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ABSTRACT

The integration of technology into standard curricula is expanding with availability of educational software and teacher recognition of the role of technology in improvement of students' problem-solving/critical thinking skills. The basic components in problem solving are a good problem statement, a research and development component, a testing of solutions component, and an evaluation component. Technology educators must consider that critical thinking skills are best taught within the context of specific disciplines or subject areas. A systematic approach for problem solving includes three steps: understand the problem statement, develop a systematic plan, and check solution or answer. Multimedia computer technology makes it possible to present rich problem-solving environments. This powerful technology is perceived as a way to teach not only content but also thinking or reasoning skills. Multimedia technology is a powerful educational tool that can deliver an individualized presentation of information that is difficult to achieve in the classroom or laboratory setting. Through this interactivity, learners actively develop the thinking skills necessary in technology education and other disciplines. Problems related to integrating multimedia into teaching include student complaints about additional workload and added hassle of computer access, the "computer ignorance" factor, and "inertia factor" in the faculty. (Contains 38 references.) (YLB)

USE OF TECHNOLOGY IN DEVELOPING PROBLEM SOLVING/CRITICAL/ THINKING SKILLS

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Use of Technology in Developing Problem-Solving/Critical Thinking Skills

Introduction

In the last few years, problem solving has become one of the most important fields of research in several areas such as mathematics and physics. Among the large number of studies on problem solving performances are Buchanan (1987), Lemoyne & Tremblay (1986) and Lesh (1985).

As a result of these studies, the integration of technology into standard curricula is expanding as more educational software become available and teachers recognize the role of technology in the teaching/learning process and the improvement of students' problem-solving/ critical thinking skills. Using technology to assist in interdisciplinary learning is still in its early stage (Charp, 1992). Greater use of technology in education is resulting in the reexamination of curricula across disciplines and across all levels of education.

According to Dumaine (1989), the most successful organizations in the 1990s will be called learning organizations --consummately adaptive enterprises with employees who think for themselves, identify problems and opportunities, and go after them. He also indicated that, faced with future challenges, leaders will have to be the best learners of all. The National Education Goal Panel (1992) has stated that critical thinking is now a national goal; critical thinking is needed for economic competitiveness; and without workers who can think critically, the U.S. will continue to become less and less competitive.

Hayes et al (1988) agreed that the effective corporation of the 1990s will be a learning organization, one in which employees teach themselves how to analyze and solve problems. They indicate that managers have to encourage employees' experimentation with finding better ways to do things. Besides, as Reich (1992) pointed out, the future belongs to the critical thinkers.

Problem-Solving Skills

The increasing importance of technology in everyday-life, along with the diffusion of computers has induced a lot of educational projects to focus on strategy building abilities more than on written computational performance. The reason is that research has shown a very poor correlation between the ability at performing written calculations and problem solving skills, as reported by Nesher (1986).

For example, technology competence cannot be identified with the knowledge of a given set of concepts and rules, but rather with the ability at using technological concepts and procedures to solve problems, in particular real problems. 'Real problems' refer to problems students continually deal with in their experience and that are meaningful concerning the technological structure. Real problems often embody many technological questions that require students to deal with schematization processes that are much more complex than the ones designed only to test the application of a formula, rule or definition (rote memorization).

The task for a sound educational method should not be to teach students a set of problem solving techniques. Technology educators must understand that what they teach is the process, not the techniques. Technology should allow teachers to be facilitators of learning more than lecturers. Students should be able to deal with a wide range of problem situations and construct specific strategies to obtain a correct answer, using fundamental concepts but also from their knowledge about the problem situation.

There are studies showing that content-dependent strategies should be enhanced. For example, some studies, reported in Lesh (1985), show that good problem solvers use 'strong' content-dependent strategies, whereas average or poor solvers prefer 'weak' content independent ones. Also, there is a positive correlation between problem solving skills and the mastery of the specific problem situation.

