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Use of learning theories in media design

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Abstract

This review discusses learning theories such as dimensions of learning, multiple intelligences, reading-learning styles, constructivism, and brain research. It looks at software design, multimedia programs and some experimental programs that are making attempts to integrate these theories into the design of technology.

Use of Learning Theories in Media Design

A Graduate Review

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by

Janet Adams

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Chapter 1

Introduction

Most of the technology, media, and computer programs in use by the education community today are designed in a step by step approach with little or no attention paid to how users learn and process information. Interactive media allows for limited interaction but very little student designed creativity (Liebowitz & Letsky, 1996). The "school transformation" and "effective schools" movements are calling for greater student directed learning and increased use of technology (Tuttle, 1995). Research on learning theories is producing evidence which indicates that teachers and school systems need to incorporate those theories into teaching practices using various modalities. A problem arises, however, when choosing technology, media or computer programs that support those learning theories because it is not available. In general, technology designers have not been educated about the learning theories; therefore are not sensitive to them (Luskin, 1996).

Research Questions

1. What learning theories might be incorporated into technology designs?

2. How do developers incorporate this knowledge, - dimensions of learning, brain research, multiple intelligence, learning styles and constructivist theories - into interactive media, computer programs, integrated learning systems and other technology applications? What are the challenges that the media designers have to overcome?

3. How can technology design give students the opportunity to apply their knowledge in a creative way?

Chapter 2

Literature Review

This review will outline five learning theories and discuss available information relating to their incorporation into educational technology applications. The five theories are dimensions of learning, brain research, multiple intelligences, learning styles, and constructivism.

Dimensions of Learning

Dimensions of Learning form a framework that uses research and theory to build a truly learning-centered approach to education (Marzano, 1992). It connects teaching, learning, and assessment in five interactive dimensions which include (1) Positive attitudes and perceptions about learning; (2) acquiring and integrating knowledge; (3) extending and refining knowledge; (4) using knowledge meaningfully; (5) productive habits of mind (Marzano, 1992).

Without positive attitudes and perceptions students have little chance of learning proficiently, if at all (Marzano, 1992). For learning to occur, students must have certain attitudes and perceptions. Feeling comfortable in the classroom is important to learning. A focus of effective instruction and use of technology then, is establishing positive attitudes and perceptions about learning (Marzano, 1992).

Helping students acquire new knowledge, integrating it with what they already know and retaining it is a key ingredient to learning (Marzano, 1992). For new information to be useful, it must be learned to such an extent that the student does not have to think about it when it is used. Students do this when they are successful in riding a bicycle or using sentences to tell a story.

Acquiring and integrating knowledge involves using what the student already knows to make sense out of new information, working out the kinks in the new information, and assimilating the information so that the student can use it (Marzano, 1992).

Extending and refining knowledge, the third dimension, gives students opportunities to add new distinctions and connections to new and old information by engaging in the following activities.

Abstracting
Analyzing errors
Analyzing perspectives
Classifying
Comparing
Creating and analyzing support
Making inductions
Making deductions (Marzano, 1992, p. 69)

The choices of extending and refining activities should fit naturally with the curriculum so that cognitive skills and teaching content are integrated (Marzano, 1992). Software that could accommodate this dimension would be very helpful.

Using knowledge meaningfully, the fourth dimension, is key to transferring knowledge learned from one situation to another activity (Marzano, 1992). Effective learning occurs when students are able to perform meaningful tasks using accumulated knowledge. The meaningful task of making a decision using a set of circumstances and facts is an assessment process that allows a student to see the end result of the research that was conducted. Planning instruction using appropriate technology so that students have the opportunity to use knowledge meaningfully is one of the most important decisions a teacher can make.

There are five types of tasks that encourage the meaningful use of knowledge: Decision making, investigation, experimental inquiry, problem solving, and invention (Marzano, 1992). The content should determine which of the five tasks a teacher or student might select, not vice versa. Several modes of technology are needed to respond to these tasks such as software that could compare different types of investigations of a problem or could develop a new invention using old information in a new way.

