GENERAL STRATEGIES OF PROBLEM-SOLVING*

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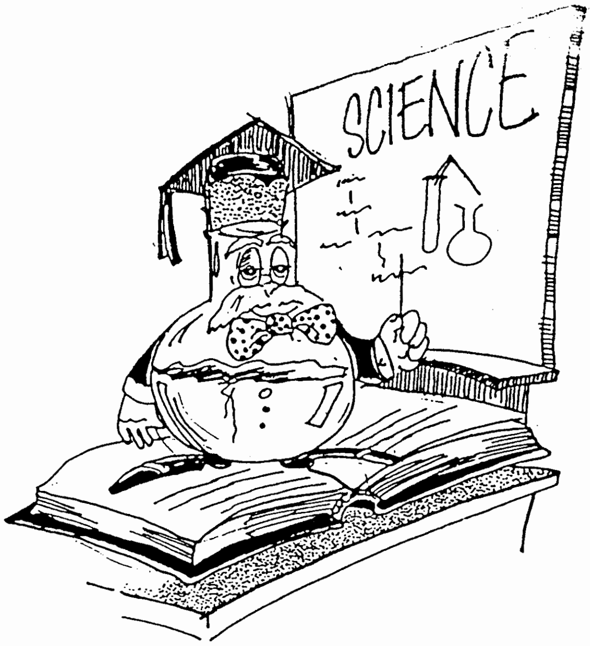

INTRODUCTION

The development of problem-solving skills is included as part of the aims and objectives in both the primary and secondary science curricula. Even when the teaching of problem-solving skills is deemed a major goal of instruction, the means for achieving this goal are far from obvious. The most common approach involves exhibiting illustrative examples of problem solutions and then providing students with practice in solving similar problems. Such approaches are neither too effective nor efficient in furthering students' learning of problem-solving skills. Research on problem solving evidently shows that students have difficulties in solving problems especially for unfamiliar problems (Woods, 1983; Lee, 1993).

Woods (1983) reviewed a number of research work in a wide range of disciplines using different research instruments and types of problems and identified differences between problem-solving styles of novices and experts. The discipline areas of these work include physics, engineering, mathematics and psychology. The problem-solving skills of experts are superior in organising and manipulating the information from the problem statements than the novices. The experts are not only effective at relating to the fundamental principles and underlying cause-effect relationships but also have a set of problem-solving strategies that leads them through the whole process of problem solving. The novices, on the other hand, rely very much on their past experience of solving the same type of problems and are unaware of any organised strategy that can help them to get unstuck. They tend to use heuristics of a formula or rule-centred approach which are less powerful strategies. For the improvement of problem-solving skills, students ought to be taught a more systematic method of problem solving, such as a general strategy of problem solving, that is applicable to solving problems of cross-disciplines and even personal problems.

WHAT ARE THE GENERAL STRATEGIES OF PROBLEM SOLVING ?

General strategies describe the steps involved during the process of problem solving such as in a model of problem solving or in an approach to a solution that is applicable to a range of problems whatever their subject content. They may not all be necessarily appropriate for every particular problem or problem solver. These general strategies are derived from results obtained in research on problem solving. In this article, some general problem-solving strategies that have described the mental processes of problem solving are briefly reviewed.

Gagné (1977) stated that "the components which appear to make problem solving possible are the rules that have previously been learned." According to him, four events are involved in problem solving. They are:

(1) presentation of the problem: the solver is presented, either verbally or otherwise, with

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the problem to be solved.

(2) definition of the problem: the solver defines the problem and distinguishes the essential features of the situation.

(3) formulation of hypotheses: the solver formulates hypotheses which may be applicable to the solution.

(4) verification of the hypotheses: the solver carries out verification of his hypotheses, or of successive ones, until he finds one that achieves the solution he seeks.

The first step is an external event whereas the rest are internal. The hypotheses or solutions that are formed in event 3 are new rules, a successful one will be learned when its application has been tested and confirmed. Gagné also stressed that another important condition for problem solving is the activation and use of a previously learned cognitive strategy. Cognitive strategy is the skills by means of which learners regulate their own internal process of attending, learning, remembering and thinking.

Woods (1985), a practitioner in the field of chemical engineering problem solving, proposed a six-step problem-solving strategy and included it in one of his courses called The McMaster Problem-Solving Program run at McMaster University. The McMaster 6-step Strategy consists of

(1) Read/I want to and I can,
(2) Define: the stated problem,
(3) Define - Explore: the implications, the real problem, the issues,
(4) Plan the Action Steps,
(5) Do it, and
(6) Look back.

