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ABSTRACT

In order to provide teachers with support for the improvement of computer-based problem solving, this paper considers the following research questions--and provides answers--about how to teach students problem solving and how to design training courses for teachers: (1) What are the teachers' and researchers' assumptions about the relation between teaching and learning?; (2) What constitutes "good teaching" in technology-based classrooms where problem solving is a goal and what do "good" teachers do that their colleagues don't do?; (3) What is the relation, if any, between "good teaching" and students' ability to problem solve successfully?; (4) Have schools or school systems successfully overcome teachers' resistance to using technology and how successfully have those teachers been trained?; (5) What results, in terms of student learning, have accrued from change strategies directed at increasing or improving the teaching of problem solving?; (6) What types of training for what duration and with what frequency with what types of teachers--veteran teachers, new teachers, teachers who believe in "hands-on" and teachers who "go by the book"--produce "good teaching?"; (7) How do different training strategies produce positive changes in students' problem-solving behavior?; (8) What different types of training strategies need to be employed to deal with differences in teachers' beliefs about what should be taught and how it should be taught?; (9) What types of training are needed to provide teachers with both the mathematical knowledge necessary to conduct problem- solving lessons and the pedagogical skill to use technology for those lessons?; (10) What differences, if any, are there in the outcomes in students' learning to be problem solvers when computation is the sole or major focus of computer use versus experience with problem solving software, and does ILS use contribute to or detract from problem-solving expertise?; and (11) What role does the choice of measures play in efforts to learn about the impact of technology on students' performance? (Contains 16 references.) (Author/AEF)

Paper

Problem Solving About Problem Solving: Framing a Research Agenda

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"Those unable to use ... (technology) face a lifetime of menial work."
What Work Requires of Schools: A SCANS Report for America 2000, p. 15

"Despite technologies available in schools, a substantial number of teachers report little or no use of computers for instruction. Their use of other technologies varies considerably." *Teachers and Technology: Making the Connection*, p. 1

"The challenge of integrating technology into schools is much more human than it is technological." *Using Technology to Support Educational Reform*, p. 83

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Abstract

Government agencies, corporate executives, educational policy makers, and futurists tell us that solving novel problems, using computers as tools for thinking, and developing flexibility of thought and action will be key requirements in the next century. But available data about students' problem solving show disappointing results. In order to provide teachers with support for the improvement of computer-based problem solving we need to ask a series of questions—and provide answers—about how to teach problem solving to students and how to design training courses for teachers so they will incorporate those strategies into their day-to-day teaching.

Introduction

For all the early promise of technology, educators seem to be using technology to do what they used to do with textbooks rather than reframing education to fit what technology can do. The promise of computers as tools for problem solving, in particular, seems to have evaporated. I can remember when educators were excited about computers. "Recursion will allow us to show students what recursion is and let them play with it," they said. "Visual hands-on approaches to geometry can happen quickly, intuitively, and easily," they declared. "At last we can bring inference, and statistics, and probability into the curriculum as we never could before."

Problem solving, a topic that many professional groups and curriculum development specialists had agreed was difficult to teach with textbooks, was viewed as an excellent candidate for increased attention in the computer age. Problem solving had long been identified as a weak spot in American education. American students did not score well on various rounds of the National Assessment of Educational Progress testing program, nor did they show themselves to good advantage when compared with students in other countries. Problem solving as defined by Polya (1973) and not as defined by the standardized tests administered to American school children—which are simply measures of how many word problems can be solved correctly—was viewed as an important component of the mathematics curriculum, but one which was difficult to operationalize within the confines of the traditional textbook-driven curriculum. So technology was greeted with acclaim by many educators intent on improving the quality and quantity of problem solving in American classrooms.

Business (1991) has told us that problem solving—the ability to deal effectively with novel situations and create flexible, workable, elegant solutions—is a key component in maintaining our country's competitiveness. It has been agreed that tomorrow's work force needs to know more than which keys to press for which hamburger order, and that the Workforce 2000 and beyond needs to use technology as part of a general problem-solving process. So more than a decade after the introduction of computers into the schools where do we stand?

Surveys of computer use have shown us that problem solving via computer hasn't been widely accomplished (Anderson, 1993). To be sure, there have been exciting developments—many of them chronicled in the OTA report *Teachers and Technology: Making the Connection* (1995). But those developments have been isolated—occurring in only a few schools or universities, and not on a systematic basis. According to the OTA report, teacher education programs seem slow to incorporate models of good technology practice into their classrooms. The OTA report also says today's teachers, in large measure, have ignored the technology revolution or have incorporated a few bits of technology here and there, but by-passed many significant developments such as geometry programs where students can actively explore their questions about relationships between lines and angles, or where students can be confronted with novel logic problems and work toward the solution of problems that call for more than mere computational competency.