Productive habits of mind, dimension 5, are used by critical, creative, and self-regulated thinkers (Marzano, 1992). Acquiring content knowledge is important but more important is the student's ability to learn on their own what they want or need to know. Habits of mind include:

> Being open minded and aware of your own thinking
> Evaluating the effectiveness of your actions
> Restraining impulsivity
> Being clear and seeking clarity
> Pushing the limits of your knowledge and abilities
> Engaging intensely in tasks even when answers or solutions are not
> immediately apparent (Marzano, 1992, p. 133).

Effective learning is a product of the interaction of these five distinct dimensions of thinking and learning (Marzano, 1992).

Brain Research

Brain Research is showing us how the brain functions, how it interacts with the outside environment, how it determines what's important, how it solves problems, how it adapts itself to its environment, and how it learns, remembers, and forgets (Sylwester, 1995). The new biologically based brain theories focus on the developmental relationship between a brain's ancestors and its current environment: the "nature versus nurture" issue.

The powerful role that emotion plays in regulating brain activity and the preponderance of parallel (rather than linear) processing in our brain, suggest that a useful model for our brain must come out of biology, not technology (Edelman, 1992). Edelman's model of the brain as a rich, layered, messy, unplanned jungle ecosystem is intriguing. He suggests that a junglelike classroom that includes many sensory, cultural stimuli, and problems that are closely related to the real-world environment in which students live, best stimulates the neural networks that are genetically tuned to that environment.

The future classroom would benefit from technology that will draw out existing abilities of a student rather than measuring that student's success with specific skills (Sylwester, 1995). It might reward students' cooperative technological solution to an environmental challenge rather than the hollow manipulation of things that merely represent a solution.

Computers and other technology forms have materially broadened our brain's knowledge of the universe (Sylwester, 1995). The curriculum should help students understand and master this technology, but it should also examine the social value of the information that lies beyond our brain's limitations.

Multiple Intelligences

Multiple Intelligences theory is a way of understanding the intellect (Gardner, 1983). Recent discoveries in cognitive science, developmental psychology and neuroscience suggest that each person's level of intelligence is actually made up of autonomous faculties that can work individually or in concert with other faculties. Gardner (1983) has identified the following seven such faculties, which he labels as "intelligences": musical, logical-mathematical, linguistic, spatial, bodily-kinesthetic, interpersonal, intrapersonal.

There are three forms of intelligence in the category of time and sequence (Sylwester, 1995). These forms - musical, logical-mathematical, and linguistic - require the ability to recall the past, experience the present, and anticipate the future.

Music can communicate emotion which is central to our being; therefore communication must get beyond nouns and verbs to the feelings that give meaning to mere names and actions (Sylwester, 1995). Songs go far beyond words in their ability to insert emotion into communication. Musical elements such as melody, harmony, rhythm, and volume become part of the message.

Use of music in the world of technology adds a dimension that seems to meet a human need (Sylwester, 1995).

Logical-mathematical Intelligence relates to the if-then and cause-effect thinking (Sylwester, 1995). Both hemispheres in our brain process logic and mathematics. The computer games that condense and expand patterns of time and space and require the player to make decisions quickly help the student develop the logical-mathematical process.

Linguistic information is composed of codes that allow our language to use fewer than 100 meaningless sounds and written symbols to process great amounts of meaningful information (Sylwester, 1995). Various forms of storytelling allow students to chain together events into a context that makes sense to them based on their previous experiences.

However stories on existing CD-Roms and other technology forms force the user to follow a predetermined path to get to the end of a story (van der Mast, 1995). CD-Rom designers need to develop programs that allow students

to rearrange or add words to the story. If, for example, students could experiment with a different ending of a story they would be using decision making skills in a creative way.

Intelligence forms in the space and place category are spatial intelligence and bodily-kinesthetic intelligence (Sylwester, 1995). They deal with such concepts as here and there, stop and go, large and small, in and out, touch and ignore. Action in this category allows us to maneuver our way through our environment.

