Routine & Nonroutine Problem Solving

Applying understanding of mathematical ideas and operations to problem-solving situations is another component of MEBA™. **Routine problem solving** stresses the use of sets of known or prescribed procedures (algorithms) to solve problems. Initially in MEBA™ the problems presented to students are simple one-step situations requiring a simple procedure to be performed. Gradually, students are asked to solve more complex problems that involve multiple steps and include irrelevant data. Commencing with the concrete level, students are asked to develop their own story problem situations and demonstrate the solution process with manipulatives and/or pictures and later with symbols. Such problems are later presented to the class for solution.

One-step, two-step, or multiple-step routine problems can be easily assessed with paper and pencil tests typically focusing on the algorithm or algorithms being used. Because of this, routine problem solving receives a great deal of attention by classroom teachers. With the advent of computers, which can quickly perform the most complex arrangements of algorithms for multi-step routine problems, the amount of instructional time and the extent to which these problems are tested is being reassessed. Today's typical workplace does not require a high level of proficiency in solving multi-step routine problems without the use of a calculator or computer. However, an increased need for employees with abilities in nonroutine problem solving has occurred in today's workplace.

Nonroutine problem solving stresses the use of heuristics and often requires little to no use of algorithms. **Heuristics** are procedures or strategies that do not guarantee a solution to a problem but provide a more highly probable method for discovering the solution to a problem. Building a model and drawing a picture of the problem are two basic problem-solving heuristics. SIMs™ incorporates these heuristics as a natural part of instruction. Other problem-solving heuristics such as describing the problem situation, making the problem simpler, finding irrelevant information, working backwards, and classifying information are also emphasized.

There are two types of nonroutine problem solving situations, static and active. **Static nonroutine problems** have a fixed known goal and fixed known elements which are used to resolve the problem. Solving a jigsaw puzzle is an example of a static nonroutine problem. Given all pieces to a puzzle and a picture of the goal, learners are challenged to arrange the pieces to complete the picture. Various heuristics such as classifying the pieces by color, connecting the pieces which form the border, or connecting the pieces which form a salient feature to the puzzle, such as a flag pole, are typical ways in which people attempt to resolve such problems. **Active nonroutine problem solving** may have a fixed goal with changing elements; a changing goal or alternative goals with fixed elements; or changing or alternative goals with changing elements. The heuristics used in this form of problem solving are known as strategies. A summary chart to contrast routine and nonroutine problem solving can be found on page 22.

To develop the thought processes that are inherent in **active nonroutine problem solving** MEBA incorporates the **Mathematics Pentathlon®** which features a program of strategic and interactive games. The name of the program, **Mathematics Pentathlon®**, was coined to liken it to a worldwide series of athletic events, the Decathlon component of the Olympics. In the world of athletics the Decathlon is appreciated for valuing and rewarding individuals who have developed a diverse range of athletic abilities. In contrast, the world of mathematics has not, for many decades, valued or rewarded individuals with a diverse range of mathematics abilities. The **Mathematics Pentathlon®** games promote diversity in mathematical thinking by integrating spatial/geometric, arithmetic/computational, and logical/scientific reasoning at each division level. (The games are organized into four division levels, K-1, 2-3, 4-5, and 6-7 with five games at each level.) Since each of the five games requires students to broaden their thought processes, it attracts students from a wide range of ability levels, from those considered "gifted and talented" to "average" to "at-risk."

The format of games was chosen for two reasons. First, games that are of a strategic nature require students to consider multiple options and formulate strategies based on expected countermoves from the other player. The **Mathematics Pentathlon®** further promotes this type of thought by organizing students into groups of four and teams of two. Teams alternate taking turns and team partners alternate making decisions about particular plays by discussing aloud the various options and possibilities. In this manner, all group members grow in their understanding of multiple options and strategies. As students play these games over the course of time, they learn to make a plan based on better available options as well as to reaccess and adjust this plan based on what the other team acted upon to change their prior ideas. Through this interactive process of sharing ideas/possibilities students learn to think many steps ahead, blending both inductive and deductive thinking. Second, games were chosen as a format since they are a powerful motivational tool that attracts students from a diverse range of ability and interest level to spend more time on task developing basic skills as well as problem-solving skills. While race-type games based on chance are commonly used in classrooms, they do not typically capture students' curiousity for long periods of time. Students may play such games once or twice, but then lose interest since they are not seriously challenged. The **active nonroutine nature of the Mathematics Pentathlon®** have seriously challenged students to mature in their ability to think strategically and resolve problems that are continually undergoing change.

The **Mathematics Pentathlon®** program is comprised of five gameboards and manuals with related concrete/pictorial materials at each of the four division levels. To prepare students to play these active, nonroutine, problem-solving games, prerequisite activities are suggested and described in two related books, ***Adventures in Problem Solving Books I & II***. Since active, nonroutine problem solving cannot be assessed with conventional methods, assessment ideas for **Mathematics Pentathlon®** are provided in ***Investigation Exercises Books I & II***. These publications provide numerous non-traditional paper-pencil ideas for assessing students' understanding of mathematical relationships/skills that directly relate to the games and ***Adventures in Problem Solving*** activities. In addition, students are challenged to critically examine various game-playing options and choose better moves.

PROBLEM SOLVING

ROUTINE

stresses the use of sets of known or prescribed procedures (algorithms) to solve problems

STRENGTH: easily assessed by paper-pencil tests

WEAKNESS: least relevant to human problem solving

NONROUTINE

stresses the use of <u>heuristics</u> which do not guarantee a solution to a problem but provide a more highly probable method for solving problems

STATIC

fixed, known goal and known elements

ACTIVE

- **fixed goal(s) with changing elements**
- **changing or alternative goal(s) with fixed elements**
- **changing or alternative goal(s) with changing elements**

STRENGTH: most relevant to human problem solving

WEAKNESS: least able to be assessed by paper-pencil tests