as a miraculous yet unpredictable means of mitigating educational attrition, but as an efficacious means of enabling intentional changes in teaching and learning processes.

Some business schools have already begun building classroom facilities that incorporate information technologies in hopes of improving the learning and teaching processes. For example, the University of Maryland houses an electronic classroom that enables groups of students to work together while communicating electronically and anonymously (Alavi, 1994). At Harvard Business School, a pilot program was conducted where each student's dormitory room was equipped with a personal computer networked to share laser printers and scanners in common living spaces. Interactive computer applications and simulation exercises were used to supplement the traditional case study preparation. Students had access to digitized videos on factories, production processes, marketing campaigns, and interviews with protagonists from the case study firms, allowing the students "to 'visit' the factory they were studying and 'meet' the key players in the case" before going to class. The students also had access to Headline News, a consolidation of major news from leading magazines and newspapers across the world, and a plethora of economic and financial databases from commercial providers to augment the industry analysis (*The Harbus News,* 1994).

Although promising, these developments remain isolated experiments even within their own institutions. While such developments represent attempts to provide technology tools to improve the teaching and/or learning processes, they are often undertaken without a thorough assessment of the learning gains desired or even possible. For instance, high expectations without clear objectives and realistic goals may lead to the development of state-of-the-art facilities, at once impressive yet intimidating, replete with potential yet lacking clear guidelines on how to use the technology to achieve learning improvements. Early research in the area of learning improvements that may be facilitated with information technology is thus needed. The objective of this paper is to delineate technologies currently available to support traditional and non-traditional methods of learning in order to help guide universities in their learning technology investment decisions, to help professors effectively apply the new classroom technologies, and to manage the expectations of university administrators and professors concerning the benefits of the technologies.

The premise of this paper is that the effectiveness of information technology in contributing to learning will be a function of how well the technology supports a particular model of learning and the appropriateness of the model to a particular learning situation. The paper begins with a discussion of the most commonly advocated models of learning. How the assumptions of IT are intertwined with the assumptions of the learning models is then analyzed. The mapping of pedagogical assumptions helps to identify the types of technologies that automate the traditional learning model and those that begin to enable transformation into a new model. Borrowing from the technology and organizational change literature, three transformational visions are described: informate up, informate down, and transform to a virtual learning space. The paper concludes with a discussion of technologies that management schools might consider investing in if they desire radical changes in their educational processes.

Theories of Learning: Assumptions

The use of IT in an educational setting will reflect either purposely or inadvertently some model of learning. The following review of learning models is not exhaustive; rather it seeks to highlight major differences among the more widely accepted models of learning in terms of their assumptions, goals, and instructional implications.

Learning models are often classified as being behavioral or cognitive. Objectivism, also referred to as the traditional model of learning, is the behavioral model of learning and represents a traditional view of learning. The primary competing cognitive model is constructivism. The constructivist model has a number of derivations including collaborativism and cognitive information processing. The socioculturalism model shares some assumptions and goals with constructivism, but challenges some others.[1]

The objectivist model of learning

The objectivist model of learning is based on Skinner's stimulus-response theory: learning is a change in the behavioral disposition of an organism (Jonassen, 1993) that can be shaped by selective reinforcement. The tenet of the model is that there is an objective reality and that the goal of learning is to understand this reality and

1 Social learning theory is yet another model of learning and lies somewhere in the middle of an objectivist-constructivist continuum. The interested reader is referred to Grusec (1992).

modify behavior accordingly (Jonassen, 1993). The goal of teaching is to facilitate the transfer of knowledge from the expert to the learner. Errors in understanding are the result of imperfect or incomplete knowledge transfer. The model makes several pedagogical assumptions regarding learning and instruction. In terms of learning, the first assumption is that there exists a reality that is agreed upon by individuals. Second, this reality can be represented and transferred to a learner. Third, the purpose of the mind is to act as a mirror of reality rather than as an interpreter of reality (Jonassen, 1993). Fourth, all learners use essentially the same processes for representing and understanding the world.

In terms of instruction, the objectivist model assumes that the goal of teaching is to efficiently transmit knowledge from the expert to the learner. Instructors structure reality into abstract or generalized representations that can be transferred and then recalled by students (Yarusso, 1992). For example, words in a language are symbolic representations of the external world enabling individuals to communicate using symbols rather than pointing to actual objects. Individuals must share the same understanding of the words in order to communicate efficiently. The objectivist model also assumes that the instructor is the source of objective knowledge that is related, rather then created, during class. The instructor should be in control of the material and pace of learning. Via questions, the instructor assesses whether transfer occurred. Another assumption is that students learn best in isolated and intensive confrontations with a subject matter.

The lecture method of teaching embeds the pedagogical assumptions of the objectivist model of learning. The lecture method is the most frequently used instructional method in higher education (McKeachie, 1990). To an objectivist, the presentation of information is critical. Any mechanism that enhances the communication of the knowledge should enhance the transfer, or student learning. The model also implies that the pace of instruction should be designed modularly with students' progressing on one topic area before proceeding to the next one.

The objectivist model may be the most appropriate model in some contexts—for example, in factual or procedural-based learning. However, models challenging objectivism have emerged. The most widely accepted alternate model is constructivism and its derivations—collaborativism and cognitive information processing.

The constructivist model of learning

Constructivism denies the existence of an external reality independent of each individual's mind. Rather than transmitted, knowledge is created, or constructed, by each learner. The mind is not a tool for reproducing the external reality, but rather the mind produces its own, unique conception of events (Jonassen, 1993). Each reality is somewhat different, based on learners' experiences and biases. More moderate constructivists do not preclude the possibility of the existence of an objective world, but assume that each individual constructs his or her own reality of the objective world (Yarusso, 1992). Eventually, having analyzed different interpretations of information, the learner is able to detach himself from a subjective world of personal experience to the formation of abstract concepts to represent reality (O'Loughlin, 1992). Learning, then, is the formation of abstract concepts to represent reality; learning is that which "decentrizes" the individual from the material. Learning is reflected in "intellectual growth that leads to scientific reasoning, abstract thought, and formal operations" (O'Loughlin, 1992).

The constructivist model calls for learner-centered instruction: individuals are assumed to learn better when they are forced to discover things themselves rather than when they are told, or instructed. Students must control the pace of instruction. Based upon the work of Piaget, the learner must have experience with hypothesizing and predicting, manipulating objects, posing questions, researching answers, imagining, investigating, and inventing, in order for knowledge construction to occur (O'Loughlin, 1992).[2]

[2] It should be noted that Piaget's theory, which forms the foundation of constructivism, was based on his studies of the psychological development of children. Although children need physical actions to grasp new information, adults need vivid examples and illustrations (O'Loughlin, 1992). Thus, while the concepts underlying constructivism may seem appealing to those who disagree with the underlying assumptions of traditionalism, they may be less applicable to adult learning situations.

The teacher serves as the creative mediator of the process. Classtime might become a project-oriented session where the instructor provides tools for helping learners construct their own views of reality. Learning focuses on discovering conceptual relationships, exploring multiple representations or perspectives on an issue, and/or immersing the learner in the real-world context in which the learning is relevant (Jonassen, 1993). Lastly, constructivism advocates non-criterion forms of performance assessments such as student learning journals (Hawkins, 1993).

However, in practice, constructivism is often reduced to students' searching for the preordained knowledge that could be more efficiently transmitted via the instructor. This tends to happen particularly with fact-based or procedural learning. Critics of constructivism argue that there is little benefit in having learners construct such preordained knowledge; it is only when learners are allowed to construct new meaning, such as in higher-order learning, that the goals of constructivism are truly achieved. However, it can also be argued that greater understanding of factual and procedural material results when learners are forced to discover the knowledge themselves than when they are merely told.

The cooperative model of learning

An offspring of the constructivist model is the cooperative, or collaborative, learning model. Whereas in constructivism learning is assumed to occur as an individual interacts with objects, in collaborativism, learning emerges through interaction of individuals with other individuals (Slavin, 1990). Learning occurs as individuals exercise, verify, solidify, and improve their mental models through discussion and information sharing. The contribution of different understandings leads to a new, shared knowledge (Whipple, 1987). Whereas instructor-led communication is inherently linear, collaborative groups allow more branching and concentricity (Flynn, 1992). Although the major goal of cooperative learning is the construction of shared understanding through interaction with other individuals, an implicit goal is improving communication and listening skills and eliciting participation.