Spatial intelligence focuses on our visual and tactile ability to use artistic, architectural, and navigational processes to adapt and re-create elements of our environment (Sylwester, 1995).

Differences in the way males and females maneuver or navigate directions when using maps or their memory are further evidence that technology designers should offer more than one form or path to solve a problem. Researchers suggest that when giving and receiving directions men generally prefer to consult a map, while women rely more on landmarks (Pool, 1994).

Our brain seems to divide the maneuvering and navigational task. The left hemisphere typically processes verbal directions and the right hemisphere processes our inspection of a map depicting the route (Restak, 1994). Designing a product that accommodates these different approaches to problem solving is a challenge for designers.

Bodily-kinesthetic intelligence relates to the control over body movements (Sylwester, 1995). This requires the development of procedural memories and muscular changes that free our conscious mind to focus on

strategy. This is apparent in the actions of the pianist, mime actor, or the ball handling skills of the basketball or football player.

The two forms of intelligence in the personal and social awareness category focus on our sense of self (Sylwester, 1995). Intrapersonal intelligence is as Socrates said "Know thyself." It takes a lifetime to do this; thus the emphasis in today's education and work circles on life long learning and experience (Morton, 1996). The prefrontal cortex section of the brain where this intelligence is located doesn't mature until late adolescence, so the ability to understand and discuss complex and conflicting feelings about an issue is an advanced form of this intelligence.

Interpersonal intelligence allows us to discern differences among people and their complex emotions (Sylwester, 1995). Children, through their family, discover the social nature of life. This awareness grows as they explore their neighborhoods and other social groups that are a part of their culture. A classroom that capitalizes on the diversity of its students provides an excellent opportunity for comparisons of family values with those of other families through cooperative learning groups and project activities. A computer program that offered a format to accommodate and manipulate this information would allow students opportunities to explore, compare and contrast many social and family environments (Resnick, 1996).

A challenge in responding to Gardner's (1983) theory is how to educate toward a student's strong and weak intelligences. This political issue often surfaces around talent and gifted and remedial programs (Morton, 1996). What is to be done for the student who excels in mathematical elements but struggles with putting an understandable sentence together? Do remedial reading teachers shore up the student's lack of understanding of reading strategies or

does the teacher support and encourage the storytelling ability the student possesses? Perhaps computer programs will offer a solution to this issue.

Reading Learning Styles

Reading Learning Style is unique to each learner (Carbo, 1996). Reading style characteristics include the learner's choice of environment, the learner's emotional make up, the learner's sociological preferences, and the learner's physical and psychological characteristics (Carbo, 1996). Student needs drive instruction in the reading learning style theory. To utilize this learning style theory the teacher must identify the students' strength; match reading methods, materials, and strategies to those strengths; and provide sufficient modeling and demonstration of reading. Well-written, high interest reading materials, and comfortable, relaxed environments encourage the student to be receptive to learning.

Different reading methods and materials demand different reading strengths of the learner (Carbo, 1996). If a student has the strengths for which the method and materials are designed, a match occurs and the student learns to read easily and has an enjoyable experience. If there is a mismatch between the student and the approach, the instruction itself will hinder that student's learning to read. Computerized integrated learning systems that use the same format, language, and procedure for all students do not allow for individual learning styles; therefore the end results of these programs show that little improvement happens for the bottom third of our students academically. Increasing the reading ability of the bottom third of our students lies at the heart of our nation's most pressing educational and social imperatives (Carbo,1996).

