Defying Gravity:
A pardigm for developing teacher skills and attitudes in CBL courseware development.

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Training Teachers to Develop Cognitively-Based Interactive Multimedia

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Abstract

The computer has transformed the process of learning as well as the manner in which societies view education. It is now an integral part

of the classroom scene, from the primary grades through tertiary education, around the world. With the development of this technology there has come a deliberate effort by educators to define, refine, and delineate the role of this exceptional tool.

The proliferation of technology at home and at work has made it easier for teachers to progress from wordprocessing and recordkeeping to designing and implementing computer programs that teach and reinforce significant curriculum concepts. This advancement in computer assisted

instruction (CAI) has come about in part because of the availability of

software tools called hypermedia (HyperCardTMxe "HyperCard™",

ToolBookTMxe "ToolBook™", Macromedia DirectorTMxe "Macromedia Director™", and Authorware ProfessionalTM) which make it easier for non-computer specialists to develop and design their own teaching applications. The potential for teachers to participate in the development of CAIxe "Authorware Professional™) which make it easier for non-computer specialists to develop and design their own teaching applications. The potential for teachers to participate in .i.the development of CAI" has been enhanced through these applications. ;It is now possible for instructors to develop their own educational courseware. While these applications provide the tools for developing software, teachers can often find it difficult to transfer traditional instructional practices to the computer format.

Background

The Republic of Singapore has become one of the worlds most successful newly industrialized nations due primarily to itís imaginative utilization of information and communications technologies in business,

industry, government and education. If everything goes as planned, fifteen years from now Singapore, the ìIntelligent Island,î will be one

of the first countries in the world to have a nationwide infrastructure

capable of connecting computers in every home to office, school, or factory. With the publication of A Vision of an Intelligent Island: IT 2000 Report the Republic has imaginatively focused on itís vision of the future.

The vision of the Intelligent Island is based on the far-reaching use of IT. It sees Singaporeans tapping into a vast well of electronically-stored information and services which they can use to their best ends - to improve their business, to make their work easier and to enhance their personal and social lives.

The contributions of teachers and educational institutions are critical for helping Singapore to achieve the status of an intelligent island.

In light of this vision, it is significant that students who will have received intensive training in instructional technology will comprise over half of Singaporeís teachers by the year 2000. Hopefully, this group of educators will routinely use technology in their classrooms while providing encouragement for other teachers to do likewise.

Research and Product Development in Educational Technology

The Instructional Science (IS) Division of The National Institute of Education is actively involved in the on-going development, assessment and implementation of programs, products and methods to improve the teaching and learning process, primarily through the use of educational technology. The IS Division is currently developing research-based materials targeted for use in Singaporean schools. Information from a recent study released by the Singapore Ministry of Education (MOE), indicates that class size in Singaporeís schools is not a primary factor affecting the quality of either educational opportunity or learning outcomes. Several studies now in progress at NIE are investigating ways to teach large student populations in addition to focusing on other issues addressed in the MOE findings.

In 1991 the National Institute of Education (NIE) became part of Nanyang Technological University (NTU) and all preservice teachers were required to demonstrate competency in using educational technology as a core requirement. Teacher training includes an intensive course covering the use of electronic media such as the OHP, photography, videotape and computers. The goals of the course are in line with the ambitious vision which intends to make the city-state a leader in the use and application of information technologies by the end of the century.

Computers Inducing Change In Schools -- Around the World

Recently, students and teachers have been given a great deal of exposure to computer technology in schools . Brown, Collins, and Duguid (1989) refer to this exposure as conveying to students and teachers a measure of ìauthenticityî to the use of the equipment in the classroom setting. David Dwyer (1994) on the Apple Classrooms of TomorrowSM (ACOTSM) project reports that primary-grade students:

. . . practice basic skills at individualized rates, including keyboarding. They compose their writing on computers using a variety of word-processing software. Their reports are sometimes desktop published and sometimes produced with multimedia toolsóvideo cameras, VCRs ,videodisks, animation tools, flatbed and hand-held scanners, and sound digitizers. Second graders program using Logo_ and HyperTalk. By third grade, students construct robotic devices and program their movements using LegoLogo_, and they master telecommunication, database, and graphic software.