A Guide To Problem Solving

According to the outcomes of an International Conference on Critical Thinking (1993), a well-cultivated critical thinker:

a. raises vital questions and problems, formulating them clear and precisely;
b. gathers and assesses relevant information, using abstractions to interpret it effectively;
c. comes to well-reasoned conclusions and solutions, testing them against relevant criteria and standards;
d. thinks open-mindedly within alternative systems of thought, recognizing and assessing, as need be, their assumptions, implications, and practical consequences; and
e. communicates effectively with others in figuring out solutions to complex problems.

The basic components in problem solving are a good problem statement, a research and development component, a testing of solutions component, and an evaluation component as shown in Figure 1 (Lindbeck, 1972; Waetjen, 1989). Technology educators must consider that critical thinking skills are best taught within the context of specific disciplines or subject areas (McEwen, 1993). Therefore, a systematic approach for problem-solving is as follows (see Figure 2):

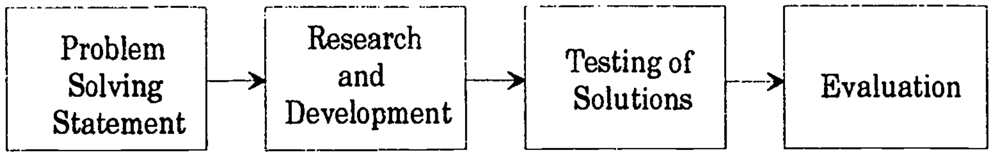

Figure 1. Basic components in problem solving.

1. Understand the problem statement
   a. Read the problem carefully
   b. Determine what to look for
   c. Identify relevant information
2. Develop a systematic plan
   a. Break down the problem in small steps
   b. Identify all the information or concepts that pertain to each step
   c. Select the best information or concepts to solve each step
   d. Decide how to integrate all the identified information or concepts
3. Check solution or answer
   a. Verify that *all* the important information or concepts are used
   b. Check that solution or answer is feasible
   c. State solution in a written report and/or diagram and/or by actually solving the problem.

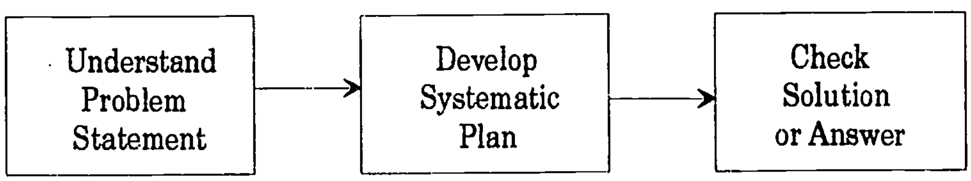

Figure 2. Systematic approach for problem solving.

Multimedia in Developing Problem-Solving Critical Thinking Skills

According to Menn (1993), we remember only about 10% of what we read; 20%, if we hear it; 30%, if we can see visuals related to what we are hearing; 50%, if we watch someone do something while explaining it; but almost 90%, if we do the job ourselves–if only as a simulation. In other words, interactive multimedia–properly developed and properly implemented–could revolutionize education.

Traditional teaching of problem solving has generally abstracted problems from the real world and simplified them into supposedly meaningful and understandable chunks. From the student's point of view, the result has often been problems that seem capricious, trivial, and often silly. From society's point of view, the result is a very large number of students who are unable to solve problems in their work or in their lives (Olds 1993). With multimedia computer technology, it is now possible to present rich problem solving environments. This powerful media is perceived as a way to teach not only content but also thinking, or reasoning, skills--those skills necessary to solve problems in the real *world.*

Problem solving is an interactive process in which students examine available information, identify critical features, then compare and analyze the relationships among the information to make informed decisions. To develop such critical thinking skills on students, technology educators must consider teaching principles such as (a) emphasizing the critical features of a problem, (b) presenting material frequently in varied contexts, (c) guiding the learner through successive steps of complexity, (d) providing opportunities for practice with immediate feedback, and (e) making connections between new information and previously acquired knowledge. Multimedia can be an effective tool for incorporating these teaching principles through the integration of video, graphics, animation, and sound, and through the strategic application of behavioral principles. Multimedia applications enhance classroom presentations and provide the learner an opportunity for independent exploration and practice. Students ultimately develop such component skills as screening, discriminating, comparing, and evaluating problem information.