Constructivism

Constructivism is a theory about knowledge and learning that connects theory to practice (Brooks and Brooks, 1993). It synthesizes current work in cognitive psychology, philosophy and anthropology. The theory defines knowledge as temporary, developmental, socially and culturally mediated and thus, non-objective (Brooks and Brooks, 1993). The learner is a thinker, creator, and constructor. Constructivism is about looking at how students learn. "Hands-on" experimentation and learner-generated questions, investigations, hypotheses, models, emergent literacy, and authentic assessment are at the core of this theory. There are five principles of a constructivist pedagogy: (1) posing problems of emerging relevance to learners; (2) structuring learning around "big ideas" or primary concepts; (3) seeking and valuing students' points of view; (4) adapting curriculum to address students' suppositions; and (5) assessing student learning in the context of teaching (Fosnot, Brooks and Brooks, 1993).

Constructivist classroom environments are ones where investigative research is done at the source of the issue rather than using information copied from a textbook or where student inquiry and thinking drive the lessons. Constructivist environments utilize cooperative learning situations where discussion and challenge are encouraged and where individual students are valued for their questioning, reasoning, and problem solving skills rather than only measuring their ability to give the right answer.

Implications for Design

Educators are increasingly interested in providing students with processing and computational tools that support exploration and experimentation. However, designing such tools is easier said than

done (Resnick, 1995). To accomplish this, several pieces of information have to be taken into consideration by designers and then woven together.

One of the information pieces is an understanding of the learner's preconceptions and expectations and how the learner integrates new experiences into existing frameworks (Resnick, 1995). The challenge is for the media designer to provide scaffolding to support this process which, for example, could accommodate the constructivist theory (Brooks and Brooks, 1993). The scaffolding concept could be a software program that is a skeleton or outline which a student could interact with or build upon to integrate a new idea or concept (Resnick, 1995). Learners could also challenge existing paradigms or seek a different solution or approach to solving a problem by using such a program.

A second piece of information involves an understanding of domain knowledge (Resnick, 1995). If a new computational tool or activity is designed to help students learn reading strategies, the designer should know something about reading strategies. The tool should suggest new ways of thinking about the concepts related to that domain or learning style, yet most designers are not steeped in specific content area knowledge.

A third piece of information encompasses an understanding of computational ideas and paradigms (Resnick, 1995). Designers need to understand their chosen medium. Well-designed computational tools and activities can provide students with new ways of thinking. Capturing a design that can be adapted for the kinesthetic, audio, or visual learner would be a helpful tool in teaching and learning reading strategies and accommodating multiple intelligences.

In recent years computer scientists have developed and experimented with a wide range of new programming paradigms: object orientation, logic, constraints, and parallelism (Resnick, 1995). Each offers new design possibilities, new ways to create things with computers, new ways to think about computations. However, these projects are just that, experimentations still in the research mode.

A problem with designing and integrating learning theories into media is a centralized mindset which sees things in a specific way or pattern (Keller, 1985). The centralized mindset is not just a misconception of scientifically naive high-school students. It seems to affect the thinking of nearly everyone. People tend to assume that some type of centralized control or instinct manages cars on an interstate, flocks of geese in the sky, hordes of bees in a bee hive, bacteria in immune systems and predictable computer programs that give a correct answer. That, in fact, is not a given. Each of these entities interact with the communities where they are located.

Scientists remain committed to centralized explanations, even in the face of discrediting evidence. For many years, this has been a self-reinforcing spiral so centralized tools and models were constructed, which further encouraged a centralized view of the world. Until recently, there was little pressure against this centralized spiral. Even if someone wanted to experiment with decentralized approaches there were few tools or opportunities to do so (Resnick, 1995). Creativity in this area was not rewarded.

The centralization spiral is now starting to unwind because of the awareness of learning theories that challenge the old approaches (Resnick, 1995). Some new computational tools based on the paradigm of massive parallelism are supporting and encouraging new ways of thinking. In some

cases these new tools can encourage new approaches to mathematical problems and conceptualizing mathematical ideas. They can support explorations into the workings of real-world systems. These new tools will provide an opportunity for students and others to move beyond the centralized mindset, suggesting an expanded set of models and metaphors for making sense of the world (Resnick, 1995).