The ACOTSM project has provided a benchmark experiment to set new goals and standards by which technology can be integrated into the educational environment. Among the discoveries of the project:

o Teachers were not hopeless technical illiterates. In fact, over time they personally appropriated technology for creative expression and personal work.
o Children did not become social isolates. In fact, cooperative and task-related interaction among students in the ACOTSM classrooms was spontaneous and more extensive than in traditional classrooms.
o Children's interest in and engagement with the technology did not decline with routine use. In fact, they demonstrated a steady fascination with the technology and used it more frequently and imaginatively as their technical competence increased.
o Children, even very young ones, did not find the keyboard a barrier to fluid use of the computer. In fact, with as little as 15 minutes of keyboarding practice daily for six weeks, second and third graders commonly typed 20-30 words per minute with 95% accuracy. By comparison, children at that age typically write nine to eleven words per minute with pens or pencils.
o Software did not prove to be a limiting factor. In fact, ACOTSM high-school teachers took an early lead in imaginative integration of technology across their curriculum by adapting general productivity toolsó   word processors, graphics programs, databases, spreadsheets, and HyperCardTMóto educational ends. Elementary teachers, too, learned the benefits of tool software and by the second year of the project, drill-and- practice software was used less and tool software more.

In the process teachers were successfully translating traditional materials for instruction ie. text-based, and lecture-recitation-seatwork, into the new electronic medium (Dwyer, 1994).

Trends for the future

The use of computer technology in education has seen many trends which have provided methods for the integration of computers into the learning environment to enhance student development. Each has made progress toward a more definitive understanding of the computerís relationship to/with the learner and learning. As in the above example when teachers and students work collaboratively with the aid of technology as a tool for learning new paradigms result. Some even qualify as trends or trend setting ideas, processes, or models.

In looking at several trends (Collins, 1994) which are emerging from the research being done on using technology for instruction, several examples appear as possible bellwethers.

1. A shift from whole class to small group instruction

From the ACOTSM project we find that Gearhart, Herman, baker. Novak, and whittier (1990) found a remarkable decrease in activities which were led by the teacher and a comparative increase in activities where students functioned collaboratively and independently.

2. A shift from lecture and recitation to coaching.

Also from the ACOTSM project we find that Gearhart, et al. (1990) detected a shift from teacher directed activities to ones which were primarily facilitated by the teacher where the teacher provided the coaching -- assuming the role of guide and observer.

3. A shift from assessment based on test performance to assessment based on products, progress, and effort.

According to Johassen, Wilson, Wang, and Grabinger (1993) in learner controlled environments the learners detemine the information accessed, they choose the activities they engage in and the type of information which goes into the project/product. The assessment of this type of activity creates a need for movement away from the traditional classroom test.

Schofield and Verban (1988) state in instances where teachers set up a project based curriculum the evaluation of the students tends to be based on the products that emerge from the studentís efforts.

4. A shift from students all learning the same things to learning different things.

With the increasing use of computer technology in the classroom, Dwyer, et al.(1990) and Carverís (1990) observations point to the fact that on complex projects students are comfortable working on specific aspects of the project and then integrating their information for the final report.

5. A shift from the primacy of verbal thinking to the integration of visual and verbal thinking.

The integration of visual and verbal thinking is a relatively new area of study for educators but evidence (Eriksson, 1988; Resabek & Ragan, 1988; and Thompson, 1988) points to the usefulness of visual thinking skills, problem solving and creative expression in our shift toward a more visual society.

These patterns provide a basis for this study which examines the potential of hypermedia as a classroom tool. An analysis of the above results raises some fundamental questions. For example, what form will the tools for the new application paradigms take? The present classroom tools are ones which facilitate the recording and organizing of information i.e.. word-processing and data base management. The new tools characterized by hypermedia applications provide for a more broad dimension of expression. Their strength lies in the presentation and viewing of information in a variety of non-linear and multi-modal approaches. These hypermedia tools address the non-linearity of learning. They present the selection of information in textual, graphic, auditory and visual (video and animation) form --meeting the needs of a variety of learning styles. No longer does the individual need to know the physical location of the information or data. They can simply select the connections, usually called links, they need. Addressing a new concept without having to scroll through or read sequentially all of the irrelevant information is a definite advantage.