Consequently, in addition to sharing the pedagogical assumptions of constructivism, collaboratists also assume that knowledge is created as it is shared, and the more it is shared, the more is learned. Another pedagogical assumption is that learners have prior knowledge they can contribute to the discussion. A third assumption is that participation is critical to learning. A fourth assumption is that learners will participate if given optimal conditions such as small groups to work with.

One implication of the cooperative model for instructional methods is that the instructor's role is to facilitate maximal information and knowledge sharing among learners rather than controlling the content and delivery of learning. Another implication is that the instructor's role is to provide feedback during class although feedback from the learner's peers is similarly critical. For example, students are found to plan more extensively and write more carefully when they are communicating with an audience of peers than when they are being evaluated solely by the instructor (Bagley and Hunter, 1992). However, groups without instructor feedback are unable to attain the same level of understanding or mastery as groups with both peer and instructor feedback (Stephenson, 1992). A third implication for instruction is the need for cooperative assessment strategies. The traditional competitive assessment strategies may disable learning: a learner may be motivated to withhold knowledge that would otherwise be shared with peers.

Studies have demonstrated that cooperative learning is superior to individualistic instruction in a wide array of content areas in terms of increases in individual achievement, positive changes in social attitudes, and general enhancement of motivation to learn (Flynn, 1992). Learners tend to generate higher-level reasoning strategies, a greater diversity of ideas and procedures, more critical thinking, and more creative responses when they are actively learning in cooperative groups than when they are learning individually or competitively (Schlechter, 1990). Even when the instructional environment of group projects was not geared toward cooperative learning, cooperative learning occurred and contributed to longer-term retention (Schlechter, 1990).

The cognitive information processing model of learning

The cognitive information processing model is another extension of the constructivist model and focuses on cognitive processes used in learning. Learning involves processing instructional input to develop, test, and refine mental models in long-term memory until they are effective and reliable enough in problem-solving situations (Schuell, 1986). The frequency and intensity with which a student cognitively processes instructional input controls the pace of learning. Instructional inputs that are unnoticed, or unprocessed, by learners cannot have any impact on mental models (Bovy, 1981; Brunning, 1983).

A major assumption of the model is that learners differ in terms of their preferred learning style. Instructional methods that match an individual's learning style will be the most effective (Bovy, 1981). This suggests the need for individualized instruction. The cognitive processing model also assumes that the individual's prior knowledge is represented by a mental model in memory and that the mental model, or schemata, is an important determinant of how effectively the learner will process new information. The implication is that the instructional support required is inversely related to the depth of existing knowledge as well as to the effectiveness of the learner's information processing style (Bovy, 1981). A third assumption is that given a learner's limited information processing capacity, attention is selective (Bovy, 1981). Selective attention is an interrelated function of the display, the cognitive structure of the learner, and the prior experience of the learner. Preinstructional methods such as topic outlines and learning goals might improve learning because they direct attention (Brunning, 1983).

The sociocultural model of learning

Whereas collaborativism and the cognitive information processing model are extensions of constructivism, the sociocultural model is both an extension of and a reaction against some assumptions of constructivism. In particular, socioculturalists disagree with Piaget's view that the goal of learning is the formation of abstract concepts to represent reality. Rather, knowledge cannot be divorced from the historical and cultural background of the learner (O'Loughlin, 1992). The more meaningful, the more deeply or elaboratively processed, the more situated in context, and the more rooted in cultural background, metacognition, and personal knowledge an event is, the more readily it is learned (Iran-Nejad, et al., 1990). While socioculturalists embrace the concept that there is no one external reality, they argue that constructivism and collaborativism force the minority culture into adopting the understanding derived by the majority. Even a collaborative work group does not foster participation for minorities: "shared understanding" is biased by cultural and social factors.

The major assumption of socioculturalism is that middle-class Anglo male America has prevented a genuinely emancipatory environment "in which students begin to construct meaning on their own terms and in their own interests" (O'Loughlin, 1992). The objectivist model of learning is seen as one that negates the subjective voices that students develop from their own culture and becomes an instrument of power perpetuating the social class inherent in society by forcing all students to speak in the dialogue acceptable to the instructor and peers (O'Loughlin, 1992). The major implication of socioculturalism is that students should participate on their own terms. Instruction should not deliver a single interpretation of reality nor a culturally biased interpretation of reality. In comparison to the constructivist and cognitive models, the sociocultural model is in a nascent stage, and practical applications of the model to instruction are still being formulated.

Summary

The learning theories are summarized in Table 1.

Figure 1 graphically illustrates the similarities and differences among learning models.[3]

The objective model assumes that an instructor should be in control of the learning environment

[3] The figure maps current learning theories only. Because it is a multidimensional figure presented in two dimensions, certain hypothetical models (such as a model where the instructor is in control, but knowledge is created by students) cannot be represented on this figure.

Table 1. Summary of Learning Models

Model	Basic Premise	Goals	Major Assumptions	Implications for Instruction
Objectivism	Learning is the uncritical absorption of objective knowledge.	Transfer of knowledge from instructor to student. Recall of knowledge.	Instructor houses all necessary knowledge. Students learn best in isolated and intensive subject matter.	Instructor is in control of material and pace. Instructor provides stimulus.
Constructivism	Learning is a process of constructing knowledge by an individual.	Formation of abstract concepts to represent reality. Assigning meaning to events and information.	Individuals learn better when they discover things themselves and when they control the pace of learning.	Learner-centered active learning. Instructor for support rather than direction.
Collaborativism	Learning emerges through shared understandings of more than one learner.	Promote group skills—communication, listening, participation. Promote socialization.	Involvement is critical to learning. Learners have some prior knowledge.	Communication-oriented. Instructor as questioner and discussion leader.
Cognitive Information Processing	Learning is the processing and transfer of new knowledge into long-term memory.	Improve cognitive processing abilities of learners. Improve recall and retention.	Limited selective attention. Prior knowledge affects level of instructional support needed.	Aspects of stimulus can affect attention. Instructors need feedback on student learning.
Socioculturism	Learning is subjective and individualistic.	Empowerment. Emancipatory learning. Action-oriented, socially conscious learners with a view to change rather than accept or understand society.	Anglos have distorted knowledge and framed information in their own terms. Learning occurs best in environments where personally well known.	Instruction is always culturally value laden. Instruction is embedded in a person's everyday cultural/social context.

(i.e., pace and material), that learning is dissemination of knowledge, that dissemination best occurs via abstract representations of the reality, and that learning occurs best in isolated settings (i.e., the context of the learning environment need not be "real"). Collaborativism assumes that the control of the learning environment should rest with the peer groups, that learning is the sharing of knowledge representative of disparate points of view, that knowledge is personally experienced but can be shared through collaborating, and that the realism of context is high in the sense that individual experiences prior to learning are real but low in the sense that the experiences are shared vicariously through discourse. Constructivism assumes that the learner needs to be in control of the learning environment, that learning is the creation of