A Model

The world is full of decentralized systems, but most people have difficulty understanding the workings of such systems, often assuming centralized control where none exists (Heppner & Grenander, 1990). A new modeling environment called StarLogo is being developed for pre-college students (Resnick, 1995). It will explore the workings of decentralized systems. For example, a user can write rules for thousands of "artificial ants" then observe the colony-level behaviors that arise from all the interactions of the ants. This approach can be adapted to study bird flocks, market economies or any systems that are of interest to the learner.

The premise underlying StarLogo is that people, by designing and playing with decentralized systems in StarLogo, will move beyond this centralized mindset, and develop new ways of thinking about and understanding systems (Resnick, 1995). Understanding an issue or system from different prospectives produces an overall concept that is richer and of a different nature than having only one awareness of an issue. It has the potential to supplement and reinforce other ways of thinking about an idea, concept or strategy, making it possible for new problem-solving approaches to traditional problems.

Human-Computer Interaction

The problem of human-computer interaction (HCI) is an issue of not only matching system functionality to the needs of the user in a specific educational or work context, but also a question of presenting an image of the system that can be easily understood by the user (Booth, 1992). Attempts to support design in such a way so as to overcome these problems are characterized as having moved through the 'guidelines' approach of the 1970's to an 'analytic methods' perspective in the 1980's (Booth, 1992). Designers have evolved from using a set of steps for users to follow when using a math or physics program (Catrambone, 1994) to a design system where designers strive to develop programs that can analyze information.

Developing educational software started within traditional instructional departments in universities (van der Mast, 1995). The required expertise on hardware and software was supplied by individual amateurs. Today, developing educational software is also carried out by information system developers; with the required expertise on subject matter and instruction technology being supplied by individuals considered to be "problem owners" or "consumers". In both cases, the main bottle neck for developing educational software successfully is communication and the cooperation between the different disciplines involved (van der Mast, 1995). Another void is lack of incorporation of learning styles or theories into programs.

The problem of designing interfaces so that users can operate them will continue because when the user has mastered a form, process or program a new approach or idea will emerge so further education or upgrading will be necessary (van der Mast, 1995).

to achieve (Morton, 1996). The difficulty of understanding this crucial difference is exacerbated by the focus on "tool use," which insists that the computer is there to enhance abilities already developed.

The computer should be seen as a necessary part of an educational environment that is designed to engage students in the learning process rather than as a means of improving achievement (Morton, 1996). For example a computer integrated learning system, Computer Curriculum Corporation, requires a student to complete a set of problems in a specific time frame with the goal of obtaining or achieving a certain score. The program offers no explanation to the learner as to why the chosen answer is correct or incorrect. There is no opportunity for the child to become involved with thinking skills or to add, rearrange or change information.

Special education teachers are sensitive to a child's capabilities and how that child learns and manipulates information (Morton, 1996). The special education teacher concentrates on the child's strengths and develops systems and strategies that fill in the gaps where weaknesses are evident. They are accustomed to "using what works" for the student to be able to achieve and for learning to occur.

Computer as Part of the Environment

If the computer is not to be seen as the means of improving achievement in education, then it should be seen as an integral part of an environment that is structured to engage students in the learning process (Morton, 1996). It should be an education approach that focuses on gathering information, learning how to transform the information into new knowledge, changing the role of teacher to one of a facilitator, involving children in experiential learning, and expanding

the world of lifelong learning. Educational planners and media developers have overlooked these perspectives almost entirely.

In the development of standards and outcomes, nationally and regionally, there is almost no mention of a supporting environment of computer technology. But the skills that graduating students take with them into the world must be a major focus of any serious effort to reform schools. Such computer-based skills as the ability to access and manipulate current information, the ability to communicate globally, the ability to expand creativity, and the ability to test new knowledge through sharing and rebuilding can only be developed in a supportive computer-based environment (Resnick, 1995).

Creating a Meaningful Environment

How the designer engages the learner with the technology product is key to meaningful learning; therefore the designer will need to consider several approaches to gain and maintain the learners interest (Resnick, 1995).