"There is no good software out there," had been a long-time defense against problem solving via computers. But professional groups have issued lists of software deemed noteworthy. It isn't necessary for teachers to sift through mountains of poor software packages to find one or two that may work in their classrooms.

"There are not enough computers," had also been a long time defense. But recent data (OTA, 1995) show that computer-to-student ratios are getting better all the time. Yes, some of the computers are 8 bit machines but one can still do worthwhile problem solving with 8 bit machines, and a judicious re-allocation of machines around the school system will certainly yield computer configurations to address many different types of needs (Marshall 1993a).

The issue, whether we like it or not, is primarily based on human perceptions, attitudes, and intentions as Means (1993) pointed out. These issues will not be resolved by purchasing additional computers or providing new and different software. Nor will they be solved by providing training—just any type of training under just any type of conditions. We need data, not declarations about the need for teacher training. We need models of what works, not mandates for more training.

Good data tell us what happened, why it happened, the conditions under which it happened, and what didn't happen and why. Many teachers are afraid to devote time to problem solving because they're not sure about the benefit to their students since research on problem solving often suggests that computer-based problem solving has no effect on students. So we need to know how good instruction does produce results.

Many research studies have been compromised by poor designs, inappropriate measures, and faulty assumptions. For example, Charters and Jones (1973) offered several conditions that educational research must meet: Researchers must ask the right questions and they must ask enough questions to describe the situation; researchers must make sure that if control groups are used the students in both groups really are similar, and that teachers or "the treatment" are described properly when comparison studies are conducted; researchers must make sure that "the treatment" was actually implemented and implemented in ways described by the project designers. If not, they must detail where the differences occurred and what contributed to those differences.

But research in computer use has failed to follow the wisdom of Charters and Jones's suggestions. We are rich in survey data—"How many computers are used and for what subject areas?" (Becker, 1983). We have responses and analysis of questionnaire data—"How has using computers changed the way you teach?" (Hadley and Sheingold, 1993). We have learned about innovative ways to deliver training, but we have no idea how different strategies for training can and do produce intended results.

Before we begin to design and deliver large-scale training (if indeed, the money ever becomes available), we need to answer some fundamental questions. Since computer-based problem solving was viewed as an important educational step forward, but seems to have been avoided by many technology-using teachers, asking questions about problem solving is a good place to start a rigorous examination of what's happening and why in technology-equipped classrooms.

While work on a research agenda has been initiated within the International Society for Technology in Education (ISTE) (Roblyer, Smith and Robin, 1995), the work fails to acknowledge such key issues as the epistemological assumptions of the researchers or teachers and ignores many important issues at the classroom level, so this paper seeks to continue and amplify the discussion about research, its aims and operations.

Research Questions About Problem Solving

Research Question #1

What are the teachers' and researchers' assumptions about the relation between teaching and learning?

For a long time, the behaviorist paradigm has dominated education in general and educational research in particular. We must acknowledge that good problem-solving instruction won't fit the behaviorist mode of teaching and many traditional types of pre-/post-studies are not robust enough to capture the effects of good problem-solving instruction; nor are the measures used sufficient enough to capture the effects of good practice (Marshall, 1993b). Research studies are needed that fully describe the different types of problem-solving lessons, the extent to which the teachers followed the goals of the software, and the types of thinking strategies students practiced and applied.

Research Question #2

What constitutes "good teaching" in technology-based classrooms where problem solving is a goal and what do "good" teachers do that their colleagues don't do?

First of all, let's acknowledge that we have only sketchy criteria for what constitutes good teaching in computer settings, especially when it comes to problem solving. Responses to surveys that tell us how satisfied teachers are or how dissatisfied they are with what they're doing (Hadley and Sheingold, 1993). We also have *Guidelines for Good Practice* (1991), but have we communicated what a "good lesson" looks like? Do teachers know what good technology-based problem solving looks like? Is it different from work with manipulatives used alone, or with activity books and textbooks? Do we know what practices lead to what results in children's thinking as a result of interactions with technology? To date, answers to these questions are sketchy at best.

Research Question #3

What is the relation, if any, between "good teaching" and students' ability to problem solve successfully?

Models exist for "good" lessons. For example, a "good" week in a math class is supposed to consist of the teacher modeling the application of a new algorithm on Monday, calling students to the board on Tuesday to work on variations of the problems, providing time for seat-work in textbooks and workbooks on Wednesday and Thursday, and then testing students on Friday. Is that a good model for problem solving? If not, what do good problem-solving lessons look like? How do we know if those models work? Do those models have differential effects on students?

Research Question #4

How have schools or school systems successfully overcome teachers' resistance to using technology and how successfully have those teachers been trained?

