Lee Pesky Learning Center

The Educator

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Developing Fact Fluency in Mathematics

by Sam Strother
Associate Director
Developing Mathematical Thinking Institute

Math fact fluency is perhaps the most frequently debated topic in all of mathematics education. Almost all educators and parents would agree that quick and accurate retrieval of basic math facts is a desirable skill, however, fact fluency's importance and emphasis in the classroom varies greatly from class to class. Some educators believe that a drill-and-practice approach, emphasizing memorization and giving students multiple exposures to individual facts, will produce the greatest increase in fact fluency. Others argue that attempting to increase fluency through drill will not enhance students' school experience and that solving word problems and investigating mathematical patterns instead is a more engaging and worthwhile method of building knowledge of facts.

As in most emotionally charged debates, the correct answer is usually lost amid the 'noise' created when advocates of either side repeat their views at ever-increasing volumes and with greater and greater intensity. This is certainly the case for fact fluency, a topic that has been studied and debated for almost 100 years in the United States. We now know how to build children's math fact fluency. We've actually known how for decades. At this point, both sides of the current incarnation of the fact fluency 'argument' may as well be arguing whether we should use smoke signals or calligraphy to communicate. Neither position makes much sense in a world dominated by email, websites, and cell phones. With regard to fact fluency, neither approach--drill nor pure investigations--is good enough for our students. Fortunately, examining the history of fact fluency and some of the latest research on the topic will provide a clear answer and lead to an effective, research-based approach to building math fact fluency.

Some may wonder, "What's wrong with drill?" The reality is that drill is not an inherently 'bad' approach to learning some skills. Drill is just inefficient in terms of building fact fluency. If you are an advocate of drill, think for a moment about what that looks like in a typical classroom. Students likely take timed practice tests each day and may sometimes practice flash cards, chant number facts, or play drill-based games in an effort to enhance their fluency. But what happens when there are facts they don't know? Where is the instruction or opportunity to improve in the drill method? If a student doesn't know 7+9 or 6x8 on Monday, what happens to help this student before he or she is subjected to new tests and drills on Tuesday? The theory behind the drill-and-practice approach is actually born from a body of research predominantly conducted on animals and infants, not school children or adults trying to learn something as complex as mathematics. The basic hypothesis was that if students were exposed to facts over and over again, the information would bond in their minds and be retained. For students with strong numerical memories, this may work for some facts. We all know (or may be) people who seem to have an uncanny ability to remember phone numbers, addresses, or number sequences. But most students do not have this innate memory capacity.

From the 1920's through the 1960's a group of educational theorists, referred to as 'drill theorists', advocated an approach to teaching that mimicked the popular industrial assembly line. Topics were to be segmented into simple components and students would learn new information by routine drill and practice of these small, isolated skills. However, opponents of this approach (often called 'meaning theorists') rejected the drill method and advocated an approach that encouraged students to make connections between what they were learning and what they already knew. In classrooms emphasizing this meaning-based approach, students would practice by looking at patterns and finding related facts that could help them solve facts they didn't know. For 7+9, students might know 7+10 and would simply, "…take 1 away…" to derive the answer to 7+9. When solving 6x8, students often know 5x8 and can simply add another 1x8.

Every 10 to 15 years, beginning around 1925, large-scale studies were conducted comparing students' basic fact fluency in classrooms utilizing either drill or meaning-based approaches. By the late 1960's, all of the largest studies indicated that meaning-based classrooms consistently outperformed drill-based classrooms. To date, no legitimate study has produced significant evidence that drill surpasses the meaning theorists' approach in building fact fluency.

