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ABSTRACT

Greater learning can be promoted by delivering information through a variety of media and through the use of interactive applications. In this paper, the effect of information technology on learning is seen as a function of how well interactive technologies support a specific model of learning and how appropriate that model is to the learning situation. Assumptions of learning theories are reviewed and combined with specific technologies. A framework is described that uses the broad categories of objectivism and constructivism, with subsets including collaborative, cognitive information processing, and sociocultural learning, to classify learning models. Four functions (i.e., automate, informate up, informate down, and transform) of the use of information technology for instruction are linked to the pertinent technologies. Using this framework, the paper suggests an educational strategy incorporating various technologies based on these theories and combinations. A model combining the learning theories, the functionality, the type of outcome, and an appropriate technology is proposed. Four figures present a summary of learning models, dimensions of learning theories, a taxonomy of the impact of information technology on learning, and dimensions of learning theories and technology. (MES)

INFORMATION TECHNOLOGY-BASED INSTRUCTIONAL STRATEGIES

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Greater learning can be promoted by delivering information through a variety of media and through the use of interactive applications. In this paper, the effect of information technology on learning is seen as a function of how well interactive technologies support a specific model of learning and how appropriate that model is to the learning situation. Assumptions of learning theories are reviewed and combined with specific technologies. Using the framework provided by Leidner and Jarvenpaa (1995), this paper suggests an educational strategy incorporating various technologies based on these theories and combinations.

INTRODUCTION

Interactive technologies improve the appeal and motivational effects of activities related to learning. However, learning models themselves should not be overlooked; they assist in the selection of appropriate technologies for the learner or the learning environment. The effect of information technology on learning is seen as a function of how well technology supports a specific model of learning and how appropriate that model is to the learning situation [Leidner and Jarvenpaa 1995]. Models also provide a framework for specific Information Technology (IT) functionality for the purpose of the instruction and, the control of pace and content of learning.

Following this premise, this paper reviews the assumptions of learning theories and IT functionality, and combines them with specific technologies. Then, it applies these theories in education and creates a roadmap for deciding which technologies are suitable for specific learning objectives. As each model is defined, an IT functionality is reviewed. Finally, a model combining the learning theories, the functionality, the type of outcome and an appropriate technology is proposed.

LEARNING MODELS

Learning models are often classified in distinct categories. They can be alternated or offered in conjunction, and the use of one model does not exclude the use of another. The broadest categories of this classification are objectivism and constructivism, with subsets including collaborative, cognitive information processing, and sociocultural learning [Leidner and Jarvenpaa, 1995].

Objectivism is a behavioral-type of model that holds that learning occurs in response to an external stimulus. Objectivists profess the existence of an external objective reality that exists independently from the observer. Learning occurs when individuals understand this reality and modify their behavior accordingly. One of the assumptions of this model is that this independent reality can be represented through abstract models and transferred to the learner. In this model, teaching consists of transferring knowledge from the expert to the learner. This transfer can be automated between and among individuals. Efficiency in teaching is measured by the appeal component of the presentation of information. This model is most appropriate for learning "facts" or procedures. It can be used in the situations where facts and figures about an organization need to be distributed. Presentation graphics and slides can portray information in charts highlighting the organization's internal structure, project requirements and other text-based information that needs to be presented in a more appealing mode.

Constructivism is a learning model that starts from opposite assumptions from objectivism. In this model, learning is not as much a process of knowledge assimilation as it is a basis for constructing mental models, in which knowledge is created in the mind of the learner. Constructivism excludes the existence of a reality external to the learner reality. The consequence of this model is that reality differs for each individual and the latter controls the pace and depth of his/her instruction. The instructor is only the mediator in a growth process that requires hypothesizing, questioning and discovering the conceptual relationships between and among various objects. This type of learning can be used for recreating situations in which the student experiences a simulation of the business and then builds his own world based on that simulated understanding.

Cooperative or Collaborative learning is an extension of the constructivist model. The difference lies in the assumption that the creation of mental models is the result not of individual efforts, but of collaboration among individuals that elaborate principles for shared understanding. Knowledge is created through the act of sharing and the instructor is a facilitator of communication. This type of learning increases motivation to explore [Flynn, 1992]. It also increases the level of critical thinking, pushes for a greater diversity of ideas, and promotes interaction. Suitable technologies used in this context are listservs that provide a discussion environment or Internet conferences that promote simultaneous interaction. Discussion groups through collaborative software promoting synchronous communication also fall within this category.