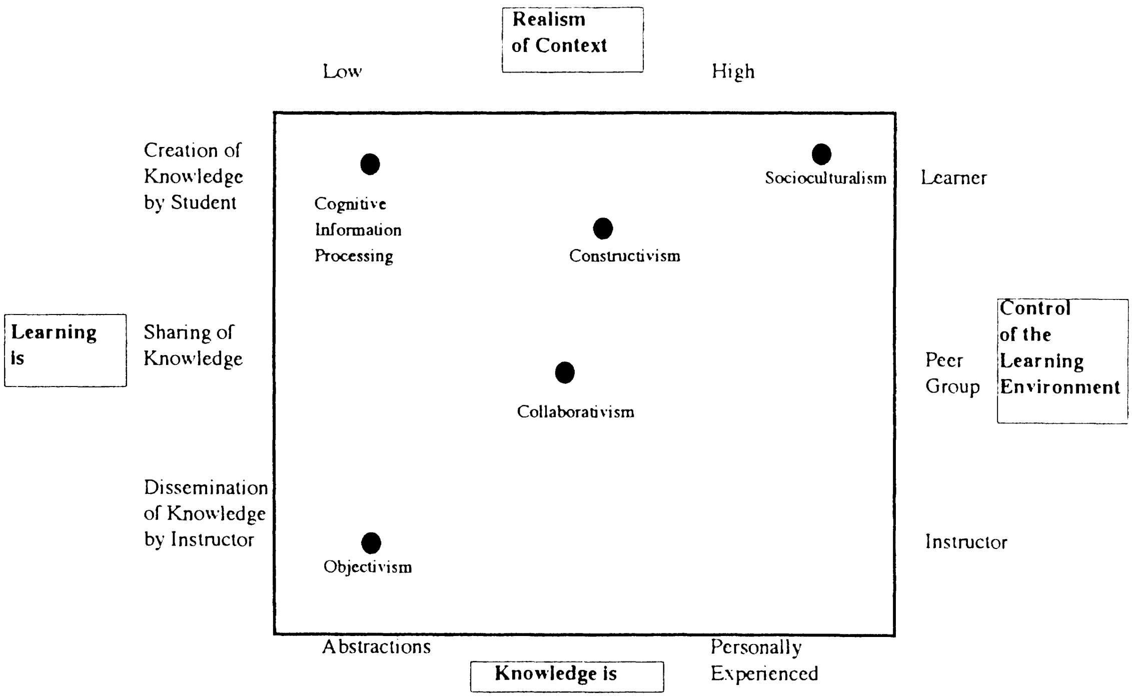

Figure 1. The Dimensions of the Learning Theories

knowledge, and that the realism of the context for learning needs to be high. Cognitive information processing differs from constructivism in emphasizing that learning is the formation of abstract concepts to represent reality and that the context need not necessarily be high in order for such abstraction to occur. Socioculturism assumes that the learner must be in control of learning, that learning is interpretation of knowledge by the learner, that specificity and immersion in experiential activities promote learning, and that learning best occurs in the context in which it will be used.

No particular model is the best approach; indeed, different learning approaches will be appropriate depending on the circumstances—course content, student experience, maturity, intelligence, and instructor goals, skills, and preferences, among others. However, the instructor must be cognizant of the choice of a learning model. Moreover, the instructor should be aware of the different learning models and the different outcomes anticipated by the models. The chosen model must take into account the many dimensions of a given course. Information technology can then be a facilitator of the effective application of the learning models. The next section establishes links between the assumptions of the learning models and the assumptions of the information technologies in use in educational settings.

Information Technologies: Surfacing Educational Assumptions

The technology discussion is organized according to what is labeled visions of electronic classrooms—each vision representing a different potential impact of IT on learning. These visions were derived from the organizational research on IT visions (Schein, 1992; Zuboff, 1988): automating, informating up, informating down, and transforming. Some technologies can facilitate more than one vision. Both positive and negative potential outcomes of technologies are discussed. The technologies are also discussed in terms of the underlying assumptions regarding the way in which they facilitate learning and relate this to the learning models of the previous section.

The vision to automate: automated classrooms

The vision to automate is the perception that IT is a means of replacing expensive, unreliable human labor with information technology. In organizations characterized by the vision to automate, the role of IT is to provide operational savings and improve quality by performing structured, routine, operational tasks reliably and efficiently. Because teaching and learning are at best semi-structured activities, neither is conducive to automation. Yet certain aspects of instruction, particularly the delivery of information characteristics of the objectivist model of learning, are prone to automation.

Information technologies whose purpose is to provide tools for manipulating and presenting instructional material in a classroom are referred to in this paper as classroom automation technology. These include: (1) instructor consoles equipped with presentation software and display controls, (2) instructor consoles and stand-alone student computers, (3) computer-assisted instruction (drill and practice programs), and (4) distance learning.

Instructor Console

The instructor console refers to a computer equipped with end-user software and used by an instructor in a classroom. The technology may be a permanent fixture of the classroom or may be brought in on a cart. The primary goals are the facilitation of presentations—freeing the instructor from the tedium of writing on a chalkboard and making the presentation more vivid and memorable for students.

A study at Northwestern University (Janda, 1989) examines the impact of the instructor console in large (over 200 students) government classes on student attitudes toward showing short video clips on events in American politics, projecting topic outlines of lecture notes on a screen during class, and providing students the ability to print the instructor's lecture outlines. The most well-liked method was video clips, but these were also judged the least helpful to learning. The ability to print the instructor's lecture notes were the second most well-liked aspect of the technology. The less-liked topic outlines projected from a computer were deemed most helpful to learning.

At Baylor University (Leidner, 1994), the instructor consoles in smaller classes contributed to both perceived and actual structure. Students perceived the courses taught in the automated classrooms to be more organized than courses taught in traditional classrooms. The advanced preparation of a presentation or a software demonstration enforced a structure to the class that might not otherwise have existed. Students reported high satisfaction in the automated classroom, but did not report greater learning than in a traditional classroom for a variety of different courses. The structure might have contributed to the students' satisfaction with the learning process although the technology might have eliminated the informal discussion that would have promoted knowledge creation.

Similarly, a study conducted by the Air Force Academy found no significant difference in performance, although it found significant improvements in student attitudes about the instructor and the course when students were taught in classrooms equipped with instructor workstations and videodisks versus when taught in a traditional classroom (Gist, et al., 1988). A newness effect—a fascination with the technology —might also explain the results. This is similar to results found with transparencies in the early 1970s (Neter and Chervany, 1973). As a consequence, although the automated classrooms may hold little advantage over traditional classrooms in terms of actual student learning, they may influence student attitudes toward the quality of the instructor and toward the organization of the course.

The use of an instructor console is based on several pedagogical assumptions. One is that teaching is about presenting material; technology can improve both the process and product of presentation. The improvement occurs through the use of color and graphics. Prior research has found that graphics can create interest and appeal to the users, can increase the comprehension of the information, and can help the information be more easily remembered (DeSanctis, 1984). Color has been shown to increase attention but not necessarily comprehension of information (DeSanctis, 1984). Similarly, borrowing from graphics research in the organizational context, the mode of presentation of classroom information may affect student comprehension, student recall, and student performance as well as student attitude (Benbasat and Dexter, 1985; Watson and Driver, 1983).

The instructor console technology most closely maps to the objectivist models of learning and instruction. The instructor maintains control over the content and pace of instruction, the focus is on knowledge dissemination rather than knowledge creation, and the instructor remains the primary source of knowledge. The technology maps secondarily to the cognitive information processing model. The more structured and vivid the transmission, the easier it is for a learner to absorb the information.[4] The cognitive information processing model would attribute this result to outlines that are learning strategies that help students more readily process and organize information in their memory. However, outlines could also be manually provided or written on a chalkboard. The role of the technology is to increase the ease of displaying an outline, rather than causing the outline to be effective.

Instructor Console and Stand-Alone Student Computers

A slightly more advanced automated classroom would include stand-alone[5] computers on students' desks to provide them with access to the same software packages as the instructor. This helps students learn by enabling them to emulate an instructor's steps on a particular software package. Another approach is for the instructor to give students a problem to analyze using the appropriate software and assist the students when they encounter problems (Leidner and Jarvenpaa, 1993). The former use of the technology supports the objectivist model of learning; the latter, constructivism.

At the college level, a positive relationship was found between student control of learning with motivation and performance (Fisher and Grant, 1983). Engaging in in-class analysis of various alternatives to a problem allows students to construct knowledge via computers. One study (Leidner and Jarvenpaa, 1993), however, found a low percentage of use for such constructivist learning and a higher percentage of use for software demonstrations where students were merely emulating the instructor. The sessions in which students were allowed to analyze data in teams of two proved to be the most constructive method in the classroom; during these sessions, exploratory discussions at a high conceptual level were common. A similar finding was reported in Carrier and Sales (1987).

