Problem Solving: Powerful Ideas Shaping Our Educational System

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In L&L vol. 27 no. 1, I listed and briefly discussed 10 powerful ideas of information technology (IT) that are helping shape the present and future of IT in education. Each of these powerful ideas cuts across many disciplines, makes effective use of IT, and has enduring value. This editorial is about problem solving—number 6 on the powerful ideas list. It also focuses on number 3 (effective procedure) and number 7 (modeling and simulation). (Read the complete list online at www.iste.org/L&L.)

What Is a Problem?

Each academic discipline can be defined by the types of problems that it addresses, the methodologies it has developed, and its accomplishments. Clearly, when a math teacher talks about math problems, the story is quite a bit different than when a psychotherapist talks about a patient's problems or an elementary teacher talks about a student's learning problems. Thus, the meaning of "problem" differs significantly from discipline to discipline.

However, there is some commonality. You have a problem when you experience a situation in which there is a difference between the way things are and the way that you would like them to be. You can then decide whether to apply your personal resources (e.g., time, knowledge, skills, and money) to achieve the desired goal or accomplish the desired task.

Paramount Idea

When you work to solve a problem or accomplish a task, you are building on your own and others' previous work. In doing so, you are following the most important idea in problem solving.

Previous work includes humans' development of reading, writing, and arithmetic. It includes the teaching of your parents and others who helped you learn to speak and listen. It includes the developers and manufacturers of the tools that you use. Your previous work includes learning to read, write, calculate, speak, listen, and use tools. Moreover, it includes learning to understand a wide range of problems and how to solve many different problems. IT brings new dimensions to problem solving because it brings new ways to store and make use of the previous work of others.

Procedures and Procedural Thinking

Computer scientists define the term effective procedure as a detailed step-by-step set of instructions that can be mechanically interpreted and carried out by a specified agent, such as a computer or automated equipment. From a computer scientist's point of view, procedural thinking includes developing, representing, testing, and debugging effective procedures and using them to solve problems and accomplish tasks. Each discipline has developed and makes use of many different procedures, but not all of them can be carried out by a computer. That is, many of the procedures within the various disciplines are not what computer scientists call effective procedures. Instead, they are procedures that require careful thinking and adjustments as they are applied. Psychotherapists have procedures that they use during therapy, and teachers have procedures they use with disruptive students. These are a lot different than a procedure for solving a quadratic equation or doing long division!

Computer Modeling and Simulation

The 1998 Nobel Prize in chemistry was awarded to two computational chemists: Walter Kohn, University of California at Santa Barbara, and John A. Pople, Northwestern University, Evanston, Illinois (Wu, 1998). Computer-based modeling and simulation is now a powerful aid to knowing and making use of all of the sciences as well as many other disciplines such as economics and business. For example, a spreadsheet is now a routine aid to developing business models and simulating possible business activities. A person can work with such a spreadsheet model, exploring "what if" alternatives to the possible solution of a problem.

Such modeling and simulation is a powerful new aid to problem solving. That is because the computer can be used to carry out effective procedures that help to solve the problem. A standard way to solve a complex problem is to break it down into a collection of smaller, more manageable subproblems. The goal in this "breaking down" process is to arrive at subproblems that one can solve. There are an increasing number of these subproblems that a computer can solve both rapidly and accurately. Thus, a problem solver who knows about these effective procedures and learns to take advantage of them gains a substantial advantage (over non-computer users) in solving a wide range of problems.

A somewhat different way to think about this is that to solve a problem or accomplish a task, one typically carries out a variety of procedures. Problem solving is often quite difficult because one does not know what procedures to use, and in what order. Moreover, many procedures are quite complex–they require a long time to learn to do, and they may require substantial time, effort, and care to apply. An increasing number of the procedures one needs to use are effective procedures that can be carried out by a computer. This means that the human problem solver can spend more time doing the thinking parts and less time doing the carry-out-the-procedure parts when solving a complex problem.

Educational Implications

One of the goals of education is to help students learn to understand and solve a wide variety of problems. We know that it takes many years of education and experience to achieve a high level of expertise in even one discipline. But most of the problems of the world are interdisciplinary. Thus, our schools and our students face a daunting task.

I suggest four major ideas that will help with this task:

1. Expose your students to the various disciplines they study through the problems they address, the methodologies they use, the procedures they have developed, and the results they have accomplished. Make explicit the procedural thinking and building on the work of others that are a critical part of expertise within the discipline.

2. Help students learn about effective procedures and their steadily growing usefulness in solving a wide range of problems.

3. Help your students learn to represent (model, simulate) problems on a computer so that they can take advantage of the power of the computer as an aid to answering "what if" questions.
4. Emphasize interdisciplinary problem solving and the process of breaking complex problems into manageable subproblems.

Reference

Wu, C. (1998). Chemistry computations earn Nobel prize. *Science News*, 154(16), 247.