Teachers have developed a resistance to change. Some believe that technology is a fad that will go away. Given the revolving door nature of most educational innovations in the USA, their beliefs seem reasonable. Teachers have become weary about investing their energies in efforts that will disappear when the superintendent leaves for another school district. Do we know how to move resistant teachers to becoming computer-using teachers? Do we know how to help teachers who use computers for nothing but word processing move toward integrating problem solving into their technology routines?

Research Question #5

What results, in terms of student learning, have accrued from change strategies directed at increasing or improving the teaching of problem solving?

Training is as training does. For years we have been hearing that training is a key element in converting the technology-avoider into the technology-user. But 15 years into the technology revolution, we don't have a clear set of guidelines about what types of training bring about what types of change in teachers and even less evidence of the impact on students of our interventions. We have anecdotal evidence about programs that bring teachers into the technology fold, but we have no data on the effectiveness of that training on the newly-trained teacher's ability to (1) implement what has been presented, (2) implement it in a sustained way and a way that's faithful to the intent of the developers of the programs and the goals of the workshop presenters, and (3) positively affect student outcomes as a result of that change.

Research Question #6

What types of training for what duration and with what frequency with what types of teachers—veteran teachers, new teachers, teachers who believe in "hands-on" and teachers who "go by the book"—produce "good teaching?"

Does having a fellow teacher team teach with technology promote better results than "pull out" training? Is the cost of training a major variable? Does training before the school year begins have more impact than school-year wide training? What types of teachers—new-to-teaching or veterans, behaviorists, or constructivists—profit from what kinds of teacher training models?

Do we even know what questions to ask about training? We have little or no data on how much of what has been presented in training is actually used in classrooms—and what data we have tends to be from small samples or unrepresentative samples. We have little or no data on how long newly-trained teachers actually implement the changes they've seen. We do have evidence (Marshall, 1996) that some trainers fail to understand the software packages they themselves are using in training situations.

We need more information on the specific features of training programs that produce reproducible results. Good faith and good intentions are insufficient when we consider the demands for good practice. We need systematic evidence of what is necessary and what is sufficient in training situations.

Research Question #7

How do different training strategies produce positive changes in students' problem-solving behavior?

What "we, the trainers" know is not what "you, the teachers" value. Let's be clear at the outset. Data show us that mathematics is taught for less than 20 minutes a day in some classrooms and that computation lessons—primarily "seatwork"—dominate the instructional plan. Lessons devoted to skills recommended by professional organizations (1989)—geometry, probability and statistics, logic—are seldom, if ever taught. Textbooks still tend to treat these topics, if at all, by including chapters at the back of the book—a clear signal that teachers can take it or leave it. Now maybe this pattern of computational dominance is rooted in the fact that teachers haven't been adequately trained to do more than computation. But we need to know if these issues are implicated in our students' failure to problem solve successfully.

Teachers teach what they believe in or what their communities value. Computation is still highly valued as a skill, and many teachers and parents believe that computation—the "one right way and one right answer" approach—is the only appropriate subject matter, especially at the elementary school level. Take 20 minutes per day for instruction, do a little computation, and there's not much time left over for other mathematical activities. Do these practices compromise students' ability to problem solve? If so, how do we encourage teachers to teach beyond computation and, in the process, enhance students' problem-solving abilities?

Research Question #8

What different types of training strategies need to be employed to deal with differences in teachers' beliefs about what should be taught and how it should be taught?

Some teachers are firm believers in a behaviorist approach to teaching and learning. For many of them, problem solving instruction, at least in the elementary schools, is not an appropriate use of students' time. Other teachers say teaching problem solving will have little effect on students' performance on standardized tests—the benchmark against which many instructional activities are weighed. How do we promote an acceptance of problem solving in those classrooms? And does that acceptance translate into improved problem solving ability for our students?

Research Question #9

What types of training are needed to provide teachers with both the mathematical knowledge necessary to conduct problem-solving lessons and the pedagogical skill to use technology for those lessons?

Once there was a "cottage industry" approach where software developers who thought they had important ideas that had not been addressed in textbooks developed interesting ways to present those ideas via technology. But we often found that the topics introduced were new to many teachers and frightening to some because their own educational experiences in mathematics had not been rich enough to give them a foundation in a broad range of mathematical topics.

Today we have the increasing presence of large-scale producers of Integrated Learning Systems (ILSs) that tend to present computationally-based activities to the exclusion of problem-solving activities. At this time many believe that the ILS producers will eventually dominate the market to a greater extent than they do today. Some would say that to invest time and energy in learning problem solving and learning to teach problem solving, is a waste of time because in practice schools will ignore the demands of business leaders and government officials and follow the lead of the ILS producers. How do we help teachers acquire expertise in selecting topics and delivering lessons based on good problem solving of their own design instead of relying on ILSs?

