Learning and Using Math Procedures

Math is built upon a logical structure of patterns, rules, and procedures. The use of basic rules and sequences of steps (algorithms) helps students compute math more effectively. Moreover, many rules and algorithms (such as the rule for multiplying by zero, steps for column addition, and the process for long division) are based upon numerical relationships and important math concepts. An understanding of rules and procedures in math fosters an understanding of mathematical concepts and the ability to solve problems with computation.

Necessary SubSkills	Common Obstacles	Helpful Tips
Student recognizes when a rule or procedure is called for in a problem.	Student has trouble knowing if a rule or procedure is required to solve a problem.	view
Student applies math rules correctly when computing or working through a problem.	Student has trouble applying rules to solve a problem, such as the rules for borrowing or carrying.	view
Student can learn and work with multi-step algorithms for computing.	Student gets confused when working with algorithms that involve several steps, for example, when doing long division.	view

Recognizing Rules and Procedures/Impact of Attention and Memory

As students develop their mathematical awareness, they begin to discover the rules that guide computation and problem solving. Attention skills play an important role in the learning and recognition of these rules. For example, recognizing basic rules, e.g., that the '+' sign means combine quantities, or that a fraction is represented as the part over the whole, etc., depends in part upon a student's ability to concentrate consistently, attend to detail, and connect new information to what is already known.

Rules in math are based upon patterns. Students must learn to recognize the patterns in different math situations and the rules associated with each pattern.

Once a rule pattern has been learned, the student can then store it in long-term memory, and access the rule when the pattern occurs in a new situation. For example, once a student learns the rules for regrouping (borrowing and carrying) in subtraction problems, when faced with a new subtraction problem requiring regrouping, he/she can recognize the pattern and call up the proper rules to mind.

Here are some strategies that may help develop and strengthen students' abilities to learn and recognize rules in math.

Helpful Hints

- Help students see how patterns and rules reflect mathematical concepts. For example, first explain that the rules for regrouping rise from the concept of place

value, then show the role regrouping plays in addition, subtraction, multiplication and division. This allows students to focus on the reasoning behind the rules. Moreover, instead of memorizing eight different sets of rules, students memorize two processes (borrowing and carrying) with variations.

- As students learn and practice rules, use written cues to remind them how the rules work (for example, printing the phrase: "big number goes on top" next to subtraction problems serves as a reminder about the number relationships in subtraction).
- Use concrete objects, drawings, check marks, etc. to illustrate mathematic rules whenever possible, so students can associate the abstract process with a visual image.
- Use color-coding to help students become aware of how and when rules are in play (e.g. making the bigger numbers in a group of subtraction problems green, the smaller numbers in each problem blue, using highlighting or underlining to identify plus or minus signs, etc.)
- When focusing on specific rules or procedures, separate different types of problems on the page. As students become more comfortable with the rules, gradually combine problems of different types.
- Have students practice identifying rules in problems without actually doing the related computations. For example, a student given the problem '4 + 0' might respond that the '+' sign means to add, and that adding zero to any number results in the original number. Or, given the problem '3/4 X 1/3,' a student might respond that the 'X' sign means multiply, and the rule for multiplying fractions is to multiply the top numbers together and the bottom numbers together.
- Have students categorize related math problems together as variations of a larger rule. (e.g., the steps for 4/5 = __%, and the steps for 80% = _/_ are different, but the steps fall within the larger rule for converting fractions to percentages).
- Have students practice identifying math problems that are examples of specific rules (e.g., by operation), then have them create their own math problems where the rules apply.

Applying Rules/Impact of Memory and Higher Order Cognition

Academic areas such as mathematics depend a great deal on systems of rules (rules for computing numbers, rules for working with fractions, rules for solving equations, etc.). Rules provide a consistent structure for calculating and problem solving. As students are required to apply more and more rules in math, their abilities in memory and higher order cognition are called into play. When working through a math problem, students must remember which rules apply to the problem and which do not. In addition, they must hold aspects of the problem in mind while accessing and applying rules.

It is common for children to overuse a rule when they first begin to learn it. Through further practice, students learn when the rule does and does not apply, and are able to apply the rule more appropriately. This conditional knowledge of rules is a function of higher order thinking.

Here are some strategies to develop and strengthen students' applications of rules during math.

Helpful Hints

- Promote students' recognition of math patterns to guide them in the use of rules. For example, teach students to ask themselves, "Have I seen this type of problem before' What rule did I use' Do I apply the same rule for this problem'" etc.

- Encourage students to be monitor their own progress as they use rules, for example, stopping after completing each problem, or each line of problems, to ask themselves, "How am I doing so far' Am I using the rule I need to'" etc.
- Build students' knowledge of when to apply rules and how rules are relevant using real life situations. For example, to teach the rules for rounding numbers, use items from a restaurant menu, "for sale" notices from classified ads, mileage on a map, etc. Have students talk about when it would be appropriate to use rounded numbers, and when the exact figure would be needed.

Multi-Step Algorithms/Impact of Attention, Memory, and Sequential and Spatial Organization

Algorithms provide us with a blueprint, or set of guidelines, for working with math problems. An algorithm is a set of specific steps used to compute a problem. The algorithm for long division, for example, consists of the repeating sequence: divide, multiply, subtract, and bring down. For some students, learning and applying algorithms can be a challenge.

For students to use algorithms, they must rely on many attention skills including the ability to sustain attention to detail, to plan a solution, and to self-monitor progress. In addition, students must be able to call up algorithms from long-term memory and to hold a number of steps in their minds while working through multi-step solutions.

Students must also keep in mind the fact that algorithms are sequential in nature, having an order in which steps must be completed. The order of operations algorithm, for example, states that rather than moving from left to right to solve an equation like 3 + 6 X 4, the equation must be solved in a specific order based on the operation involved (in this case, first the multiplication: 6 X 4, then the addition: 3+24). Students must remember and follow the correct sequence to solve the problem correctly.

In addition to attending to the sequential aspect of algorithms, students must use spatial abilities to apply many procedures. When working with column addition and subtraction, or multiple-digit multiplication, for example, students must keep numbers aligned and spaced correctly on the page to do the calculations effectively.

Students with weak skills in any of the above areas may have difficulty working with algorithms.

Here are some strategies to help develop and strengthen students' use of multi-step algorithms in math.

Helpful Hints

- Teach students to break multi-step problems (including equations with several computations, word problems, etc.) into smaller parts. For example, ask students to first look over the entire problem, then to break the problem into parts and identify which parts require the use of algorithm(s). Next, have them choose the algorithm to be applied for each part, and finally, ask them to solve the problem, reflecting on their answers at each step. Note: A checklist may come in handy for students to use to break down problems into stages.
- Encourage students to practice using a calculator and the computer, math tools that will be useful in their school and work careers. As students progress in their

mathematical development, they can continue to explore the many capabilities of these tools.

- Incorporate mnemonics. Mnemonics are memory techniques, like making up words or rhymes, to help us remember things such as the steps in a process. Use mnemonics to help students remember steps to math algorithms. For example, Daddy, Mama, Sister, Brother can be used for the long division algorithm (Divide, Multiply, Subtract, Bring down).