The use of instructor console and stand-alone computers assumes that altering the delivery of information by presentation technologies or by allowing students to emulate an instructor will improve the learning process. These assumptions align with the objectivist model, whereas the assumption that learning will be more effective if the student is required to actively perform procedures during class supports a constructivist model of learning.

Computer-Assisted Instruction (CAI)/Computer-Based Training (CBT)

Computer-assisted instruction (CAI) is an interactive software program that provides information in sequential or non-linear modes to increase a student's knowledge and understanding of a subject matter (Lay, 1989-90).[6] Among the most lauded goals of CAI is to give control of the learning process to the learner.

[4] Yet media research consistently fails to find significant learning differences across varying delivery mechanisms (Clark 1991). Clark argues that the reason for this is that many different media attributes accomplish the same learning goal and that any teaching method could be designed into a variety of media presentations.

[5] We say stand-alone meaning that the computers are not equipped with communication facilities between the computers nor with access to external sources of information.

[6] CAI has been the term used for interactive computer-based systems used in educational systems, while similar systems used in organizational training have been commonly referred to as Computer-Based Training. More recently, Interactive Learning System (ILS) has become the term encompassing both interactive computer-assisted instruction and interactive computer-based training. This varies from the earlier CAI and CBT because it gives more control over the sequence of information presented to the learner.

However, though based on constructivist rhetoric, most CAI and computer-based training (CBT) have provided drill and practice tutorials that presented information in a highly structured, linear fashion. Thus, while purporting to individualize instruction and allow individuals to process information according to their preferred learning style, CAI and CBT primarily served as reliable and consistent delivery sources of course material. Advances in technology enabled the development of more interactive CAI that was less structured and gave more control over the sequence of information presentation to the learner. These systems are sometimes referred to as interactive learning systems (ILS); yet these too are based on ensuring that learners are exposed to predetermined knowledge even though much more of the control for the sequencing of the information is given to the learner.

While studies of CAI have found increased learning (Clark, 1986), these results could also be attributed to aspects incorporated into the system such as feedback, drill and practice, and self-paced progression that are independent of the technology (i.e., they could be incorporated into other non-computer media). For example, one study comparing manual drill-and-practice to computer-based drill-and-practice found that it was not the media (the computer) that affected performance, but rather the drill-and-practice method itself that was just as effectively carried out manually as with the computer (Clark, 1991).

While CAI, CBT, and ILS vary, pedagogical assumptions regarding the way these technologies improve learning typically include: learners learn more effectively and efficiently when they are in control of the pace, feedback is a critical part of effective learning, and active involvement leads to more effective learning than passive involvement. Thus, CAI is based on the stimulus-response-feedback views of learning that are associated with the objectivist model of learning. Though CAI may enable more efficient interaction, interacting with the computer cannot be taken as a substitute for human interaction. CAI is therefore more rooted in the objective rather than collaborative or sociocultural models of learning. The structure built into the system tends to prevent constructivist learning because it enables learners to construct new knowledge; the student is guided so that he/she reaches the predefined knowledge built into the system. However, CAI may ease the cognitive load of sorting through material and may enable students to process information at their own pace. Thus, CAI, CBT, and ILS can be viewed as enhancing the cognitive information processing of students by making the learning process more individually tailored.

Distance Learning

Distance learning is the transmission of a course from one location to another. The goal is to provide education to locations that might not have the resources to offer courses or enable employees to take a course without leaving the organization's premises. There are many examples of distance learning. One example is TI-IN Network, Inc., a Texas-based private company that provides over 30 high school courses and staff development opportunities via satellite to more than 250 subscribing school districts and other educational agencies in Texas as well as 20 other states. Experienced and qualified instructors holding at least a master's degree in the subject broadcast their courses from studios in San Antonio, and the schools receive the signals via satellite. In Minnesota, rural school districts use a system of fiber optics, multiple video monitors, and cameras to link together classrooms up to 78 miles apart so that the teacher can see the students in up to three other locations simultaneously. The originating classroom has one camera on the teacher, one on the students, and one on the teachers' desk (U.S. Congress, 1988). MBA programs in Arizona, California, Monterrey (Mexico), and Western Ontario (Canada), among others, provide video conferencing alternatives to attending regular classes.

Distance learning supports the objectivist model of knowledge transmission, only now the knowledge is transmitted to students at different locations. From a learning theory perspective, it can be argued that distance learning supports the sociocultural model of learning by allowing students to remain embedded in their cultural environments rather than forcing them to adopt a new culture. However, the learners are still forced to adopt the language and culture of the instructor since the instructor remains the nucleus of the class. Distance learning facilities can be equipped with facilities to enable students to communicate with each other and hence to promote collaborative learning across distances. Such environments are examined in the section "Informating Down."

The vision to informate up: providing an instructor access to information

The vision to informate up is defined as the goal of using IT as a management control tool to keep managers informed of detailed aspects of their organization's performance (Schein, 1992). In an educational context, such a vision would entail giving the instructor feedback concerning student understanding of class material in a timely fashion so that the instructor could clarify misunderstandings and misinterpretations. Aspects of typical college classrooms that prevent informating up may include student proclivity to be reticent during class, lack of effective cues to let the instructor know when information is being misconstrued, and the unavailability of the instructor at the time when the student has a question. One technological response is key response pads; another is e-mail between instructors and their students.

Key Response Pads

Key response pads enable a large class of students to participate by responding to questions with a yes/no response or rating agreement to an issue on a scale from 0 to 9. The goal of key response pad technology is to make the instructor more aware of whether students are following the content being discussed so that he/she can modify the flow and intensity of information transfer if necessary. For instance, a study of IBM's electronic training facility shows that while the lecture mode of teaching was much more time-efficient in terms of the material covered, the attentiveness of the students was greater in the "facilitation" mode in which frequent student responses were elicited via key response technology (Horowitz, 1988).

Key response pad technology assumes that the instructor is the nucleus of the classroom and that information is being delivered by the instructor. This pedagogical assumption is closely linked to the objectivist model of learning. By enabling an instructor to ask questions based on material being covered and to assess the degree of understanding by the responses, key response pad technology facilitates more effective knowledge transmission and comprehension. The technology is secondarily related to cognitive information processing. The technology promotes feedback on students' learning.

An extension of key response pad technology would be to provide a full keyboard so that students could ask and answer questions using full sentences. Such a facility is provided at the University of Arizona's electronic classroom "Exemplar" (Briggs, et al., 1992; Briggs and Ramesh, 1992). The students' inputs are anonymously displayed on a common screen. The professor can then discuss each input. In this case, the technology is more closely linked to the cognitive information processing model of learning. One weakness with the question and answer facility of Exemplar is its infeasibility for large classes. In a large class of 30 or more students, it would be very time-consuming for the instructor to go down the list of responses. This would likely lead to a great deal of boredom. Students whose responses were not discussed by the instructor would receive negative reinforcement for the desired participative behavior and might tend to not contribute to future questions. Such questions as the ideal class size and the level of learning possible with response pad technology should be addressed in future research.

Electronic Mail Between Instructor and Students

Another technology that can informate up is electronic mail between instructors and students outside of the classroom.[7] Electronic mail allows students to ask questions as they are reviewing material outside of class and to receive delayed

7 Electronic mail is a technology that can be used to support several of the visions. The nature of the use will therefore be specified to indicate why it is relevant to the particular vision being discussed. For informating up, e-mail between instructors and students is relevant, whereas student-to-student e-mail is relevant for informating down or virtual learning depending on the context of use.

feedback from the instructor. Electronic mail might facilitate communication between students and instructors, particularly in large (30 students plus) classes, that tends to discourage questions. The delay in feedback from a cognitive perspective is undesirable, yet the ability to ask the question as it arises might outweigh the disadvantage of the delayed response.

One account of electronic mail's value to students is the "dial a teacher" electronic mail provided by educational psychology professors at the Stephen F. Austin University to student teachers. Student teachers addressed questions to the "experts" concerning child behavioral problems, course preparation problems, and instructional problems. Many of the messages received from the student teachers requested help with lesson-plan ideas on specific topics or certain kinds of individual discipline problems (Lowe, 1993). A similar system is used at Iowa State University. Patterns of communication there found that the most common topic of communication for new teachers was on general education issues, followed by technical issues and classroom management issues (Thompson and Hayes, 1993).