Cognitive Information Processing is another facet of constructivism. It assumes that learners differ in the way they process information and that only the instructional methods that match the individual preferred learning style will be most effective [Bovy, 1981]. Prior knowledge influences these preferences and the learner will select only the information that is built upon that knowledge. In order to focus the attention only on those processes that are most effective to attain understanding, other information will be selectively excluded. Hypermedia, and therefore, Web-based communication is useful in this context. Learners follow the path that best complies with their pre-existing mental maps and can select information accordingly. Applications include Web tutorials and multimedia software in which users focus on the media that is best suited to their learning style.

Sociocultural learning is closer to system-based theories and rejects the idea that learners can create their own images of reality that are apart from the external environment. The living, historical and cultural background of the learner influences the understanding [O'Loughlin, 1992]. This model is particularly useful in distance learning where the delivery of the message needs to take into account the cultural context in which the information is distributed. From an educational standpoint, this is particularly useful in the integration of company culture with the changes brought about by the changes in the adoption of technology. The tacit culture is taken into consideration and the message is adjusted to lessen the impact on the population. The implications for education can be summarized in Figure 1.

FIGURE 1
SUMMARY OF LEARNING MODELS

Model	***Basic Premise***	***Goals***	***Implications for Instruction***
Objectivism	Learning is the uncritical absorption of objective knowledge	Transfer of knowledge from instructor to students	Information is best presented through graphics, figures and other appealing designs that complement text.
Constructivism	Learning is a process of constructing knowledge by an individual	Formation of abstract concepts to represent reality	Learning through recreating experience that simulate direct field visits
Cooperativism	Learning emerges through shared understandings of more than one learner	Promote group-skills – communication, listening, participation	Use of listservs and on-line conferencing to stimulate discussion
Cognitive Information Processing	Learning is the processing and transfer of new knowledge into long-term memory	Improve processing abilities, recall and retention	Use of multimedia or hypertext gives learners the ability to select, organize and process knowledge in a mode that favors long-term retention
Socioculturalism	Learning is subjective and individualistic	Action-oriented, to change society rather than accept or understand	Technology helps preserving competitive advantage from the cooperation on networked computers that favor integration.

Adapted from Leidner and Jarvenpaa [1995:270]

The above relationships between theoretical models of learning and the implications for education are mediated by the technological medium. The role that information technology assumes in each of the described models is further investigated by focusing on the ways IT facilitates learning to meet a specific functionality. Leidner and Jarvenpaa [1995] assign four different functions (automate, informate up, informate down, and transform) to the use of IT for instruction. They propose a taxonomy with two dimensions --- the purpose of instruction (knowledge dissemination vis à vis knowledge creation), and the control of pace and content of learning. In the following sections, the four functions are linked with pertinent technologies for education.

Automate

Automation is used for replacing expensive human labor with technology. Although teaching and learning rarely fit automation, there are parts of these activities that are characterized by repetition and can be delivered more efficiently through visual aids used by the instructor such as transparencies, instructor consoles, stand alone student computers, computer assisted instruction and distance learning. Studies show that the use of slides, outlines, and transparencies contribute to increasing learners' motivation [Janda, 1989]. Although significant differences in performance were not found [Gist, McQuade, Lorenzen, Schmidt, Boudot, & Fuller, 1988-89], the inclusion of automation in the learning setting increases students' liking of the instructor. The latter is primarily acting as a presenter of information, a colorful and organized presentation has effects in gaining attention and promoting comprehension.

Within the automation function of IT, a significant role has been taken by Computer Assisted Instruction (CAI). CAI or other applications of it (Computer Based Training - CBT) consist of interactive software programs that provide information in several modes (sequential as well as non-linear, static as well as dynamic) in order to increase the understanding and mastering of the subject by learners. The assumption is that control of pace and active involvement through feedback is more effective. This structure is still objectivist as the knowledge already exists pre-defined in the system and is not constructed by the learner. The form of interaction is still *stimulus-response-reinforcement* with feedback activities provided through tests, questions and answers. Schwier & Misanchuk [1993] saw this reinforcement as facilitating elicitation and assessment processes. The appropriate technological means to provide this instruction is *multimedia*. Multimedia technology fulfills the automation function by meeting the objectives and operating within the framework of the objectivist model.

Learning through <u>multimedia</u> also adds a component of flexibility, dynamism, and interaction in the amount of information that can be accessed. Multimedia exploits several synchronized media (not just a collection of unrelated multiple media) to obtain learning and to help build cognitive models. It combines the benefits of learning from audio and video components into an environment that offer the user the ability to control the pace of instruction, a major inhibitor in learning from television or radio. For example, in the case of **interactive video**, the use of this tool is essential for stimulating the user to form an opinion. On the basis of the information retrievable on the screen (cases, videos, sound), the user creates the development of the story and makes a value judgment.