In the first step, 'Read/I want to and I can', the problem solver reads the whole problem. This is also a stage of motivation. He/she gets himself/herself mentally prepared that he/she is going to solve the problem. In 'Define the stated problem', the problem solver understands the words, identifies stated objectives, draws diagrams, and identifies the system, constraints and criteria. In the next step, the problem solver makes implications by recalling past experience, theory and fundamentals that seem pertinent. He/she translates the problem to another form. The problem solver then assembles resources and selects tactics, e.g. working backwards and breaking up the main problem into subproblems, in 'Plan the Action Steps'. In the fifth step, 'Do It', the problem solver tackles the problem and gets the solution. Finally, he/she checks the solution.

Lee (1986) studied 129 protocols of problem solving by 10 teachers and their 32 students (3 protocols each) in the field of chemistry. A general strategy of problem solving consisting of two phases and seven processes emerged:

(1) Translation of the problem statement
- (a) Comprehending the whole problem
- (b) Translating the parts of the problem statement so that they have meaning
- (c) Setting goal(s) or subgoal(s)

(2) Moves towards a solution
- (a) Selecting information from the translation
- (b) Retrieving 'rule(s)' or 'fact(s)' from memory
- (c) Achieving goal(s) and/or subgoal(s) (by explicit or implicit linking of Processes 2a and 2b)
- (d) Checking the path(s) of the solution or the answer(s)

In Phase 1, Processes 1a, 1b and 1c in their own way, were all concerned with translation by problem solvers of the problem statements so that these statements took on a personal meaning for them. The translations resulting from these three processes provided the problem solvers the information that was necessary for them to move on towards a solution. In Phase 2, Processes 2a, 2b, 2c and 2d are all processes of moving towards a solution. The checking process 2d occurred throughout Processes 2a, 2b and 2c as well as at the end of the protocols, so in practice it is not a separate phase.

COMPARISONS OF THE THREE STRATEGIES

The three strategies have some similarities and some differences. The similarities among the strategies proposed by Gagné (1977), Woods (1985) and Lee (1986) are summarised in Table 1, in three stages, namely, *Problem Presentation, Plan and Solution, and Checking.*

Researcher	Stage 1 Problem Presentation	Stage 2 Plan and Solution	Stage 3 Checking
Gagné (1977)	1. Presentation of the problem	3. Formulation of hypotheses	4. Verification of the hypotheses*
	2. Definition of the problem	4. Verification of the hypotheses*	
Woods (1985)	1. Read/I want to and I can	4. Plan the action steps.	6. look back
	2. Define the stated problem	5. Do it	
	3. Define-explore the issue		
Lee (1986)	1a. Comprehending the whole problem	1c. Setting goal(s) or subgoal(s)*	2d. Checking the path(s) of the solution or the answer(s)
	1b. Translating the parts of the problem statement so that they have meaning	2a. Selecting information from the translation	
	1c. Setting goal(s) or subgoal(s)*	2b. Retrieving 'rules(s)' or 'fact(s)' from memory	
		2c. Achieving goal(s) and/or subgoal(s) [by explicit or implicit linking of Processes 2a and 2b]	

*Processes are present in more than one stage.

Table 1 Comparison of the three problem solving strategies

As shown in Table 1, the three strategies can be considered as stage-typed models. The description of the stages and how information is processed in each stage vary. While elements like those identified by Gagné (1977) and Woods (1985) are present in Lee's (1986) seven processes, the thought processes described by Lee are more finely divided and operationally defined. Lee's general strategy describes not only the stages involved in the problem-solving protocols but also the detailed process by which the problem solvers take in, organize, transform, retrieve, link, and develop information for solving a problem. It reflects how information is processed in the problem solvers' mind for solving a problem.

WHY IS A GENERAL STRATEGY USEFUL?

A strategy is an organised approach that breaks the overall mental task of problem solving down into stages. This, in itself, helps us to tackle parts of the problem process one at a time. In addition, having a strategy helps us, especially the novice problem solvers, to overcome the initial panic we feel when we experience a problem that is tough to solve. Lastly, using a strategy can improve our problem solving performance. Carmichael et al. (1987) reported the success of a modified course in general chemistry at one of the American universities. A new component of teaching problem-solving skills including strategies was added to the content modules. The report shows that the problem-solving approach of teaching chemistry significantly improved the students' achievement results. Furthermore, the students in this course consistently rated the course highly in a university-wide course evaluation procedure.

CONCLUSION

For improving problem-solving skills, we can start off by teaching students a general strategy of problem solving. Teachers may like to use one of the above strategies or a modified strategy that consists of the stages of problem presentation, plan and solution, and checking. It is important to teach **explicitly** a general strategy of problem solving to students as it serves as a guideline of what steps can be taken in pursuit of problem solving. This is particularly useful when they are stuck. The use of general strategy can also help to boost students' confidence in problem solving because they become aware of their thinking process whereby solving problems. Consequently, the students achieve better problem solving performance.

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