Research Question #10

What differences, if any, are there in the outcomes in students' learning to be problem solvers when computation is the sole or major focus of computer use versus experience with problem solving software, and does ILS use contribute to or detract from problem-solving expertise?

We have no idea how much exposure to computers and in what pattern—ten minutes every day, half an hour every few days, a hour a week, none of the above—produces consistent lasting effects of instruction. We don't know if computer use needs to be buttressed with complementary work with manipulatives—and, if so, at what grade levels that use is needed—or supplemented by films, books, field trips, etc. We need to design studies that explore how students learn problem solving via computer.

Research Question #11

What role does the choice of measures play in our efforts to learn about the impact of technology on students' performance?

"Why should I teach it when they don't test it?" This question has challenged innovators designing problem-solving curricula for over 30 years. Many curriculum development projects that received massive infusions of federal dollars were stymied when school systems demanded hard data to show that students taught problem solving were performing better than their peers who were doing their multiplication tables every day (Marshall, 1994). The problem faced by the curriculum developers had several facets: schools tend to trust the standardized tests currently used by most school systems in the US and only those standardized tests; those standardized tests have a sub-test called "problem solving" but the sub-test merely tests students' ability to solve word problems. The tests are not sensitive enough to detect differences in overall mathematical ability acquired from problem-solving curricula. As a result, many of the projects were deemed to have failed because students' scores in "problem solving" did not rise sufficiently to justify the school systems' continuance of a problem-solving approach.

The fact that other measures were and are available—all standardized, all subjected to appropriate methodological practices—did not deter schools and school systems from relying only on "traditional" tests. The fact that other measures could be statistically equated with traditional tests so we could have indices of both "traditional" test performance and problem solving performance has been ignored or avoided by school system decision-makers.

Until we answer these questions and other questions aimed at teasing out the multiple, and often competing, factors at work in the design of evaluations, in the implementation of technology, in the training of teachers, and the assessment of students our efforts at training teachers to use technology's full potential in order to equip students for 2000 and beyond will be stymied.

References

Anderson, R. (1993). *Computers in American Schools 1992: An Overview.* Minneapolis, MN: University of Minnesota.

Becker, H. (April, 1983). *School Uses of Microcomputers.* Center for Social Organization of Schools. Baltimore, MD: The Johns Hopkins University.

Charters, W. W. & Jones, J. (1973). On the risk of appraising non-events in program evaluation. *Educational Researcher 2,* 11.

Hadley, M. & Sheingold, K. (1993). Commonalties and distinctive patterns in teachers' integration of computers. *American Journal of Education 101*, 261–315.

Marshall, G. (1993a). New uses for old computers. *The Executive Educator 15* 11–12.

Marshall, G. (1993b). Informatics and changes in learning: The American dilemma—opposing epistemological perspectives and unanswered questions. *Informatics and Changes in Learning*. D. C. Johnson and B. Samways. (Editors). Amsterdam: Elsevier Science Publishers, 203–210.

Marshall, G. (1994). Cautionary verses: Prospects and problems in achieving the aims of the computer revolution. *Exploring a New Partnership: Children, Teachers and Technology*. J. Wright and D. Benzie. (Editors). Amsterdam: Elsevier Science Publishers, 9–19.

Marshall, G. (1995). *The ABCs of Today's Technology Decision-making in Australia, the United Kingdom, and the United States*. A paper presented at the 6th IFIP World Conference on Computers in Education. Birmingham, UK.

Marshall, G. (1996). *Time for Change: Critical Issues for Teacher Education*. Unpublished paper submitted to the IFIP Working Conference, Israel.

Means, B. et. al. (September, 1993). *Using Technology to Support Education Reform, OR-93-3231*. Washington DC: U. S. Department of Education, Office of Research.

NCTM. (1989). *Curriculum and Evaluation Standards for School Mathematics*. NCTM: Reston, VA.

Polya, G. (1973). *How To Solve It*. Princeton, NJ: Princeton University Press.

Roblyer, M., Smith, R., & Robin, B. (1995). A research agenda for topics and methods in educational technology identified by technology-using educators. *NECC '95 Proceedings*. Baltimore, MD, 80.

Secretary's Commission on Achieving Necessary Skills. (1991). *What Work Requires of Schools: A SCANS Report for America 2000*. Washington DC: US Department of Labor.

Taylor, H., Aiken, R. & van Weert, T. (1991). *Informatics Education in Secondary Schools. IFIP Working Group 3.1 Guidelines for Good Practice*.

U. S. Congress, Office of Technology Assessment. (1995). *Teachers and Technology: Making the Connection, OTA-EHR-616*. Washington DC: US Government Printing Office.

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