Interactivity can now be built in to courseware so that individuals can test hypotheses, challenge their understanding, or insert values in an equation or formulae to validate a theory or obtain alternate results based upon varying conditions. With this capability, online tutorials and computer based instructional modules can be produced which fit the learning environment and the nature of the intended audience. Navigation of the material has become one of the major obstacles in assimilating information associated with the process of learning.

The Teacher as Coach, Facilitator, Guide, Modeler -- Anything But Programmer!

From the introduction of the desk top computer in schools, the teacher as programmer is a topic which has been questioned at length in the educational community (Hilgenfeld, 1984). However the argument here will concentrate on a change in perception toward the teacherís role as

coach, facilitator, guide, and modeler.

When we look at the role of the computer programmer we see one who deliberately sets about formally writing an instruction set for a computing machine. The object is to develop a set of repeatable tasks which will function for a definite set of conditions. The job is to develop a specific set of instructions which form the basis of a product such as a wordprocessor or simulation activity. The programmer

is an expert in the language(s) of the computer

The teacher is an expert in the language(s) (processes) of education. In considering the paradigm shifts mentioned earlier, the educator is the specialist most suited to provide the necessary pedagogical

expertise in the form and content of courseware. Earlier attempts at integrating computers into the classroom brought with it a wave of computer courses whose major aim was to teach students to program in BASIC. Teachers were asked to take courses in the use of the computer and again most of the instruction was in a computer language rather than in computer applications. lethargically that movement shifted toward the emphasis of the computer as a tool/aid in the classroom setting with pre-programmed resources. These applications have improved

greatly since early ones like Apple WriterTM and VisicalcTM were introduced in the early eighties. From the evidence above, (Collins, 1994) the computer will continue to be widely used. As the technology

becomes more powerful and functional, utilization/application in the classroom will increase.

Future tools may expand in capability or may shift in focus. For example, with the revolution which has taken place in multimedia, the tools for the development of computer assisted instruction have been placed within easy reach of educators, whether they are formal developers or classroom teachers. Hypermedia programs which provide a framework or shell for development allow a person with minimal programming knowledge or skill complete access to integrate the power of graphics, sound, animation and video. Using the computer as a vehicle to combine and synthesize these different forms of media promises great potential in the educational scene. Now teachers can develop small conceptual CAI packages and they do so by concentrating on the subject and not on the frustrating exercise of computer programming.

A Structure for Effective CAI

Some research studies have investigated the role of computers in education (Taylor, 1981), and the effectiveness of teacher beliefs and practices in technology-rich environments (Dwyer,Ringstaff, and Sandholtz, 1991), etc. Additionally there are many theories of learning that can be applied to CAI design including Gagne (1983), Skinner (1957), Piaget (1970) and others. This article, focuses on the use of a traditional and well validated educational theory, Bloom's Taxonomy of Educational Objectives, for developing computer programs intended for use in an individual class or within a particular school system. Using Bloom's Taxonomy as a guideline for CAI is particularly helpful because it builds upon existing practices of effective education.

Bloomís Taxonomy of Cognitive Objectives (Bloom, et. al., 1956) has helped to change the way educators view the learning process. Bloomís Taxonomy, along with the theories of other educators such as Piaget (1970), Gagne (1965) and Bruner (1962), give teachers a practical guide for identifying goals, designing instruction and creating classroom activities. By using Bloomís Taxonomy or Piagetís Stages of Development teachers can introduce new concepts and build on prior knowledge in a planned and sequential manner.

Bloomís Taxonomy classifies different stages of knowledge from the most basic to the most complex (knowledge, comprehension, application, analysis, synthesis, evaluation). The taxonomy assumes that the earlier stages of cognition are necessary for the development of the latter stages. For primary school learners the first three levels should be attainable and teachers should include activities that reinforce learning at each level. While these levels roughly correspond to Piagetís stage of concrete operations the remaining three levels are more appropriate for secondary or tertiary education and correspond to Piagetís stage of formal operations. Many teachers have used Bloomís work to help them develop activities, sequence instruction and teach different cognitive levels of curriculum concepts. Unfortunately, for many teachers Bloomís Taxonomy often becomes just another table to memorize with hardly any connection to instructional practices. Table 2 summarizes the taxonomy and suggests some procedures for developing computer assisted instruction.

Stages of Bloomís Taxonomy of Cognitive Objectives

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Figure 1.