So, if drill doesn't work as well as the approach first advocated by the meaning theorists over 70 years ago, why aren't classrooms using a meaning-based approach to teaching fact fluency? Unfortunately, over the years, the fundamental principles underlying the meaning theory have been either watered down or ignored. Evidence pointing to the harmful effects of timed-tests on students' self-esteem has often been used to justify never giving timed tests to assess fluency. This does not make sense, as you would need to collect fluency data every 3-4 weeks to know if students are improving. Various efforts to reform math education in

References and Recommended Reading

What's Math Got to Do with It: Helping Children Learn to Love Their Most Hated Subject - and Why It's Important for America. 2008. J. Boaler. Viking Press.
Elementary and Middle School Mathematics: Teaching Developmentally. 2009. J. Van de Walle, K. Karp, J. Bay-Williams. Allyn & Bacon.
Mathematics Learning in Early Childhood: Paths Toward Excellence and Equity. 2009. National Research Council.
The Development of Arithmetic Concepts and Skills: Constructing Adaptive Expertise. 2009. A. Baroody, A. Dowker. Taylor & Francis e-Library.

the United States have also struggled to provide a coherent message regarding what teaching fact fluency should look like. The modified, and inaccurate, modern version of the meaning-based approach involves students investigating patterns and solving various word problems. While these methods are crucial to students' conceptual learning of mathematics, they tend to fail in building basic fact fluency because students don't spend enough time practicing facts.

To build fact fluency, the most effective strategy is to give students 10-15 minutes per day to practice using what are called ***derived facts strategies*** (DFS). Essentially, DFS's are using facts you know to solve facts you don't know. For the addition facts (and the related subtraction facts), the most crucial DFS's for students to learn to use are **Doubles Variations** and **Make 10 strategies**. Here are some examples of how to use different Doubles Variations and Make 10 strategies to solve some typically difficult addition facts.

Doubles Variations Strategies for 6+7

6+6+1
7+7-1

Make 10 Strategies for 8+6

8+2+4
10+6-2

For multiplication facts, knowing the 2's, 5's, and 10's are the most critical facts so students can carry out derived facts strategies with multiplication facts. Here are some examples of how to use these facts to solve 6x9.

Using x2
2x9=18
2x9=18
2x9=18

Using x5
5x9=45
1x9=9

Using x10
6x10=60
-(6x1)= -6

In the fall of 2009, the Developing Mathematical Thinking Institute conducted a study comparing 40 fourth grade students' multiplication fact fluency development to 67 fourth graders and 72 fifth graders from another school. The study ran for 25 instructional days. The first group of fourth graders (n=40), practiced their multiplication facts by following an instructional unit designed by Sarah Bautista of Lincoln Elementary in Caldwell, Idaho. Her instructional unit built meaning for the facts through various activities and then gave students the opportunity to practice their facts by using derived facts strategies. Towards the end of the unit, the fourth graders from the 'strategy classrooms' were using flash cards to practice, but were instead using them as 'strategy cards'. Strategy cards are much like traditional flash cards with one major difference: as a fact was presented on the card, pairs of students had to discuss two or three related facts that would help them solve the fact on the card.

The other fourth and fifth grade classrooms ('drill classrooms') did not use the instructional unit and instead practiced their facts using traditional methods of timed tests, flash cards (not strategy cards), and skip-count chanting. After only five weeks, the fourth grade strategy classrooms could solve more facts in a minute than the fifth grade drill classrooms and had increased their average facts per minute by almost four times what the fourth grade drill classrooms had! Furthermore, the strategy classrooms had no student decrease their total number of facts from the pre to post-test, but the fourth grade drill classrooms had an average of 2.5 students score lower on the post-test and the fifth grade drill classrooms had an average of 4.6 students score lower on the post than the pre-test.

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Lee Pesky
Learning Center

3324 Elder Street
Boise, ID 83705

Phone: 208-333-0008
Fax: 208-333-0888

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This recent study, along with the substantial history of fact fluency research, indicates that students can be successful in learning their basic facts. They simply need an opportunity to make sense of basic facts and should be encouraged to use derived facts strategies often.

For more information please visit:

- Developing Mathematical Thinking website at http://dmt.boisestate.edu
- Attend an MTI (Mathematics Thinking for Instruction) class in your area
- Read the references cited in sidebar on page 2
- Contact Cristianne Lane, Director of Professional Development, clane@LPLearningCenter.org or 208-577-1115

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