Designing Effective Project: Using Knowledge
Problem Solving

Creating Solutions

Problem solving takes place whenever we are confronted with a barrier or challenge to achieving a goal. Problems can be simply solved, such as sharpening a pencil when the tip breaks, or can take years and input from hundreds of experts, such as coming up with a solution to global warming. Problems can have social, cultural, political, and personal dimensions. Some problems may have dozens of good solutions, and some may have only a few poor solutions. What is a serious problem for one person may not be a problem at all for another. In all cases, solving problems is part of learning and part of life.

Knowledge is extremely important for solving problems, because information is the fuel that leads us to success. Anyone can relate to being stuck with a problem, such as a plugged up sink, a screaming child, or a stalled car, knowing that the problem is solvable, but just not having the information needed to solve it.

Facione (1999) describes a list of characteristics of good problem solvers developed by experts in critical thinking. These people show

- Clarity in stating the question or concern
- Orderliness in working with complexity
- Diligence in seeking relevant information
- Reasonableness in selecting and applying criteria
- Care in focusing attention on the concern at hand
- Persistence through difficulties are encountered
- Precision to the degree permitted by the subject and the circumstances

Wilson, Fernandez, and Hadaway (1993) add that those who are proficient at mathematical problem solving are aware of a variety of processes that they can use and also have the ability to invent new strategies when they encounter unexpected situations.

Problem Solving Processes

Problem solving begins with the identification of a problem. Specifying and describing a problem may be more of a creative process than an analytical one, since this stage requires the ability to see how things could be different. For example, Teri Pall, who invented the cordless phone in 1965, thought that it would be possible to talk on the phone while moving about the house. This took as much imagination as it did technical know-how.

Cognitive processes are also important in problem solving. Anderson and his colleagues (1999) explain how different thinking skills contribute to the resolution of a problem.

- *Comprehension* helps learners make a visual representation of the problem.
- *Remembering* helps people call up the information and procedures they will need.
- *Synthesis* helps them organize the knowledge they have gathered into a structure that will be most useful and efficient.
- *Evaluation* is used to decide which methods to use and whether these methods have worked.
- *Metacognitive strategies* help problem solvers set goals, make plans, change strategies in mid-stream if they need to, and make decisions about the success of the solution.

Technology and Problem Solving

The use of computer technology as a tool in problem solving has become more widespread as computers have become more sophisticated and available. A variety of types of software help

users portray problems graphically. Computer-based communication can provide learners with access to the information they need to produce solutions. It can also place students in contact with experts who can offer them strategies and encouragement.

Some kinds of computer games can provide students practice at understanding a problem, finding and organizing necessary information, developing a plan of action, “reasoning, hypothesis-testing and decision making,” and building awareness of different kinds of problem-solving tools (Wegerif, 2002, p. 28).

Wegerif (2002) eloquently describes the role that technology can play in solving problems:

Before the arrival of computers in human history it seemed natural to many to describe ‘higher order thinking’, or rationality, in terms of abstract reason on the model of formal logic or mathematics. This kind of thinking was really hard, potentially very useful and only a few people could do it well. Computers, however, find formal reasoning very easy. What they find hard is the sort of things most people take for granted like coming up creatively with new ways forward in complex, fast-changing and open-ended contexts where there is no certainty of being right. One way in which thinking skills are related to developments in technology is therefore simply that the human skills that we value most, and that are rewarded the most, are those skills that computers cannot yet imitate.

Teaching Problem Solving

In order for students to develop into expert problem solvers, they must first encounter problems that engage them and give them opportunities to develop the skills they need to learn. Through project-based learning, students have direct experience solving problems.

The types of problems that benefit students the most are the ones that perplex them. For a problem to have the most benefit for students it must be challenging enough to require the regulation of cognitive and metacognitive strategies.

One way in which teachers can improve students’ problem-solving skills is by having them focus on processes rather than outcomes. Dr. Ellen Langer, psychology professor, points out that thinking of outcomes often inhibits students in problem solving. A process orientation, thinking “How do I do it?” instead of “Can I do it?” helps them think actively of different ways in which a problem might be solved instead of focusing on the many possibilities for failure (Langer, 1989, p. 34).

A group of researchers in maths education emphasizes the importance of reflection during problem-solving activities. “It is what you learn after you have solved the problem that really counts,” they explain (Wilson, Fernandez, & Hadaway, 1993). However, they warn that developing the desire to look back in students is very difficult. This is due, in part, to the specific culture of many mathematics classrooms in which the purpose of solving a problem is just to find the answer, not to learn problem-solving skills.

Reflection can occur in classrooms in both formal and informal ways. Providing time just for writing or talking about the processes they used to solve problems can help students refine their own processes. There is also considerable research to support the notion that students improve their problem-solving skills by working in groups (Wegerif, 2002). These social situations provide them with natural ways of discussing how work on a project is progressing.

It is tempting to provide students with a heuristic, or a rule of thumb, when solving problems. For many teachers and students alike, a left-brain process like following a series of steps when confronting a challenge seems like a logical way to approach a problem. Teachers must bear in mind, however, the many ways in which students’ thinking and learning styles differ. There is considerable evidence that the right brain plays a significant role in solving problems by imagining

alternatives, viewing the whole picture, and assigning value to alternative solutions.

Huitt (1998) suggests that, along with the critical and evaluative processes that are so important in problem solving, there is a second group of skills that "tended to be more holistic and parallel, more emotional and intuitive, more creative, more visual, and more tactual/kinesthetic." He argues that successful problem solvers are creative as well as logical. Both ways of thinking are critical to success. In fact, creativity is often thought to be a special kind of problem solving process.

There are few skills as important for students to learn as problem-solving skills. Young people who can identify problems that can be solved, explore options for solutions, use appropriate thinking strategies, and manage the whole process metacognitively, are equipped for success in school, in the workplace, and in life.

Examples of Problem Solving

Problem solving is such a critical skill that it is difficult to imagine an authentic situation in which students would not be practicing it. Settling disputes on the playground, working through a disagreement with a friend, arguing with a teacher over a grade or with parents over a curfew, are the kinds of problems students must solve in their everyday life. In any kind of complex activity or project, there are also countless problems to be addressed, such as issues with technology, irresponsible group members, inadequate materials, and so forth.

Some projects, however, are built around the solving of big, important problems, often connected in some way to the community. In the Unit Plan, Go-Go Gadget: Invent a Machine, students identify work they want to perform, and invent a labor-saving machine to do the job. To help students improve their problem-solving skills during this unit, a teacher could offer mini-lessons on brainstorming, using drawing software to represent a problem, or modeling how to explain thinking processes to others.

In the Unit Plan, Don't Trash the Earth, middle years students turn trash into treasure as they divert materials from the waste stream and turn it into attractive merchandise they sell at a holiday business fair. Solving this problem requires the collection and analysis of data as well as creative thinking. A teacher could provide students with explicit instruction in the use of databases, the generation of numerous alternatives, and creatively thinking of uncommon uses for common waste materials.

In the Unit Plan, Composting: Why Bother?, high-school adolescent students also address the topic of the environment when they engage in the entire process of making new material from waste, as they turn biodegradable garbage into the gardener's "black gold" or rich compost. In this unit, students have the opportunity to practice problem solving as they compete to get organic material to decompose rather than rot. They sell compost for a classroom fundraiser. By having students stop periodically and reflect on the problems they have encountered and how they addressed them, teachers can support the transfer of skills used in one context to other similar situations.

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