Theory into Practice

It is very effective when practitioners, teaching on a day by day basis, design materials and information for their classroom. Until recently the development of computer based materials has been left to computer programmer types who understand the computer and the way it functions well, but did not necessarily know a whole lot about the art of teaching. Concepts of courseware design and lesson development gave way to the challenge of stretching the computer technology to its limit with flashy animation and graphics-- while little attention was paid to the actual content and pedagogical course design.

Addressing the Focus

At present, teachers are required to perceive instructional technology as being more than just an accumulation of hardware/software which must be used because someone said it was a good idea. They are expected to become profecient in ITs use, but even more importantly, they need to develop an understanding, at the functional level, for the processes of educationís changing role. In this discussion we will explore the notion that the exercise of learning the development tool and the design of courseware allows the teacher to explore their own metacognition and discover the potential of experience and how it relates to teaching, explaining, coaching, guiding, and facilitating.

Knowledge/Facts Level

Questions which require recall of factual material.

How much is . . . How did . . .
Who is . . . Where is . . .
What is . . . Where was . . .
When was . . .

Comprehension Level

Questions which require the students to think more broadly, show more in-depth
understanding, explain using their own words.

Demonstrate the meaning of . . How is this similar to . . .
Paraphrase, . . . How is this different from . . .
In your own words, . . .Explain the meaning of
Give an example . . .(the story, a graph, etc.).

Application Level

Questions which ask the students to apply learning to a new situation or to develop a product.

What would happen if . . .Teach her the meaning of . . .
Using the story as a basis, write . . .
With your knowledge of angles, build . . .
Apply the formula to the following problem . . .

Table 1. Bloomís first three levels of cognitive objectives

A technology-based system should be designed with these characteristics in mind. First, the outcomes/learning/change which takes place is directly dependent upon the design. Second, the outcomes are only as valid as the initial design components. It is the information which is based upon the cognitive and metacognative, rather than the motivational and social aspects of the computer-based tutoring process that we have studied here, at the National Institute of Education (NIE), Singapore.

At the National Institute of Education (NIE) in Singapore we are working with educators to develop Computer-Assisted Instruction (CAI) aimed at teaching and reinforcing these emerging new basics of learning. Worldwide, there is a small but growing number of teachers who are creating their own instructional multimedia lessons combining audio, video, animation, text and graphics. In most Singaporean schools the small ratio of students to computers helps to make teacher-made software a potentially effective and motivational instructional option.

A Course, of Course

As part of teacher preparation at NIE we offer two Computer-Assisted Instruction design courses entitled Instructional Message Design, and Instructional Design and Computer-Based Learning. They are serving the needs of teachers in training by giving them experience using both HyperCard (Macintosh) and ToolBookTM(Windows) as CAI design tools. The course goal is to train teachers to author interactive multimedia presentations using the principles of Bloom's Taxonomy of Cognitive Objectives in a real computer based learning application environment as

a key to program development and student assessment. Since class time is limited to only 20 hours we follow a project-oriented approach utilizing procedures that educators are already familiar with, but

donít often use to create instructional media.

The students (all Post Graduate Diploma in Educaton candidates for

primary school teaching) are prepared with lectures involving the theory of courseware design and instruction in the elements of the ToolBookTM application basic command structure. They are shown examples of both good and poor CBL modules and given critical evaluations of these programs. Then the students are given guidelines which they are to use in the construction of their own attempt at CAI.

The lectures are designed to give the students ample opportunity to explore the elements in courseware design and allow the students to experience some of the same learning which is the focus of the theory.

Students experience their own development as they learn the necessary skills executing the ToolBookTM commands to produce their project as one would experience Bloom's levels of cognition in any concept acquisition exercise. As they progress, they become increasingly aware

of the close relationship of their own learning with their need to carefully analyze and synthesize the appropriate information necessary for an accurate and complete CBL module. Their success depends, to a great extent, upon their ability to integrate the lessons of Bloom in their computer instruction on a theoretical, philosophical, educational

and practical application level. The success is measured as the final mark received for the project.

Two important elements are addressed when teaching the CBL and design course in this way. First, we are not requiring that students be computer programmers to succeed. We provide them with the elementary controls and commands necessary to construct a usable electronic book.