Electronic mail solicits feedback concerning student understanding of course material and hence, promotes the cognitive information processing model of learning. It is, however, unclear whether this feedback is similar in quality to that obtained via a traditional verbal question-and-answer session. A study of electronic mail in organizations found that 62 percent of the messages constituted "new" information—information respondents reported they would not have otherwise sent or received (Sproull and Kiesler, 1986). People felt more comfortable sending messages to superiors than to subordinates. If these results hold in an education environment, students might feel more comfortable asking certain questions electronically than face to face. Contrary to media richness theory, e-mail has been found to be a preferred communication medium for equivocal and ambiguous messages (El-Shinnaway and Markus, 1992), and once a work group is familiar with a topic, e-mail is preferred to face-to-face communication (Zack, 1993).

The vision to informate down: providing students greater access to information

Informating down is the use of technology to provide information to lower levels in an organization. Informating down is, in Schein's words, a "more radical IT use" than automating or informating up because it may usurp the control of senior and middle management and demystify their role in the organization. In the context of education, informating down provides information to students to allow them to critically analyze information or discuss issues among a set of peers. In this section, informating down technologies are examined in two broad categories: the provision of information to learners and the provision of communication facilities to learners. Technologies designed to provide information to learners are referred to as Information Classroom Technologies, and technologies designed to provide communication facilities to learners are referred to as Communication Classroom Technologies. Such technologies can be implemented in ordinary classrooms and do not assume the building of a special physical facility to house the technology.

Information Classroom Technologies

Information classroom technologies facilitate student access to information to improve the availability or reality of learning materials. In contrast to automated classrooms that improve the efficiency of information delivery, the goal here is to make new, qualitatively better information available that would otherwise not be. Learning networks, hypermedia, simulations, and virtual reality are information classroom technologies.

Learning Networks: Learning networks are comprised of networked computers with links to shared databases developed by educators at various locations or to external databases. One study suggests that graduate business classrooms should be information-intensive environments containing such features as online access to real-world data available from commercial providers, access to company-specific databases, access to a wide variety of software for data manipulation and analysis and so on (King, et al., 1990). The CATT system (Hashim, et al., 1991), developed to complement the case teaching method, features current information from publicly available databases such as aggregate industrial annual data, U.S. census data, and NYSE and AMEX daily returns. Using such data, students are able to develop and analyze alternatives to the case problem. In fact, one study demonstrates that graduate business student groups that had access to publicly available financial information via computers performed significantly better in case analyses than study groups that had to analyze the same cases without access to such information (King, et al., 1990). Examples at lower educational levels of learning networks include Video for Exploring the World, which gives quick access to data such as human and animal motion, and the Jason project, which gives students access to data being gathered by underwater explorers (Rubin, 1993).[8]

Learning networks are linked to the constructivist model of learning: students are constructing new knowledge from existing information sources. There is no single correct interpretation nor answer to be given by the instructor; rather the students form their own ideas from the information they gather and explore.

Hypermedia: Hypermedia provides a non-linear means of browsing and sorting through computerized information. Learning networks can be organized in a hypermedia format to encourage students to search the material in the manner that suits their own system of logic. One of the features of the University of Maryland's AT&T Teaching Theater is the use of hypermedia to display lecture notes (Norman, 1992). Students can navigate through material during class while the instructor is giving a lecture. Perhaps the most widely known hypermedia tool in academic circles is the World Wide Web, used by both instructors and students to engage in information seeking and analysis. Although we are unaware of research that examines the potential of the World Wide Web in the context of classroom analyses, the potential of the Web to serve as an information resource to be utilized during class to allow students to search for information relevant to a course topic seems immense, and research examining uses of the Internet and the World Wide Web is much needed.

The hypermedia format is expected to encourage thinking, speculation, and personal judgments on the part of the learner because the learner is responsible for organizing and analyzing information (Ambrose, 1991). On the one hand, hypermedia could be considered the ultimate tool for a cognitive information processing theorist: "because hypertext is a node-link system based upon semantic structures [as opposed to a sequential access system] hypermedia can map fairly directly the structure of knowledge it is presenting" (Ambrose, 1991); on the other hand, for students with very little working knowledge in a domain, the seeming lack of structure may be disconcerting and may hinder processing.

Simulation Technologies and Virtual Reality: Simulation technology is another medium of the information classroom. Simulation can provide a condensed or vicarious experience and is based on the belief that students learn best when they experience the subject or topic. For instance, groups of students using computer simulations have been found to outperform control groups in problem-solving tasks (Gorrell and Downing, 1989). An example of a simulation is a computer-assisted international negotiation project (Torney-Purta, 1993) in which teams of five-12 college students role-play diplomats from another country and negotiate international issues through the use of a computer-networking system. Students acquire practice in higher-order thinking about social issues, in defending their positions, and in defending their ideas. Simulations are based on the constructivist model of learning—that learners need to be actively involved in learning by working with real-life facts or objects.

Virtual reality is another information classroom technology. Virtual reality provides "panoramic" presentations in three dimensions to the eyes, ears, and hands of a user. One example is a British high school that introduced the design of a virtual city where different languages are spoken to teach foreign languages (Kerney, 1993). This gives the course a more realistic context

[8] The May 1993 issue of the *Communications of the ACM* contains several examples of Information Classrooms in elementary and secondary education.

than would be possible through any other means aside from sending the students to the country. Other proposed applications include virtual reality for use in history whereby students could create a virtual reality Egyptian city where they can enter, "walk" through, and discourse with ancient Egyptians, for use in medical education whereby students could work on medical emergencies in a virtual hospital, or for use in science whereby students could create and visit a virtual solar system with planets correct in appearance, relative size, and distance from the sun (Kerney, 1993).

Virtual reality is based on the assumption that the most effective learning is that which is experiential, or based on actual experience in a context that is similar to where learning has to be later applied. A virtual reality environment supports constructivist, cooperative, and sociocultural learning: in designing the virtual reality, students are actively involved in constructing their knowledge of the particular domain for which the virtual reality is being built. Students work together to construct the virtual world by contributing their own views of how the reality should operate (much of which will be based on their own values, understanding, and culture).

Communication Technology Classrooms

Informating down can also be achieved with communication-intensive classrooms. An electronic classroom built around communication technology can be as simple as providing electronic mail to facilitate peer-to-peer communication to as complex as CATT (mentioned above), which, in addition to the information features previously mentioned, incorporates groupware to facilitate case discussions outside the physical boundaries of a classroom (Rathnam, et al., 1992). Such groupware-supported facilities might also be equipped with software to provide structure to the conversation.

Synchronous Communication Classrooms

Synchronous communication classrooms provide computers on student desks that are networked with software such as Lotus Notes, enabling simultaneous peer-to-peer communication. Studies indicate an increase in participation in classes taught using electronic peer-to-peer communication. The technology encourages all members of the class to contribute to class discussion (Bump, 1990). A typical session in a class enrolling 18 undergraduates involved more than 100 messages contributed by 18 participants. Approximately 60 percent were addressed by students to other students rather than to the instructor (Slatin, 1990). In a two-day period, in the English Department's electronic classroom at the University of Texas, 200 electronic comments were made of which only 10 percent were teacher comments. Twenty-eight percent of the student comments (comprising 90 percent of the total) were student to student, 61 percent were directed toward the whole class, and only 13 percent were of the student to teacher or teacher to student variety (Butler, 1990).

Groupware-Supported Synchronous Communication

Similarly, in synchronous communication classrooms using groupware, students collaborating with the technology were found to have higher perceived levels of skill development, higher perceived learning, and higher perceived interest than students collaborating in a classroom without electronic support (Alavi, 1994). In a similar study reported in this issue, Alavi, et al. (1995) added groups that were comprised of students from two different universities (distant groups). They compared their satisfaction, perceived learning climate, and performance to groups of students from the same university (local groups) engaged in three one-hour-and-fifteen-minute collaborative learning sessions using groupware-supported synchronous communication technology. The study concluded that the distant groups perceived a more positive learning climate and performed better on a multiple choice test of learning but that there was no significant difference in satisfaction measures. The only complaint received in another groupware facility was the lack of structure (Jessup, 1993). Some groupware-supported classrooms embed structure to facilitate conversation and reduce information overload (e.g., CATT and EXEMPLAR).

