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Mathematical Problem Solving through Reflection and Rescription

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Teachers and students hold pivotal positions in the teaching and learning of problem-solving skills. Understanding and using of reflection and rescription are key to both professional teaching and student learning. Reflection and rescription underpin the metacognitive, cognitive, and social/affective learning strategies used to solve mathematical word problems. These strategies not only guide students to answer word problems, but provide them with meaningful ways to deal with everyday problems. This article provides an overview of a procedure for solving word problems using learning strategies grounded in reflection and rescription.

Reflection and Rescription

Students can better manage the process of problem solving through reflection and rescription. Reflection is careful thought about what is being done and rescription is refining ways of solving problems. Learning to a large extent is a reflective activity which takes place through the action of the learner. Analytical reflection enables students to conceptualize and formulate their own rules and principles. With these personal theories to guide their behavior, they can use strategies as self-talk and self-regulation as springboards for solving mathematical word problems.

Along with reflection, students develop a conscious process through rescription when they become aware and create a mental picture backed by clear intentions. Steven Covey (1994) used the term, rescription, in his book, Seven Habits of Highly Effective People, when he wrote that change must first come from within oneself. Students

are told that they have sort of a mental "automatic pilot" that lets them do things without thinking. Although this capacity is useful, it can limit patterns of thinking and behavior. Further, they have many scripts in their heads that were taught to them or were synthesized by them. Rescripting involves a paradigm shift or refining of existing scripts to see things in a new way.

When students recognize the scripts they use are ineffective, incomplete, or inaccurate, rescription is required. Unsuccessful problem solvers need to explore and use other alternate ways to solve problems. Foong (1994) reported on the differences in the processes of solving mathematical problems between successful and unsuccessful solvers in a previous Teaching and Learning journal. He found that successful problem solvers understood the problem more correctly, planned their solutions in more detail, used more metacognitive processes, and showed less negative emotional expressions of frustration and confusion than unsuccessful problem solvers.

Teachers can assist rescription by students through linking different approaches to mathematical problem solving. For example, Fong Ho Kheong (1994) asserted how a cognitive strategy, the "model's approach," can be better linked to the algebraic method of solving problems in Singapore schools.

In short, reflection on the process of solving mathematical word problems is important for students to learn. As students reflect, use imagery, talk to themselves, and reconcile new ideas with their schema of previous concepts, they gain ways to solve the problem (McNeal, 1995). Rather than a static checklist, they rescript themselves or plan new ways to find the answer. Reflection and rescription enable students to better solve mathematical word problems through cognitive and affective learning strategies.

Learning Strategies for Mathematics

The following components of metagcognitive, cognitive, and social/affective strategies are ways students can consciously use to solve mathematical word problems:

Metacognitive strategies	To plan, regulate and assess their own learning of concepts and skills:
• selective attention	Students focus on the question asked and the words or idea which cue the operation. For example, subtraction is the correct operation when the problem compares how many more are in one set than another, when the problem asks how many more are needed or are taken away, or when the problem asks how many are left. Students are taught to selectively attend to the specific data which will be needed to solve the problem (Anghileri, 1995).
• organizational planning	What plan or multiple-step plan is needed to get the answer?
• self-regulation	Students take responsibility for their learning by monitoring, questioning themselves, and adjusting their plan. Through self-monitoring, they can check and change their progress toward finding the answer.
Cognitive strategies	To mentally and physically interact with the information:
• elaborating	Students ask what they already know about the problem and how does the information relate to other information.
• imagery	Teachers can encourage students to form a mental picture of the word problem. Students can classify and understand the problem through devising a chart, table or list. The mental representations then can guide the

	direction of the problem-solving steps. So students can use both an internal and external representation of the problem. Effective problem solvers who use imagery often can find a pattern or a way to solve the mathematical word problem.
• making inferences	In understanding the question, students use inference to guess at the meaning of some terms which may be suggested by the context in which the words are used. Are there words that are not understood?
Social/Affective strategies	To use their feelings and work with others to assist learning
• clarification	Students ask questions to understand the problem.
• self-talk	Students are confident that they can find a solution and decide what ways they need to find the answer.
• cooperating	By pairs or in small groups, students work with others to solve the problem. Students can learn different ways and skills from other students when they solve word problems together (McNeal, 1995).

Teachers can teach reflection and rescription to students by following a QDPAL procedure of focusing on the question, selecting relevant data, planning what to do, estimating and checking the answer, and using a learning log. This procedure encompasses the metacognitive, cognitive, and social/affective learning strategies described previously.

QDPAL: Question, Data, Plan, Answer, Learning log

The QDPAL procedure is a way in which students can systematically and logically solve mathematical word problems:

Q uestion understand what the question is.

Through elaboration, students are better able to relate the information to what they know. If they are puzzled about solving the problem, they can summarize the problem in their own words, or draw a chart or picture of the problem. They ask themselves what they know and what else they need to know?

Teachers ask students to rewrite the question as a statement and leave a blank space for the correct answer. For example, how many pencils in each satchel can be stated as there are _____ pencils in each satchel. Or teachers encourage students to talk about the problem using their own words which make sense to them.

D ata ask what data are needed to solve the problem.

Through selective attention, students find the key words by focusing on the question and the words which cue the operation.

Data in word problems may contain irrelevant distracter numbers or important data may not be stated directly in the problem. For example, students may be required to use their own knowledge to supply some missing data such as multiplying by 60 to convert minutes to seconds.

P lan plan what to do.

Students can draw a picture to represent the problem, share their drawing with other students and discuss how they used their imagery to solve the problem. Students can also predict or estimate what the possible answer is.

A nswer solve the problem by following the plan.

Check to see if the answer is correct and whether it makes sense.

L earning Log

An essential key to reflective learning is to keep a learning log. In this way, students can consciously reflect and rescript what they have learned including the concepts, vocabulary, and QDPAL procedure.

Conclusion

The metacognitive, cognitive, and social/affective strategies used in the QDPAL procedure are effective ways for students to solve mathematical word problems. Teachers play an important role in this process. Teachers model how word problems are structured and discuss the main parts of the word problem, namely the situation, data, and question asked. Teachers explain the usefulness of organizational planning and assign students to write word problems. Students who write their own word problems and have their classmates scrutinize them, learn how to solve word problems better (Anghileri, (1995). In addition, teachers can have students create mathematical word problems for evaluation in a pre-test for study. While teachers have taken primary responsibility for assessing students' performance in the past, today in effective classrooms self-and-peer assessments are important (Shannon & Zawojewski, 1995; Wertheimer, 1995). Students are empowered to solve mathematical word problems when they assess their own learning and use reflection and rescription.

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