Second, after thoroughly covering all the elements of Bloom we then show them the extent to which they can apply the first three levels of the Taxonomy. They construct a class project which is built around a theme such as the environment or keeping healthy. The students then apply one of their courses of study to the theme and design a computer based learning package which incorporates the above elements into their

project. We have chosen the first three levels of Bloom to be accomplished within the CAI module because of the short nature of the course (2 units), and the complexity of learning, concurrently, the cognitive theory and the functional scripting of the computer.

Preliminary Description of Results

An opinionnaire was developed to gather data on studentís attitudes toward the use of computer-based learning and their confidence in applying the cognitive objectives of Bloomís Taxonomy to their projects. Three classes (n=48) were sampled.

The students were asked to answer the questions based on a five-point Likert scale (1 to 5) ranging from not confident to strongly confident respectively. For this report an analysis of four questions of the larger study have been included which directly relate to the introduction of the Bloom objectives. A correlated samples t test was

used to compare the data observations in the first opinionnaire to the

data observations in the second treatment.

Hypothesis: Studentís will be no more confident if asked to use their knowledge of Bloonís Taxonomy to create instructional activities after their exposure to Bloom and the treatment exercise than before.

Means and standard deviations of the pre- and post-test were computed, the differences between the means were analysed. The participants were

given an oppionnaire at the first session of the course as the first activity. A subsequent test containing identical questions as well as additional ones as the last activity was given in the final class meeting.

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Table 3. Questions appearing in the pre and post-test

1. I have knowledge about Bloomís Taxonomy of Cognitive Objectives

2. I feel confident that I can use Bloomís Taxonomy when creating instructional activities

Two additional questions were asked in the post-test opinionnaire, and dealt with the studentís perception of the usefulness of this experience as method in their preparation for teaching. Respondents expressed confidence in Question 3 that students would benefit from the teacherís use of Bloomís Taxonomy in the development of courseware like the design course project. The mean results of the forth question showed less confidence on the part of the students that the transfer of

trainig would aply to the design of course materials in general.

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Table 5. Questions apperaing in the post-test only

3. The average student will learn better if I present information in courseware using Bloomís Taxonomy as a guide.

4. Now that I have used Bloomís Taxonomy to create a computer-based learning program I believe this experience can help me to design other types of materials for instructional purposes.

As we proceed with the development of methods which will help us to accelerate the learning of the core command set for ToolbookTM we hope to parallel that with improved methodology which will provide students with better methods of accessing their own meta-cognitive and cognitive

activity as they learn about their own learning. Much of the above activity reports on the exploration of a new dimension in the way in which we present the notion of the application of new classroom tools in the process of learning and developing Bloomís cognitive objectives

and the way in which cognitive objectives still form a basis

Bloomís solid structure (In fact, a recent search of the ERIC Database in the library turned up over 400 references to Bloomís Taxonomy of Cognitive Objectives.) can form a basis for the development of

cognitive and meta-cognitive skills within the framework of a tool which provides a glimpse of the future and the types of tools which teachers will use to provide course ware/work in unique and creative ways.

Summary

The new wave of object-oriented programming has allowed the developers of the Hypermedia tools to place these highly sophisticated software machines in the hands of individuals in such a way that they can understand and apply them to a wide variety of applications in training and education. No longer is the use of CAI only limited to the highly technical oriented segment of the educational community. The teacher with normal skills and some study can learn to develop tutorials, drill

and practice programs and even sophisticated multimedia productions. Coupling the computer with the mass storage devices now available such as CD-ROM elaborate presentations can be developed and displayed on a variety of common computers. The challenge however is to ensure that the design of the material is not only accurate and interesting to hold

the learners attention but also is pedagogically sound so that the information presented follows well researched and documented successful

educational procedures and guidelines.
Experienced teachers have been using tools such as Bloomís Taxonomy of Cognitive Objectives, Piagetís Stages of Development, Gagneís Events of

Instruction and other theoretical models to improve the teaching and learning process in their classrooms.

Using Bloomís Taxonomy as part of the CAI development process is one way to insure that computer-assisted-instruction will be more than just

a novelty or a one-time activity for passing a college course. The activities, procedures and questions that evolve from this process are also suitable for other instructional formats and can be used in many subject areas. This leads one to postulate whether re-inventing the wheel is a cyclic phenomonon.

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