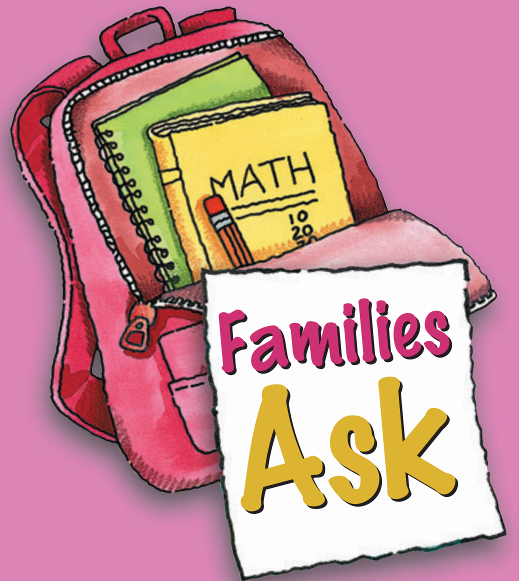

SHERRI MARTINIE

THE PURPOSE OF THE "FAMILIES Ask" department is to help classroom teachers respond to questions commonly asked by caregivers of their students. For each publication, a commonly asked question will be posed; a rationale for the response will be presented for teachers; and a reproducible page will be offered for duplication and distribution to parents, other caregivers, administrators, or community members—anyone involved in the mathematics education of middle school students.

Here is this month's question:

Isn't it more efficient for children just to learn rules and have understanding come later when they are more mature?

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"Families Ask" responds to questions commonly asked about current issues in mathematics education. It includes a "Familes Ask Take-Home Page" to share with parents, caretakers, and other interested members of the community. Send submissions to this department by accessing **mtms.msubmit.net.**

Rules or Understanding?

The role of understanding in learning mathematics has been referred to in textbooks from the 1800s and has been supported throughout the 1900s by psychologists, philosophers, and educators. Despite its persistent appearance, the importance of understanding continues to be questioned for several reasons. First, many adults view school mathematics as something separate from the mathematics needed in everyday life. The mathematics they learned in school was dominated by isolated facts, skills, rules, and procedures to be memorized and practiced. It has been reported that the mathematics curriculum is shallow, undemanding, and covers too many topics superficially (Kilpatrick, Swafford, and Findell 2001).

If parents view mathematics as something "we only do in school," then it is no wonder that they would question the purpose of investing large amounts of time getting students to understand the mathematics that we teach (Hiebert et al. 1997).

Second, mathematics used to be viewed as an elite subject, but now it is seen as being essential for all citizens (Hiebert et al. 1997). The belief that all students can learn mathematics has not always prevailed. For too long, the role of teachers has been underestimated and their contributions overlooked. It is important that teachers know what it means to understand mathematics, how to teach for understanding, and how to communicate this information with parents.

The 1990s have been dubbed the "decade of the brain," because of the progress of cognitive psychology in terms of understanding how the brain works (Bransford, Brown, and Cocking 1999). An analysis of what has been learned has led to a more complete picture of what it means to be "mathematically proficient." A model of five intertwined strands of proficiency captures this picture. These strands are (1) conceptual understanding, (2) procedural fluency, (3) strategic competence, (4) adaptive reasoning, and (5) productive disposition. These strands have been described extensively in *Adding It Up: Helping Children Learn Mathematics* (Kilpatrick, Swafford, and Findell 2001) We will focus briefly on conceptual understanding and procedural fluency. However, the importance of all five strands should not be overlooked.

Procedural fluency is the "how" in mathematics. It involves performing procedures accurately, efficiently, and with flexibility. On the other hand, conceptual understanding is the "why" in mathematics. It involves understanding what makes the operations work. Conceptual understanding enables students to comprehend the ideas that they study and find connections among them as well as between the concepts and the procedures they perform. Students need *both* procedural fluency and conceptual understanding. The question then becomes, which one comes first? Students should first learn about a concept, then procedures should build on that concept. These procedures then enable them to learn new concepts that support new procedures and so on. This is illustrated with an example in the take-home page. One convincing study is by Pesek and Kirshner (2002), who studied students exposed to learning about area and perimeter. They concluded that "initial rote learning of a concept can create interference to later meaningful learning" (p. 106). Students who were exposed to procedural instruction before they received conceptual instruction "achieved no more, and most probably less, conceptual understanding than students exposed to only the relational [conceptual] unit" (p. 106). Students who learned area and perimeter as a set of how-to rules referred to formulas, operations, and fixed procedures to solve problems. In contrast, the students whose initial experiences were conceptual used flexible and meaningful ways to develop solutions.