The learning process through multimedia promotes formative evaluation, ease of use and navigation. Although research on the effects of multimedia is not definitive, Kuzma [1991] concluded that multimedia remains the most powerful tool for learning by incorporating the benefits of other means of communication into the benefits of learning with computers. Learning with <u>computers</u> is important for the cognitive process requiring building models to promote understanding. As an aspect of multimedia learning, **hypermedia** learning occurs through access to a series of links explaining the context, the meaning of a word, or displaying related video and charts. Access to information is increased exponentially. The drawback is the risk of disorienting the user, particularly if he falls into the category of "linear thinkers" rather than "associative thinkers". The user needs to build a map or storyboard to navigate. However, the use of hyperlinking is particularly appropriate in another representation of the automation function: *distance learning*.

The **distance learning** mode of instruction still consists in simple knowledge transmission introducing the variable of learners now based in different locations. Because of the latter geographical dimension, this application also displays traits of the sociocultural model of learning, as it allows learners to remain in their familiar environment while their learning occurs. This approach does not force users to adopt and adjust to a new culture that could be present in the primary location of instruction.

Informate Up

This function includes a flow of information not only from the provider of instruction to the learners, but also vice versa. The feedback is intended to appraise the instructor on the level of understanding of the material presented and promote the adjustment of the presentations. Technological tools that allow this type of feedback are instruments for on-line communication such as email. Although the communication is asynchronous, the ability to ask questions through a medium favors interaction. This interaction could be not otherwise attainable either because of the psychological characteristics of the learner or because of the existence of distance between the source and the recipient of instruction.

Informate Down

Technology allows the provision of information to learners both through the delivery mechanism described in the automation function and by providing communication facilities for the learners. Learning networks are an example of this level that supports the constructivist model of learning: users are forced to create new knowledge based on the information available to them.

Hypermedia can also be included in this function when it stimulates the learner to analyze and organize information [Ambrose, 1991]. Virtual reality is used for this function when it allows simulations that encourage problem solving. The belief is that learners understand best when they experience the subject or topic. Gorrell and Downing [1989] have demonstrated that groups of students using computer simulations outperform control groups at problem solving. Virtual reality allows a "panoramic" view that constructs the closest representation of the actual environment. Learners are actively involved in constructing their knowledge in the virtual world mirroring the actual world.

Other applications of this function can be found in synchronous GroupWare communication settings in which learners communicate anonymously with other students in the same setting. This cooperative learning technology is used in strategy formulation in hierarchical contexts in which suggestions can be hindered by the fear of the authority. In planning, it is useful at the meeting level when decisions on policies need to be formulated.