Multimedia is indeed a powerful educational tool that can deliver an individualized presentation of information that is difficult to achieve in the classroom, or even in a laboratory setting. It allows a learner to construct and test different solutions to a problem by interacting with data, sound and graphics. Through this interactivity, learners actively develop the thinking skills necessary in technology education and other disciplines (Aminmansour, 1993; Barker, 1993; Quinn, et al, 1993; Tomek, et al, 1991).

Computers in Acquiring Problem-Solving Skills

Problem-solving critical thinking skill is an important area of instruction (Resnick, 1987) and an obvious approach is to use computer support for such instruction (Quinn, 1988). While one approach would be to have the computer present information on cognitive skills (Quinn, 1992a), or to model the information processing aspects of such skills (Quinn, 1992b), the development of problem-solving critical thinking skills not only requires the presentation of information on such skills, but on opportunities to practice and refine them (Collins, Brown, & Newman, 1989). Thus, another possibility is for the computer to serve as a powerful practice environment (Sherwood, 1990).

On the other hand, some researchers have challenged the role of the computer as an authorized teacher for transmitting knowledge. Self and his colleagues suggested that the computer can be treated as a collaborator or a co-learner. Self, 1985; Self, 1986; Gilmore &

Self, 1988; and Cumming & Self, 1990 argued that the teacher's role played by the computer should be de-emphasized. Chan & Baskin, 1988 and 1990, proposed that the computer be considered as two coexisting agents, a teacher and a learning companion. More recently, Pathepu, Greer, and McCalla (1991) suggest treating the computer as a student and the human learner as a teacher.

Disadvantage of Computer Simulation

Interactive computer simulations of technology experiments are increasingly common. Such programs are potentially popular with students and teachers as substitutes for laboratory experiments in technology education. However, there are two major problems: first, computer simulations usually do not show details of the experimental set-up. Such details are important if the program is to be maximally useful for teaching because manipulative skills' acquisition is an important aspect of practical laboratory classes. Second, such simulations generally rely on mathematical models of actual experiments. Therefore, they deprive students of the opportunity of working with real experimental data using real instruments, which are critical factors in technology education.

Problems in Integrating Multimedia into Teaching

It is one thing to design or select a model that greatly facilitates student learning and is easy to use; it is quite another to persuade professors to implement the program in their classes. Some of the problems are (Smith & Debenham, 1993):

1. Students complain more about the additional workload and the added "hassle" of computer access.

2. The "computer ignorance" factor is a major obstacle for both students and professors. Many have never used a computer before, especially for instruction, and must be taught. Faculty do not like to "feel stupid" about the new technology and, consequently, resist innovative applications.
3. There is an "inertia" factor in the faculty: it is hard to change the way things have been done for so long. They, like most people, are reluctant to alter comfortable ways of doing their job. This is especially true when the potential changes will lead to academic displacement and less job security.

Conclusions

The increased amount of knowledge base has forced educators to change their strategies in regards to preparation of students for the world of tomorrow. Plain memorization is outdated. Educators must teach students how to improve their problem-solving skills, to learn how to learn and improve their strategies for asking good questions.

The effectiveness of problem-solving is not possible without good thought problems. It requires time and planning to create problems that allow students to try different solution strategies, that can be varied and extended, that provide a good chance for success, that have content, and that ask students to apply what they know to new situations.

Solving problems is not easy; it is hard work. However, technology educators are enthusiastic about solving problems. When students perceive teachers' enthusiasm, they tend to solve problems with more enthusiasm. We always have to encourage and guide students to do their best.

The use of computers and multi-media has opened new possibilities for educators and students in acquiring the necessary skills needed in the ever changing technological era. A good design of multi-media in education is an invaluable resource and aid for students to learn at their own pace. They can learn the basic concepts of any subject on their own and use teachers' expertise to learn more advanced and difficult concepts. For technology educators, the use of multi-media frees them to do basic chores and concentrate on tasks that may benefit students.

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