Research at another synchronous communication classroom examined whether technology-enabled collaborative learning involving case analyses is superior to individual constructive learning involving individual case analyses. The goal of both these methods was to increase student interest in the course, increase student understanding of the material, and promote critical thinking (Leidner and Fuller, 1995). Students engaged in eight 1.5-hour case analyses during the course of the semester. The study found that students working collaboratively via anonymous groupware in either small or large groups were more interested in the material and perceived themselves to learn more than students who worked individually. The study also found that students who worked individually outperformed students who collaborated in small or large groups. This may suggest that though collaborating, students were not processing and assimilating the information; though exposed to a diversity of ideas, they did not incorporate the ideas into their own cognitive framework. This merits further research because a primary goal of communication technology classrooms is not just to expose students to more ideas, but to enable them to critically evaluate a diversity of ideas in the creation of their own interpretation of important issues.

The pedagogical assumptions underlying synchronous communication classrooms are that (1) participation is critical to university learning, (2) lack of participation is primarily attributable to student inhibitions about talking in front of others, (3) anonymity will allow students to freely express themselves and overcome their inhibitions, and (4) synchronous communication technologies provide an efficient mechanism for providing anonymity. The first assumption maps closely to the cooperative model of learning especially if, for practical reasons, the class is divided into smaller discussion groups. The third assumption can arguably be used to enable sociocultural learning. By providing anonymity and non-verbal communication, different cultures are allowed to express themselves without having to adopt the language or opinions of the dominating culture.

A vision to transform: virtual continuous learning spaces

The IT vision to transform is the basis for a complete transformation of an organization and industry (Schein, 1992). The role of hierarchy would change in that distributed information would make local problem solving and lateral information sharing much more feasible. IT would make it possible for an organization to be simultaneously centralized around basic strategy and goals and decentralized around implementation and control. Power and authority would shift away from position and status toward knowledge and information, and leadership would become less of a role and more of a "function"; more emphasis would fall on groups and teamwork. In the context of education, the vision to transform would involve using IT (1) to redraw the physical boundaries of the classroom, (2) to enable more teamwork, (3) to allow learning to be a continuous time-independent process, and (4) to enable multi-level, multi-speed knowledge creation. The notion of virtual learning spaces begins to operationalize these assumptions.

Virtual learning spaces are those that link geographically dispersed students with no time constraints. Virtual learning spaces sustain discourse through interruptions and across distances and give it continuity over time (Scaradamalia and Bereiter, 1993). Hence, we distinguish between informating down classrooms that can allow students to engage in collaborative sessions across distances when the collaborative sessions are time-controlled (such as with the Alavi, et al. (1995) work previously mentioned) from virtual learning spaces where the communication forms the basis of the course itself and is conducted at will—when the students want and for as long as they want. Virtual learning spaces can exist to allow a group of students within the same course to communicate at will (as with the CATT system) or to bring together students from various courses at various universities to work together.

Asynchronous Communication Across Distances

The simplest virtual learning spaces are founded on electronic mail and electronic bulletin boards. Press (1993) considers e-mail a low-tech innovation that can have a radical impact on curriculum, commuting patterns, frequency of class meetings, and student-instructor roles. An example of an asynchronous communication virtual learning space is a graduate education class taught at the University of Texas. The students meet in a classroom only three times during the semester. The rest of the course takes place using asynchronous electronic mail. The discussions via electronic mail were not only multi-level (several themes being discussed) but also multispeed (different aspects of a theme being addressed by different participants) (Harris, 1993). In another project (Knoll and Jarvenpaa, 1995), students from over 10 universities from nearly all continents are teamed up to work in globally dispersed virtual teams. For six weeks, the students complete team assignments without any face-to-face contact with their team members using electronic mail and computer conferencing technologies. An example in secondary education is geographically dispersed teams of students working together to accomplish tasks associated with science projects or environmental studies (Hawkins, 1993).

Groupware-Supported Asynchronous Communication Across Distances

Groupware-supported communication classrooms when designed for students to access from remote terminals can also become virtual learning spaces. Anonymity can be built in or the identities of the group may be known. The addition of the groupware to the asynchronous communication across distances purports to provide structuring mechanisms to the exchange of messages in order to help learners organize the information they share.

The main pedagogical assumption of the virtual learning space is that learning is a process of working toward a more complete and coherent understanding. The flow of information must allow for progressive work in a problem, with ideas remaining active over extended periods of time. Furthermore, learning is viewed as ongoing and need not occur as single well-defined topics covered in a finite period such as during a class period. In this way, the virtual learning space supports cognitive, constructivist, collaborative, and sociocultural learning models.

Summary

Table 2 summarizes the technologies and the assumptions discussed above.

Table 3 shows the linkages between the technologies and the models of learning. No vision of technology is more desirable than others. Rather, the most appropriate technology depends on the underlying model of learning that the instructor wishes to employ.

We have not investigated the specific course content and student characteristics to which the various visions may be most appropriate. Future researchers can addess these issues. For example, in the domain of business education, decision-making skills including analytical and problem-solving skills and communication skills are seen as critical. We might therefore speculate that methods requiring interaction and student involvement would be preferred over traditional methods. Thus, the informating up or transforming technologies with the corresponding collaborative or constructivist learning models might be ways to improve the quality of business education.

The Taxonomy of the Impact of IT on Learning

The previous discussion of the relationship between technology and learning suggests the following taxonomy (see Figure 2). The taxonomy suggests the impact of the four classes of learning technologies on two process dimensions: (1) control of the pace and content of learning and (2) the purpose of instruction (knowledge dissemination or knowledge creation). The taxonomy also suggests possible impacts of the visions on a number of well-established learning outcomes from education research (see Table 4). IS researchers should find it useful to draw upon well-established variables from education research rather than creating new variables as they pursue research in the area. Although a review of the educational research comparing the effectiveness of the models is beyond the scope of this paper, Table 4 lists the learning outcome variables that typically form the foundation of educational methodology research. Most of the research discussed thus far examines one or more of these learning outcome variables; they are summarized here for convenient reference. Examining well-defined learning outcome variables

Table 2. Electronic Classroom Types, Assumptions, and Related Models of Learning

Electronic Classroom Type	Principal Pedagogical Assumptions
The Vision to Automate	
Instructor Console	Instructor the center of the classroom activity. Presentation technologies can make the delivery of information more memorable and interesting.
Instructor Console and Stand-Alone Student Computers	Students learn better if they can emulate what the instructor is doing on the computer. Learning is more effective when it is interactive.
Computer-Assisted Learning	Students benefit when they control the pace of learning. Feedback should be frequent.
Distance Learning	Weakness in education is the lack of availability of good courses and faculty. Accessibility in remote locations or smaller schools can be efficiently provided via telecommunications.
The Vision to Informate Up	
Key Response Pads	The instructor needs feedback. The ability to elicit responses via technology is superior to hand-raising.
Instructor-Student E-mail	Feedback, even delayed, is better than no feedback. Limited access to instructors limits communication.
The Vision to Informate Down	
Learning Networks	Delivery of information is not a pressing problem, but rather the lack of current information from realistic contexts. Students create knowledge through information exploration.
Hypermedia/Internet	Students need to create their own knowledge structures.
Simulation/Virtual Reality	The more real the context, the more effective the learning. Students should be provided the means to experience the phenomenon during class.
Synchronous Communication Classrooms	Participation is critical to the learning process. Anonymity encourages participation.
Groupware-Supported Synchronous Communication Classrooms	Structure imposed on communication is effective in helping students learn. Communication is more efficient when structured.
The Vision to Transform	
Virtual Continuous Learning Spaces	
Asynchronous Communication Across Distances	Learning is an ongoing process. Time should be flexible. Learning need not be geographically dependent.
Groupware-Supported Asynchronous Communication Across Distances	Ad hoc communication is more effective when supported with a structure.