Constructivism suggests that learners are particularly likely to create new ideas when they are actively engaged in making external artifacts that they can reflect upon and share with others. This theory is grounded in the idea that people learn by actively constructing new knowledge, rather than having information "poured" into their head (Resnick, 1995).

Constructivism looks closely at the role of perspective-taking in learning and at how both cognitive and affective processes play a central role in building connections between old and new knowledge (Resnick, 1995). How people learn is deeply influenced by the communities and cultures with which they interact. A research learning group at Massachusetts Institute of Technology (MIT) is focusing on the social nature of thinking, recognizing that how people think and learn is strongly influenced by the communities and culture with which

they interact (Resnick, 1996). The research projects explore how new technologies and media can change relationships within existing communities, while also encouraging the development of new types of "virtual" communities over computer networks. The projects also examine the development of communities of teachers, and the development of "communities of learning" within individual classrooms and the inner-city.

Researchers must develop technological tools to support children as designers who can create their own video projects, games, robots, and simulations (Kafai, 1996). Research projects should also probe how and what children learn through the process of designing and creating (Gargarian, 1996).

Ideas about systems are important in a wide range of sciences, engineering and social sciences (Resnick, 1995). New computational media are significantly altering how researchers study and think about systems, while also making systems ideas more accessible to younger students. A MIT research project is probing how students think about systems concepts such as feedback and self-organization (Resnick, 1995). This project is also attempting to demonstrate new ways for students to learn about such concepts. The project is developing "construction kits" that allow children to create and experiment with animal behaviors, either on the computer screen or with LEGO "creatures."

Children's Construction Kit

Resnick (1995) was looking for a way to provide new ways for programmers to model, control, and think about actions that actually happen in parallel. Many things in the natural world (such as ants in a colony) and the manufactured world (such as rides in an amusement park) do act in parallel.

With Resnick's interest in parallelism he was motivated by research on a computer-controlled children's construction kit called LEGO/logo (Resnick, Ocko, Papert, 1988). It is patterned after the LEGO construction bricks children play with to build buildings and machines. The program allows children to move the bricks around to construct and program a machine. Of course, children often want more than one machine to be active at one time. For example they may want to have two cars racing at the same time. The LEGO/logo kit could only run one program which controlled one machine at a time so Resnick decided to experiment with the kit to determine if multiple processes could happen at the same time.

Resnick (1995) extended the child's "construction kit" concept by building a parallel version called MultiLogo, which put computational power directly into LEGO bricks. With these programmable bricks, children could then expand the action they wanted to occur. Children could now create "Things That Think". They could now use these new bricks to build autonomous robots; to create "active rooms" where lights would turn on whenever anyone entered a room; or to collect data related to their everyday activities. This programmable brick will provide children with a new image of computation which will give the child a sense of greater control over it.

Multiprocessing and graphical-programming capabilities are being added to the Logo programming language (Resnick, 1995). These new paradigms extend the types of projects that children can work on, perhaps even creating their own video games. They also help children develop new ways of thinking about certain mathematical and scientific concepts.

A new generation of intelligent toys with computational and communications capabilities is in the development stages (Resnick, 1995). A

Dr. LEGOHead project allows children to connect different active body parts of a LEGO character. Because Dr. LEGOHead "knows" how he has been configured, he can react accordingly. By combining computational behaviors and recognizable forms into high-level building blocks, the project makes it easy and fun for children to start programming creatures who can respond to their environment. This process allows children to explore what it means to think in a social and technological context.

Children could create their own neighborhood or school environment and program neighbors or classmates to act and interact in certain ways (Resnick, 1995). Many different social situations could be simulated and actually carried out through the use of the Dr. LEGOHead character.

Online Communications

In a study of online communications, Resnick (1995) is studying how these online communities might change the way people (especially children) learn, play and think about themselves. Participants not only "talk" and exchange messages, but they collaboratively construct the virtual world in which they interact. An online project for children called MOOSE Crossing is in the development stage (Resnick, 1996). It is the belief of the developers that this activity will help children become meaningfully engaged in reading, writing and programming as they communicate with one another.

