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ABSTRACT

Technology and Basic Skills in Mathematics (TABS) is a project to develop innovative technology-based instructional materials at the upper elementary or middle school level, emphasizing the non-computational mathematics basics of probability, geometry, estimation, and computer literacy. In each area, attempts are being made to bring together curricular analysis, analysis of microcomputer capabilities, measurement of individual differences, the psychology of a responsive environment, criterion referenced evaluation, and cognitive psychology. This joint analysis leads to the project's guiding question: For what concepts or processes within a given curriculum area do the unique capabilities of the computer allow us to apply sound educational principles in new ways? The real promise of computer software in instruction lies in the capability for providing learners with new types of interactive experiences. Six levels of possible interaction have been identified: watching, finding, doing, using, constructing, and creating. To make the best use of the technologies available, we must analyze the instructional task and apply appropriate computer tools to it. (LMM)

FITTING THE TOOL WITH THE TASK:

A PROBLEM IN THE INSTRUCTIONAL USE OF MICROCOMPUTERS

by

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Fitting the Tool with the Task:
A Problem in the Instructional Use of Microcomputers

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In a recent issue of the Journal of Computer-Based Instruction, Harold Mitzel (1981) addresses the importance of theory in applying technology to instruction. To summarize Mitzel's important statement briefly (and I hope without injustice to his writings), he discussed five concepts of individualization and admonished educators and especially those educators working with computer technology for focussing on only one of these concepts, namely allowing the learner to proceed through teaching materials at a pace which is comfortable to the learner. Going on to address other aspects of the theory of instruction, Mitzel identified four theoretical roots for a theory of application of technology, and computer technology in particular, to instruction. The roots he identified were the measurement of individual differences, the psychology of a responsive environment, criterion referenced evaluation, and cognitive psychology. In a charge to his readers, Mitzel argues that the most important long-term task for those involved in computer-based instruction is to evolve and explicate a theory of instruction which draws heavily upon, but is not bound by, these roots. I believe that all the papers in this symposium are steps towards this theory. For my own part, I would like to make a few observations related to the instructional analyses we have made and the student learning we have observed in work on the TABS-Math project.

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Briefly, TABS-Math stands for Technology and Basic Skills in Mathematics, and is a project to develop innovative technology-based instructional materials at the upper elementary or middle school level. The project emphasis is on non-computational basics in mathematics: probability, geometry, estimation and computer literacy. In each of these areas we are attempting to bring together elements of the four roots identified by Mitzel as well as curricular analysis and analysis of the capability of the microcomputer.

This joint analysis leads to the question which guides the work of the project: "For what concepts or processes within a given curriculum area do the unique capabilities of the computer allow us to apply sound educational principles in new ways?" Implicit in this question is the idea that the computer is more appropriate for some learning objectives than others. In narrowing the scope of curriculum for computer development, this appropriateness is determined by examing educational theory and computer capability, and to some extent a philosophy.

One of the first principles that we have adopted for the development of materials is to look at what the computer does best. In this connection it is important to remember that computers were invented for the purpose of performing tedious tasks that human beings would rather not do. I find it ironic that much of the educational software being designed today uses the computer to lead children in the learning of just such procedures.

The first aspect of narrowing the curriculum for computer era education is, in my eyes at least, to eliminate from the pool of topics for development all those which can in reason be turned over completely to the computer as jobs in the so-called "world of work." In so doing we should relegate all

all complex computations to the computer while retaining in the curriculum basic facts and the meaning of the arithmetic operations. With regard to some computations this decision is relatively easy. However, it is not known how the study of computational technique interacts with other study to foster understanding of arithmetical operations. Educational research is needed to determine what belongs in the overlap between computer work and human work.

While the curricular narrowing sited above is related to the nature and function of the computer, a second principle for narrowing the scope of curriculur materials has to do with the nature of learning and the roles of computer capability in facilitating it. Traditionally computer based education has been thought of in four areas:

Drill and Practice (e.g., automated flash cards)
Tutorial (e.g., automated textbook)
Simulation of Situations (problem solving)
Games

Since these types were first identified, the input, output, and graphics capabilities of computers have been greatly enhanced. These changes provide the opportunity to think beyond the accepted meanings of these classifications. For example, there are many activities for which the computer is an appropriate tool, and which lend themselves to brief, frequent, and varied instructional treatments, but do not fit the usual interpretations of "drill and practice." For example, the computer can be used to involve learners in activities which involve directed exploration of systematically generated graphic phenomena, can be quite instructive although they are neither drill and practice nor tutorial, at least in the strict sense of these terms.

In the remainder of this paper I will argue that a real promise of computer software (courseware) in instruction lies not in the drill and practice or tutorial programs available today, but in the capability for providing learners with new types of interactive experiences. Carefully constructed courseware will grow out of consideration of curricular topics and computer capability in conjunction with Mitzel's four roots: individual difference, the psychology of a responsive environment, criterion referenced evaluation, and cognitive psychology.

We are all familiar with the notion of a learning continuum and its implications and interpretations. A primary questions to be asked of the computer as an instructional medium is where it fits on this continuum.

Enactive — Iconic — Symbolic

In the early days of computer based education, the available input/output device was the IBM terminal with much the same production capability as a typewriter. The mode of learning through such a terminal was, of necessity, symbolic, for although the computer could be programmed to analyze spatial relationships, for example, the terminal could communicate only through symbolic (e.g., quantitative) representations of these relationships. As hardware developed and plotters became available as peripherals for CBE systems, the computer became a useful tool for producing diagrams; thus the possibilities for computer based learning began moving toward the iconic mode.

In 1982 we have moved beyond the iconic mode toward the enactive. Interactive graphics enable us to simulate objects on the CRT; learners can then manipulate these objects through a variety of input devices ranging from keyboard through joy sticks; light pens, digitizer pads, and touch sensitive screens.

Interaction between learner and computer can take many forms; the following six levels of interaction, scated in terms of the learners activity, have been identified:

1) Watching - directed attending to a computer display, frequently aminated graphics
2) Finding - examining computer display or printout in search of a predetermined object or event
3) Doing - perfomring a requested operation
4) Using - using a computer generated object in the performance of a task
5) Constructing - causing the computer to produce a specified object using simpler computer generated objects
6) Creating - causing the computer to produce an object (graphic display, printout, etc.)

The appropriateness of each of these interactive modes to an instructional sequence is related to the instructional goal. The following matrix suggests some of the potential correspondences between goal and level of interaction currently being explored in connection with the TABS-Math project.

The enhanced capabilities of computers available for instructional purposes today have the potential for providing us with many new tools for teaching. Most of the courseware available to date does not begin to tap this potential. If we are to make the best use of the technologies available to us, we must analyze the instructional tasks and apply appropriate computer tools to it.

Area ______________________

Topic: ______________________

Level of Interaction

Cognitive Goal	Watching	Finding	Doing	Using	Constructing	Creating
Concept Development						
Practice with Concept						
Application of Concept						
Problem Solving						

Notes