Table 3. Technology Fit With the Theories of Learning

	Objectivist	Constructivist	Collaborative	Cognitive IP	Sociocultural
The Vision to Automate					
Instructor Console	XX				
Instructor Console and Stand-Alone Student Computers	XX	X			
Computer-Assisted Learning	XX			X	
Distance Learning	XX				X
The Vision to Informate Up					
Key Response Pads	XX			X	
Instructor-Student E-mail				X	
The Vision to Informate Down					
Learning Networks		XX		X	
Hypermedia/Internet		XX		XX	
Simulation/Virtual Reality		XX			
Synchronous Communication Classrooms			XX		X
Groupware-Supported Synchronous Communication Classrooms			XX	XX	X
The Vision to Transform					
Asynchronous Communication Across Distances			XX		X
Groupware-Supported Asynchronous Communication Across Distances			XX	XX	X

XX represents the primary match; X represents a secondary match as dependent measures in studies of the impact of IT-facilitated learning will promote greater comparability and interpretability of findings.

Technologies serving the automation function are closely aligned with objectivist theory, in which case the instructor remains the center of attention and in control of the learning process. The structure of the class can be described as a knowledge tree or knowledge hierarchy, with the instructor as the creator of knowledge. The instructor transfers explicit knowledge to students who are expected to be able to apply the knowledge. The automation vision promotes the efficient transfer of knowledge though leaving the processing of the knowledge by students as well as the creation of knowledge by instructors unchanged. Therefore, the impact of IT on learning is limited to an ephemeral effect on the self-variables. Nevertheless, where the goal of education is factual/procedural knowledge transfer, the vision to automate can be effective and performance improved.[9]

Technologies that informate up similarly function to assist the instructor as the nucleus of class activity but also function to improve the information an instructor receives concerning student comprehension of material. The structure can be described as a star, with the instructor as the center but receiving input from the students. The purpose of instruction is still focused on knowledge dissemination, but recognition is given to the importance of ensuring understanding or internalization of the material. Control of the pace and content of instruction is still held by the instructor. As with the vision to automate, there may be temporary effects on the self-variables as well as improvements in factual and procedural learning, but achieving conceptual learning and higher-order thinking in an informating-up environment may be difficult.

Technologies that informate down place much of the control of the content and pace of learning in the hands of students. The purpose of instruction moves away from knowledge dissemination toward knowledge creation; however, much of the knowledge is already created (is explicit), but the instructor is no longer the primary creator of the knowledge. Rather, students develop shared tacit knowledge from existing explicit information. The structure is thus a ring structure where the students become a very important part of the knowledge creation process and the instructor serves as a mediator rather than a dictator of the learning process; students will therefore learn more/less depending on their own contribution to the knowledge creation process. Technologies that informate down are most properly used in a constructive or collaborative environment, with an emphasis on conceptual learning and higher-order thinking. It can even be argued that such technologies would do little more than frustrate learners in an objective environment—forcing them to search for the right answer when it would be easier to be told. The potential exists for a longer-term effect on the self-variables since the control has been almost entirely shifted to the learner.

Lastly, technologies with the potential to transform education were discussed. Such technologies demand a rethinking of the purpose of the physical classroom facilities. The transformational vision is enabled by communication technologies that allow individuals to share tacit knowledge in a manner uninhibited by time or location. Of all the visions presented, the vision to transform gives the greatest amount of control over the learning process to the learners. This demands extensive preparation on the part of the instructor—even more than the other visions—to develop materials appropriate for such a learning environment and to monitor the progress being made in the discussions as an observer and as a guide. Knowledge is not constructed from existing explicit sources but rather created from the tacit knowledge held by individuals participating as part of a dynamic structure. The tacit knowledge of the individuals comprising the class is shared, and a new shared tacit knowledge emerges among the members. The structure is dynamic in the sense that different members have more or less importance at different periods of time depending on the amount and quality of the tacit knowledge they have to contribute to the knowledge creation of the entire group. Such a vision enables higher-order cognition and conceptual learning. It is this vision that demands the greatest shift in the roles of instructors and students and may meet with resistance on the parts of both.

[9] Thus, to the extent that effective performance is defined by the goal of learning, the taxonomy does not predict differences in performance across the visions (although there will be different types of performance across the visions).

	Automating	Informating Up	Informating Down	Transforming
Technology	Instructor Console CAI/CBT Distance Learning	Keypad Response Instructor-Student email	Learning Networks Virtual Reality Simulations	Virtual Learning Spaces
	Instructor Console and Student Workstations		Communications Classrooms	
Classroom Structure	Hierarchy/Tree	Star	Ring	Dynamic
Model	Objective	Objective, Cognitive IP	Constructive, Cognitive IP Collaborative	Collaborative, Cognitive IP Sociocultural, Constructive

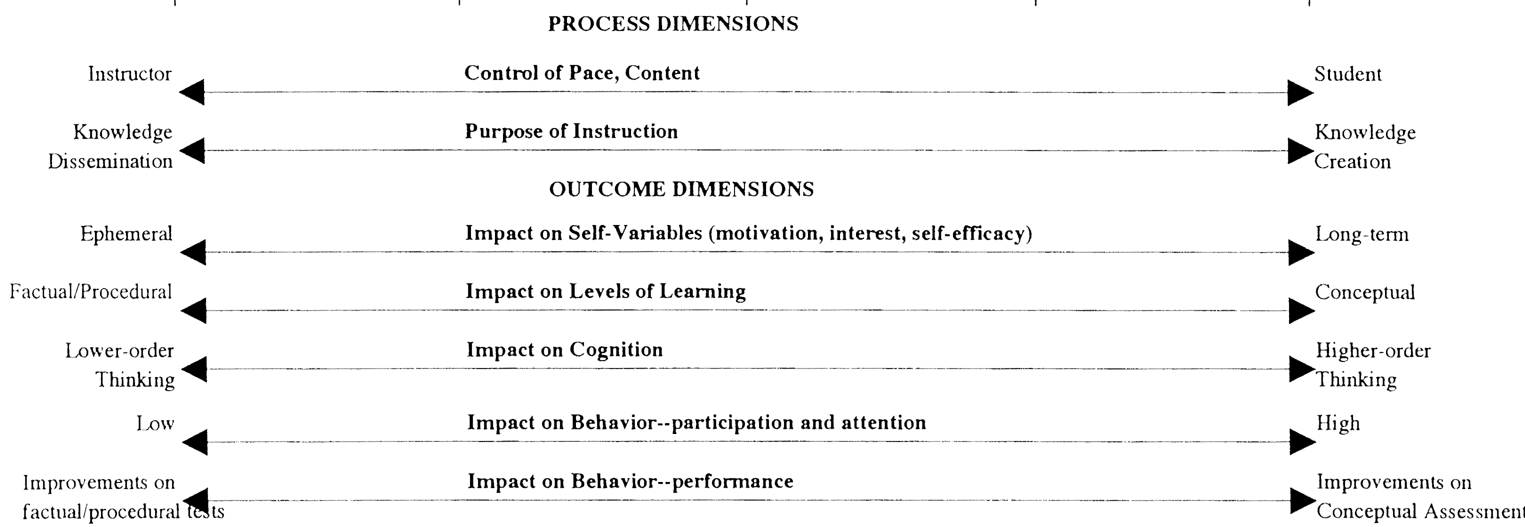

Figure 2. Taxonomy of the Impact of IT on Learning

Table 4. Educational Method Research Variables

Self-Variables		**References**
Self-efficacy	The degree to which a student feels capable of learning from a given method.	Cennamo, et al., 1991 Grusec, 1992 Martoochie & Webster, 1992 Hidi, 1990 Baldwin and Kar, 1987
Affective	The degree of satisfaction with and interest in learning from a given method.	
Motivation	The degree to which a student is motivated by a particular method.	
Learning Levels		
Context	The basis of course material, typically divided according to factual, procedural, and conceptual.	Walberg & Haertel, 1992 Tennyson, 1992 Davidson, 1990
Learning Style	The preferred mode of learning, a psychological measure.	Bostrom, et al., 1990 Hambree, 1992 Fourqurean, et al., 1990
Cognitive		
Thinking Level	Higher-order thinking versus lower-order thinking.	Tenebaum, 1982 Bruning, 1983
Strategies	The metacognitive strategies used by students to learn.	Walberg & Haertel, 1992
	The ability of learners to identify the strategies necessary for understanding and performing tasks.	
Processing	The amount and frequency with which students process new information.	Tobias, 1982 Bovy, 1981
Behavioral		
Performance	A surrogate measure of the amount of learning.	
Attention	A measure of directed non-verbal participation.	Bostrom, et al., 1990
Participation	The amount of usually verbal participation.	