Students will have opportunities to ask questions of, challenge, and collaborate with others who have an interest in a similar project. By creating their own virtual world children can experience and discuss real problems that are encountered when working with others.

Researchers are exploring ways for children to use news as a context for interaction and learning (Resnick, 1995). They are studying children's views of

traditional forms of news and creating new news-related tools and activities for children. They are looking at new ways for children to produce and discuss news, not just consume it. One system being developed will allow children to create their own online newsgroups, discussing ideas with other children who share similar interests.

When the online system development is completed, teachers acting as facilitators, could assist students in analyzing news events, evaluating its relevancy, checking its accuracy and debating its impact (Resnick, 1995). Students might role play an event and use their language arts skills to communicate anecdotes about the event.

An after-school learning center project called the Computer Clubhouse focuses on youth from under-served communities who would not otherwise have access to technological tools and activities (Resnick, 1995). At the Clubhouse, participants design their own computer graphics, robots, video games, interactive newsletters, music, simulations, multimedia presentations and animations. The project is focusing on how new "learning communities" can emerge in such settings.

Chapter 3

Conclusion

Educational software should be learner centered and as compelling as its entertainment counterparts (Soloway, 1995). Designing a computer program to fulfill both requirements is challenging. The words "software design" today are largely associated with the construction aspects of software. We have no name for the concept of "design for needs" or "design for a learning theory" in software. Many college students are credited with degrees in computer science each year, but according to Singer (1994) we have no schools or curricula that address this discipline of designing for needs or learning style. There are individuals who dabble in this activity, but they have no professional status and no community in which to share their knowledge. The practice of this activity is in a primitive state and except for some work in cognitive science on human-computer interaction, there is virtually no research going on to develop this discipline(Singer, 1994).

So perhaps we shouldn't be surprised by just how hard it is for us to get a computer or piece of technology to do what we particularly want done. This is a consequence of our obsession with construction and our failure to bring clarity and focus to software design as a whole. There is a need to identify, develop and empower those aspects of software design that have the greatest impact on software's fitness for use and learning theories.

Traditional "frontal teaching" shouldn't be ignored as a powerful pedagogy in software design (Snyder, 1995). While technology has made it fashionable to favor exploratory hypermedia formats for information, narrative is still necessary to get points across and to test whether a student understands

material. Like student-teacher and student-student relationships, "that ugly, linear point of view that we all have" (Snyder, 1995, p3) is important in learning.

A multistrategy learning system, in which several learning algorithms are available, and one in which an analysis of the learners' reasoning processes for the choices made, needs to be developed. This should include natural language and problem solving capabilities in the context of the design. Building a program with integrated learning theories using multiple cognitive tasks will allow interaction with problem solving responses.

Learners employ a wide variety of strategies when faced with learning and problem solving in a new domain (Recker, 1995). Analyses of students' simulations contribute several new results for understanding individual differences in strategy use and their role in learning. Results from an empirical study conducted by Recker (1993):

> showed that a relatively small proportion of strategies captured a large percentage of subjects' interaction behaviors, suggesting that subjects' approach to the learning task shared some underlying strategic commonalties.

> showed that lower performing students employed a high proportion of working memory intensive strategies, which may have partially accounted for their inferior performance.

> showed clusters of students identified through analyses of model parameters continued to exhibit similar behaviors during subsequent problem solving, suggesting that the clusters corresponded to genuine strategy classes. Furthermore, these clusters appeared to represent general learning and browsing strategies that were, in some sense, adaptive to the task. (p 3)

Extensive empirical evaluations with undergraduate students suggest that self-paced interactive learning environments, coupled with multimedia information access and constructive activities organized into cognitive media types, can support and help students develop deep intuitions about important concepts in a given domain (Recker, 1995).