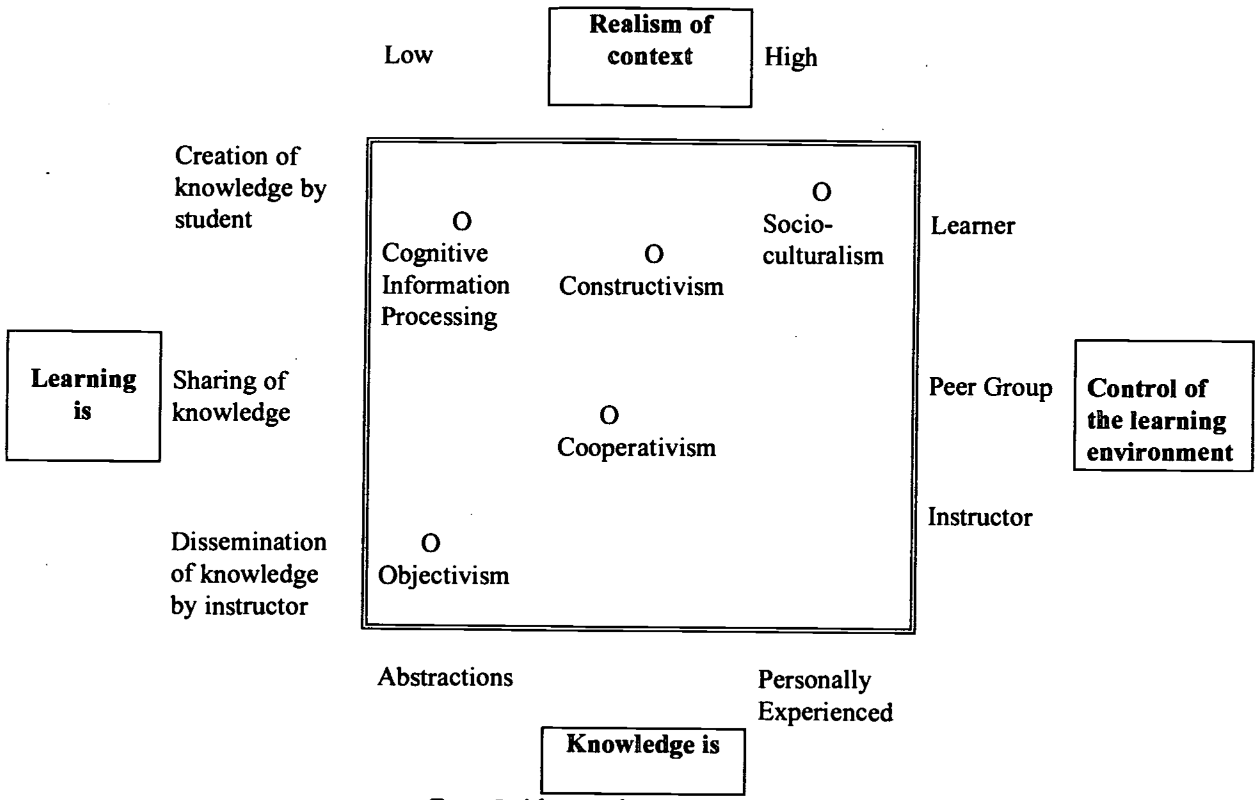
Transform

This function links learners in geographically dispersed locations with no time boundary for interaction. It creates "virtual learning spaces" to which interested parties can refer at any convenient time and on a continuous mode. Examples are Electronic Bulletin Boards, newsgroups, or community information centers. The cognition level of this function is extremely high. This automation function follows the objectivist theory and deals with factual and procedural knowledge transfer. Technology informating down leave the pace of knowledge creation in the hands of the learners. In the strategies for informating up, major emphasis is still on knowledge dissemination and importance is placed on understanding explicit information rather than producing new ones. The technologies promoting transforming start from the assumption that time and locations inhibit knowledge processes. Transforming technologies contribute to a dynamic sharing of tacit information created by the entire group of participants. This method promotes higher order cognition and conceptual learning. The variables of instruction in the above methods can be reviewed in Figures 2 and 3 based on measures such as type and intensity of the variables.

IMPLICATIONS FOR EDUCATION

Figure 2 shows the relative positioning of learning theories in terms of four dimensions: the control of the learning environment, the representation of knowledge, the realism of context and the type of learning. Figure 3 assigns specific technology to the functions previously discussed (automating, informating up and down, transforming). The bottom half of Figure 3 identifies the outcome dimensions and processes of technology use for variables such as motivation, cognition, behavior and performance. To manipulate these variables, Figure 3 suggests using technological tools, classroom structure and instructional models identified in the taxonomy.

FIGURE 2
DIMENSION OF LEARNING THEORIES



From Leidner and Jarvenpaa [1995:271]

FIGURE 3
TAXONOMY OF THE IMPACT OF IT ON LEARNING

	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 Classroom	
Classroom Structure	Hierarchy/Tree	Star	Ring	Dynamic
Model	Objective	Objective, Cognitive IP	Constructive, Cognitive IP, Collaborative	Collaborative, Cognitive IP, Sociocultural, Constructive

FIGURE 3
(continued)

PROCESS DIMENSIONS

Instructor	Control of pace, Content	Student
Knowledge dissemination	Purpose of instruction	Knowledge Creation

OUTCOME DIMENSIONS

Ephemeral	Impact of self-variables (motivation, interest, self-efficacy)	Long-term
Factual/ Procedural	Impacts on Levels of Learning	Conceptual
Lower-order thinking	Impact on Cognition	Higher-order thinking
Low	Impact on Behavior-participation and attention	High
Improvements on factual/procedural tests	Impact on behavior/performance	Improvement on conceptual assessment

Adjusted from Leidner and Jarvenpaa [1995:284]

The identification shows that the outcomes associated on the right side of the latter diagram lead to higher cognition levels; are learner-centered; involve a higher order of thinking; and obtain longer-term effects. The analysis presented in this literature review confirms that moving left to right (from the automation to the transforming functions) leads to higher level results.

This observation suggests recommending a directional implementation strategy (left to right) to meet the educational goals. For example, one of the goals could be attaining behavioral changes, which Figure 3 suggests. It also shows that the technology suitable for this purpose is the creation of "virtual learning spaces."