Future Research Challenges

Numerous challenges remain in the area of improvements to management education, many of which require effort from IT researchers interested in educational environments. In reviewing the literature on IT in education and developing the taxonomy presented in Figure 2, several areas in need of research present themselves and are briefly discussed below.

1. Research is needed on technologies that informate down and up.

Research at the university level thus far has focused primarily on the technologies to support informating down via collaborative learning. Collaborative technologies have a strong research tradition in IS, and certainly learning environments provide an excellent opportunity to incorporate such technologies. This field of research deserves thorough attention, especially such questions as whether structuring mechanisms when incorporated into communication classrooms facilitate information processing by students or obstruct knowledge creation by forcing consensus. However, avenues for other IT-based methods to informate up or down should also be undertaken. In particular, attention needs to be given to developing technologies to support informating up. This is the area that has been given the least attention so far. It will be interesting to understand how communication patterns are altered when e-mail is widely used between instructors and students and how to effectively use key response-pad technology to provide real-time feedback on students' learning.

2. Research is needed on technology applications to promote sociocultural learning.

Papert (1984) lamented in 1984 that few were looking for ways to use the computer to allow knowledge to be acquired and presented in a form that matched different cultural and personality types. Little has changed since. There is a need to discover ways to use information technology to enable sociocultural learning—to immerse students in the context of the material, yet enabling them to communicate and contribute their own ideas and values based upon their own culture. These goals well support the multicultural objectives to which many universities subscribe.

3. Research is needed on the added value of technology to the learning models.

It may be that merely augmenting the objectivist model with constructivist models will produce the greatest learning impact and that technology changes will only contribute minor improvements. On the other hand, information technology might serve as a catalyst and reinforcer for effective applications of non-traditional learning models. Consequently, future research needs to compare the effectiveness of information technology incorporated into the model of learning versus the model without technology (rather than comparing one model of learning with technology to a different model of learning with or without technology). Such investigations are encouraged to build on previous work and as much as possible use variables such as those listed in Table 4 that have been the center of much previous educational methodology research.

4. Research is needed on the influence of moderating variables on the learning models and their technological enhancements.

The second section presented five models of learning but did not advance any model as the preferred model because the appropriate choice depends on many factors such as course content and student characteristics. There is little research that elaborates on the factors that might affect the successful application of the models of learning. Some studies of collaborative learning in a virtual learning space have supported the point that for mature, motivated learners this mode of learning can be more effective than the traditional classroom, but for less motivated and mature learners, the effect is the opposite (Hiltz, 1988; Singer, et al., 1988). Students lacking the necessary basic skills and self-discipline may do better in a traditionally delivered mode (Hiltz, 1988). Aside from these findings, little is known about the prerequisites to the effective application of informating down, informating up, and transformational technologies in learning environments. It could well be that the brightest and most motivated students will prefer to learn in an individual competitive environment rather than sharing their knowledge with less motivated, less bright students.

In his theory of knowledge creation in organizations, Nonaka (1994) suggests several enabling conditions of knowledge creation: creative chaos, autonomy, redundancy of information, requisite variety and intention. Nonaka suggests that without some form of shared experience, it is extremely difficult for people to share each others' thinking processes. This model of knowledge creation (called socialization) parallels the sociocultural model of learning. Nonaka further suggests that the quality of an individual's contribution is determined by the "variety" of that individual's experience. Bovy (1981) advances the notion that high-ability students profit from the opportunity to process information in their own way and to create knowledge, whereas low-ability students tend to be handicapped by such empowerment. In addition, student reticence observed in traditional settings may be more the result of indolence rather than communication inhibitions, in which case attempts to encourage knowledge creation via teamwork, collaborative learning models, and communication technologies might meet with insurmountable obstacles. The lack of enabling conditions such as student experience, student ability, and student effort may outweigh any gains to be achieved with technology and thus should be examined before widespread investment in advanced technology. In addition, the instructor's skills in executing the learning models and in adopting technology enabling the models should be taken into account before investing in the technologies.

5. Research is needed concerning the most effective ways to foster teamwork as well as the appropriate size and duration of teams.

Teamwork is an implicit aspect of the collaborative and sociocultural models. In order to stimulate creative thinking via discussion in a team, several conditions should exist: the dialectic should be multi-faceted rather than single-faceted, individuals should be able to express their ideas freely and candidly, and there should be temporal continuity so as not to disrupt the creation of knowledge (Nonaka, 1994). This suggests a need for multiple channels of communication—some continuous and a few anonymous. Given the need for shared experiences, teams might remain stable over time and across courses even though the importance of the members' contributions will vary depending on their existing knowledge.

Teamwork is a means of knowledge creation rather than an end in itself. Research needs to consider optimal team size, team leadership issues, team assessment strategies, and the impact of the longevity of the teamwork. Research also needs to consider the effects of teamwork on the satisfaction of the learners. The studies on satisfaction must include virtual global student teams (e.g., Knoll and Jarvenpaa, 1995), where members often come from different educational institutions with differing educational goals and assessment strategies and must consider the amount of the knowledge the learner has to contribute versus the knowledge the learner gains from the sharing process.

6. Research is needed on understanding the roles of instructors and students as well as the appropriate learning assessment strategies in virtual learning spaces.

As one moves along the continuum in Figure 2, the classroom model becomes a ring or dynamic topology with major implications for the roles of students and instructors and also for assessment, both of instructors and students. In virtual learning spaces, it is not known at the outset exactly what knowledge will be acquired and created. The virtual classroom thus promotes "creative chaos" (Nonaka, 1994), removing traditional structure from the learning environment. The removal of structure means that individual students will have differing preparations to the learning experience. This also means that individual students will have differing learning objectives and experiences, and therefore, the assessment strategies must be both individualized and dynamic. Individual student learning portfolios are increasingly used in such an environment (Becker, 1987).

In the virtual learning environment, the instructor provides visions for directions, orients the chaotic situation that results from multiple individuals simultaneously creating and sharing knowledge, and sets the deadline by which the visions will be realized. Effective instruction in this context might mean asking the proper questions rather than guiding students toward the proper responses, facilitating the sharing of information to enable knowledge to be constructed rather than constructing and distributing knowledge themselves, and monitoring rather than leading the knowledge creation process.

Students are likely to resist the new learning models as much as the instructors. In the virtual learning space, students are as much responsible for the quality and amount of learning as the instructor. Students accustomed to objective assessment and clear topics may be unable to adjust to the additional responsibility placed on them. This too demands student willingness to forfeit the certainty of objective performance-based testing procedures for course assessment procedures revolving around student contribution to the class. This is a fundamentally different way for students to think about a course; traditionally, students are accustomed to thinking in terms of what they get out of a course rather than what they contribute to the knowledge created in a course.

Conclusion

As an examination of the models of learning and of the impact of IT on learning elucidates, there are varieties of opportunities for implementing IT in management education. Technology can be used to facilitate the display of information, to increase access to external explicit information, and to increase the sharing and construction of knowledge. By studying the interactions of the technology with learning models, as well as the individual technologies themselves, a picture begins to emerge as to what constitutes alternative implementations of IT in education. Technology is not suggested as a panacea for educational problems; in fact many problems in education are social rather than learning related. Yet, technology can enable the effective application of constructive, cognitive, collaborative, and sociocultural models of learning.

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