Research also indicates that emphasizing mathematics as rules decreases motivation and achievement when compared with a more exploratory curriculum, and students are less likely to think flexibly. The best way for students to *learn* mathematics is by actively *doing* mathematics that is meaningful, interesting, and important. Parents need to understand that the mathematics their child needs for the future will require flexibility, reasoning, and logic. We want parents and students to have a user-friendly view of mathematics.

Families Ask

Take-Home Page

Families often ask a question like this:

Isn't it more efficient for children just to learn rules and have understanding come later when they are more mature?

Many adults view school mathematics as something separate from the mathematics needed in everyday life. The mathematics they learned in school was dominated by isolated facts, skills, rules, and procedures to be memorized and practiced. It has been reported that the mathematics curriculum is shallow, undemanding, and covers too many topics superficially (Kilpatrick, Swafford, and Findell 2001). Many adults also believe that only a few "gifted" people can learn mathematics. However, we know more today about how people learn, and it has changed this old view. The 1990s were dubbed "the decade of the brain" because so much was discovered about how the brain works. From this new information, what we do in the classroom has changed to reflect the way people learn. We know that mathematics needs to make sense and that it needs to be meaningful. When real-life contexts are used and when students build new information on what they already know, then the knowledge they gain is powerful. "Brain research studies say the more sense used in instruction, the better learners will be able to remember, retrieve, and connect the information in their memories" (Sutton and Krueger 2002, p. 92). Mathematics should no longer be viewed as something "we only do in school."

The question posed here is asking about two kinds of mathematics: memorizing rules, on one hand, and understanding them, on the other. Memorizing rules is referred to as procedural fluency, the "how" in performing procedures accurately, efficiently, and with flexibility. On the other hand, conceptual understanding is the "why" behind knowing what makes the operations work. It enables students to understand the concepts they study and find connections among them. The question then becomes, which one comes first? Research indicates that learning concepts and procedures occurs in a hand-over-hand manner. Students learn about a concept, followed by procedures that build on that concept, and that leads to new concepts.

When introduced to fractions, students begin with the "concept" and are taught to understand that fractions are parts of things. They are given "sharing" experiences so that they come to understand that when we divide things into parts, we create fractions. They learn that the parts need to be equal in size, to be fair shares. They then learn to write the fractions using symbols such as 1/2 or 1/4. When they understand the concept of fractions, we can then meaningfully teach them to add and subtract fractions. Because they understand the fraction concepts, they realize that they need equal-sized pieces when joining and separating (adding and subtracting); thus, they see the need for common denominators in the procedures.

Facts, rules, and methods learned with understanding are easier to remember and use, and they can be reconstructed when forgotten. Learning with understanding is more powerful than simply memorizing because the act of organizing improves retention, promotes fluency, and facilitates learning related material. If practice occurs too soon, students tend to focus on only one procedure, which limits their computational fluency by hindering their ability to consider other methods or strategies. A study was done exploring students who were taught procedures for calculating perimeter and area followed by instruction on understanding those procedures. When tested, they did not perform as well as students who were taught to focus on understanding only. It seems that once students know and use a procedure, it is difficult to get them to participate in activities that help them understand it (Kilpatrick, Swafford, and Findell 2001; Pesek and Kirshner 2002).

As a parent, you can help support your child as he or she works to make sense out of what is being studied. Ask questions about why a particular procedure works. When looking over your child's work, focus less on right answers and more on how they got them. What were they thinking? Does everybody do it the same way? If you have another way to do something, share it. Help your child see mathematics as being user-friendly.

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