Multimedia is now being touted as a current fad but multimedia educational materials have a long way to go in meeting educational standards that incorporate learning theories into multimedia software (Liebowitz and Letsky, 1996). A number of successful projects incorporating learning theories into educational multimedia software are in experimental stages such as those at the Institute for Learning Sciences at Northwestern University (Liebowitz and Letsky, 1996).

To design something is to give it the form that makes it fit for its intended use. It is a branch of human knowledge which is generally viewed as an artistic endeavor (Singer, 1994). This viewpoint is only partially accurate because design also includes engineering and science. Whether it is art, engineering, or science the form designed should be woven together to serve a purpose. It can be complex or simple.

Because more and more software users are faced with increasingly complex software needs, it is critical that we begin to address the design issue. To achieve the required clarity and focus, Singer (1994) recommends that credit and recognition be given to a research community that:

> defines a research agenda and stimulates research in software design;
> recognizes and encourages excellence in design and spreads the knowledge and methods that lead to it;

establishes a professional identity for designers;

develops a model for education for those who want to become software designers. (p. 3)

The Association for Software Design (Singer, 1994) believes that to be effective, this community must have significant representation from researchers, educators, designers, developers of software and most importantly, consumers of software.

To address the real issues of software design for use that accommodates learning theories, the status and quality of software design as an activity must be transformed and elevated.

Recommendations

Technology use will continue to be a part of educational programs because student use of the various forms of technology outside the classroom will continue to expand. Teachers will be required to use technology in the educational setting so the teacher will need to incorporate technology into school curriculums. Each of these demands will require reasoned, researched approaches involving their use.

If computers, software, CD-Roms, audio and video machines, and other multi-media forms are to assist student learning in a constructive way, the following recommendations and considerations should be addressed by the total technology community so that the many components of technology are effectively and efficiently designed and used to meet the need and learning style of the student:

1. Multimedia development is not a trivial task; to do it well requires many talents from a team that has content knowledge, learning theory

knowledge, multimedia authoring knowledge, video and audio production capabilities, graphics and user interface design skills.

2. One person normally doesn't have all the necessary skills to develop the multimedia program; the synergistic relationship of the faculty member working with the multimedia specialist is a fruitful and risk-reducing approach for building a successful multimedia application.

3. Good project management techniques must be done in order for the project to stay on schedule.

4. User feedback, testing, and evaluation are extremely helpful for refining the multimedia program.

5. An infrastructure, such as a Center for Multimedia Development, is greatly needed to assist faculty in developing joint multimedia programs and for climbing the learning curve on multimedia development.

6. Media development should be based on an understanding of human learning styles and characteristics and on how humans interact with a media product.

7. Designers understand the technical nature of design choices. They must also be educated with an in depth knowledge of the emotional rationale that supports design choices.

8. Interactive media experiences should trigger emotions that cause thinking, learning, perceiving, conceptualizing and imaging. Cognitive capacities are the vehicle through which humans translate information; therefore designers should be trained to recognize that attention, perceptions, sensations, illusions are enabling experiences that cause the user/learner to gain effective, meaningful encounters with media.

9. Money must now, be carefully invested in the "why" of interactive creation. At this point in time much money has been invested in the "how" of interactive media.

10. For media to accommodate learning theories it should focus on semantics (meaning in language), semiotics (signs and symbols), and synthetics (diverse stimuli engage a response from another sense).

11. Research on learning styles shows that each learner learns in a different way. Therefore a diversity of approaches in technology design is needed to accommodate various learners' needs.

The marriage between technology and learning theories, at this stage of technology development, is up to the classroom teacher. In order to create a meaningful learning tapestry where brain research, dimensions of learning, multiple intelligences, learning styles, and constructivist approaches are woven into processing information and learning, the teacher will have to develop her own designs. Time and resources, systems and autonomy will play a role in how these theories are implemented. The teacher will have to do most of the designing because media materials are not available at this time that speak to the various theories in an integrated format. Teachers will have to utilize more modalities and more cooperative learning approaches. They can use the media products that contain some of the learning theory characteristics and fill in the voids with other modalities and experiments.

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