Educators, particularly those identifying with the sociocultural model, believe that the different learning theories can be combined to achieve the mentioned objectives. In the taxonomy, for example, transforming is obtained by using multiple models. A "systemic approach" to education would call for such integration. Nevertheless, as some technologies imply higher implementation costs, it is useful to associate specific technologies to specific models. This can be done combining the dimensions of Figure 2 with the technology associated to the learning models and the directional relationships identified in Figure 3 to create Figure 4. Now, Figure 4 is a model for the implementation strategies for education.

FIGURE 4
DIMENSION OF LEARNING THEORIES AND TECHNOLOGY

TECHNOLOGY

	Multimedia (CAI/CBT); Presentation graphics; Hypertext/ Web inform.;	Use of several media; Listservs; Newsgroup; Web Conferencing	Simulation software; Virtual reality; Learning Networks;		
<u>OBJECTIVE</u>	Low	Medium **Realism of Context**	High	<u>OBJECTIVE</u>	
Creation of knowledge by student	[A] O Cognitive Information Processing	O Constructivism	O Socio-culturalism	Learner	Simulation software; Virtual reality; Learning Networks;
Sharing of knowledge **Learning**		O Cooperativism		**Control** Peer Group	Listservs; Newsgroup; Web Confer.; GroupWare;
Dissemination of knowledge by instructor	O Objectivism		[B]	Instructor	Presentation graphics; Multimedia (CAI/CBT); Hypertext/ Web inform.;
		Knowledge is			
<u>OBJECTIVE</u>	Abstractions		Personally Experienced	<u>OBJECTIVE</u>	

<u>TECHNOLOGY</u>

Combination [A] & [B]= Multimedia, Presentation Graphics, Hypertext, Web for Information & Simulation software, Virtual Reality, Learning Networks with LEARNER & INSTRUCTOR control.

The inclusion of technology in the Figure expands the applications of multiple models for the attainment of educational objectives. If the main target of the education program is to provide control to the learner over the learning activity, then simulation software, virtual reality and learning networks enable not only the attainment of that objective, but also the re-creation of a highly realistic situation in which the learner personally experiences the content of instruction and creates his own knowledge. The sociocultural approach that uses the technology described increases the possibilities to reach the stated objectives. From this integration (Figure 4), it can be inferred that the combination of presentation graphics, multimedia and hypertext with simulation software and virtual reality applications favor knowledge creation by the learner. Since simulation is strongest in learner-controlled instruction with high reality context when applied in a sociocultural model, application in the cognitive information processing model tends to increase realism and the experiential nature of knowledge acquisition. Conversely, the combination [A] can be applied in the opposite dimension [B] to promote the attainment of the same results also in teacher-centered instruction. Therefore, the use of these technologies can remove the boundaries between the identified models of learning and can allow more manipulation of the objective and outcomes of instruction.

SUMMARY AND CONCLUSIONS

This paper reviews the assumptions of learning theories and combines them with specific technologies to analyze the effect of information technology as a function of a specific model of learning and a specific learning situation. It applies these theories to education raising awareness about technology needs and potential. By looking at the expansionary effects of the use of different types of technology on educational objectives, the authors suggest an educational strategy that incorporates various technologies to promote higher levels of cognition and achieve longer-term attitudinal changes in students.

This strategy has consequences in several learning contexts and holds particular promise for education. By looking at the potential for virtual reality applications to simulate personal experience, a new concept can be portrayed, whether it is achieved through learner or instructor control. The high realism of the simulated context can propose itself as a possible substitute of in-class-only instruction. Considering the potential behavioral effects of using other types of media to deliver the same message instructors and curriculum developers, as well as a broader variety of stakeholders (academic institutions, public authorities, and the private sector) need to promote the use of these technologies at all educational levels. Traditional instructional technologies are useful, but, in the long run, the lasting effects will be brought about only by <u>transformation through appropriate and objectives-matched applications</u>.

There are many opportunities waiting to be exploited. Some of these opportunities include:

1. use of Web technologies for creating sites of interest and conducting Web-conferencing activities;
2. use of listservs and newsgroups for discussing system design, programming and database initiatives;
3. use of presentation graphics to better deliver information in the classroom or in training programs;
4. use of multimedia applications to promote self-paced instruction on application packages;
5. use of GroupWare communication and decision support systems (DSS) to brainstorm on strategy implementation;
6. use of distance learning to advance the emergence of a global software development; and, finally,
7. use of virtual reality to attain the most ambitious outcome of recreating business-like learning environments.

Although the use of some of the technologies is limited by the lack of investment in producing expensive software applications, development of this software may be the answer to enhancing learning by increasing participation and interest.

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