CPM EDUCATIONAL PROGRAM

Research Base Excerpt: Synthesis of Research on Mixed, Spaced Practice, 2013

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2013 Introduction to Mixed, Spaced Practice

The biggest change in the research pertaining to CPM in the past six years has been the huge rise in interest in what is now known as *mixed, spaced practice*. At the time that the previous review summary was written there were only a few dozen papers dealing with this topic. Now there are almost 2000. Many researchers are taking the idea seriously.

It has been known for many years that spacing out review sessions over time increases the long-term retention of the knowledge; this is known as *spaced practice*. The new feature of research on the role of review in student learning is *mixed practice*, where students deal with different kinds of problems during a single review or homework session. But, as Dempster (1988) noted a quarter of a century ago, the knowledge about the effectiveness of spaced practice was almost never utilized in designing curricula. At that time, mixed practice was nowhere on the research agenda, and this new knowledge is rarely used in designing textbooks either.

The major reason that people persist in using *massed practice*—lots of similar problems of the same kind all at once—rather than spacing it out is that this kind of practice feels good immediately. Students believe they have learned what they were supposed to learn because they can follow a pattern, and teachers believe that they have taught it because they see students getting the right answers. So everyone is happy on that day. The problem is that the effect fades away quickly.

Small children often learn by following patterns and learn to engage in a practice without understanding *why* they are doing something in the way they are doing it and usually never even thinking that they should put the action in a larger context. This is fine when you are young and these personal histories of success are hard to ignore even as cognitive scientists are discovering much more about consolidation of memories. As Kornell & Bjork (2008) pointed out after a study on learning, "Participants rated massing as more effective than spacing, *even after their own test performance had demonstrated the opposite*" [emphasis added].

What does the research show about spaced practice?

By now, the "spacing effect" is an overwhelmingly well-documented phenomenon that shows that learning is improved when the learning practice is spaced over time, rather than being massed, or

happening all at once and then being ignored. In the past 70 years, dozens of researchers of psychology, workplace training and education have validated this "spacing effect." Researchers who study workplace training refer to "distributed practice" or "spaced practice" (as opposed to "massed practice") as the cause of the spacing effect while they seek methods of improving the effectiveness of training programs or workers. Roughly speaking, as long as there is some latent memory of earlier learning of a skill, delaying the reinforcement by spacing improves both transfer and long-term learning. See Carpenter et al. (2012) or Son & Simon (2012) for good summary review articles about spaced practice.

Psychologists have verified the phenomenon in babies as young as three months of age in one study [(Roveecollier et al., (1995)] and in numerous studies for school-age children up to adults and in areas as diverse as rolling kayaks [(Smith & Davies, (1995)], aircraft recognition [(Goettl, (1996)] and learning languages [(Bahrick & Phelps, (1987) and Bahrick et al., (1993)]. Because the spacing effect appears in so many contexts, it appears as Raaijmakers (2003, p. 432) commented, "that **basic principles of learning and retention are involved"** [emphasis added].

Rohrer & Pashler (2010) commented that "the temporal dynamics of learning show that learning is most durable when study time is distributed over much greater periods of time than is customary in educational settings." Rohrer (2009) went further from his study of overlearning (unneeded practice) and flatly states that "overlearning is an inefficient use of study time," and Rohrer & Taylor (2006) lamented that "most mathematics textbooks rely on a format that emphasizes overlearning and minimizes distributed practice." For further references see Seabrook et al. (2005) on learning reading, Vlach & Sandhofer (2012) on elementary age children learning science concepts, Rohrer & Pashler (2007) on learning mathematics, and Bude et al. (2011) for a study on college students learning statistics.

Even with all of this research, there is a significant reluctance to use spaced practice in the classroom. A major reason is that this practice ***slows down the initial learning at the same time that it improves long-term retention and transfer***. Rohrer et al. (2005) pointed out in a study of geography students, "The overlearners recalled far more than the low learners at the one-week test, but this difference decreased dramatically thereafter." Other studies making the same findings are Karpicke & Roediger (2007) and Vlach & Sandhofer (2012).

What does the research show about mixed practice?

The research on mixed practice—interweaving different types of mathematics problems in a single homework session—is much newer, and fewer people have published studies about it. Rohrer & Taylor (2007) found that for college students "performance was vastly superior after mixed practice." In 2010, Rohrer & Pashler found that "interleaving of different types of practice problems (which is quite rare in math and science texts) markedly improves learning." An earlier result from the research by Hatala et al. (2003), which focused on how to teach medical students to read ECGs, also showed support for mixed practice and implies that students studying subjects other than mathematics and science can benefit from this strategy. While all of these studies were done on people of college age or older, there seems to be no reason to believe that similar effects would not be found for school-age students. In fact, Rohrer (2009) provides a strong rationale for incorporating both spaced and mixed practice regularly:

> Spacing provides review that improves long-term retention, and mixing [problem types] improves students' ability to pair a problem with the appropriate concept or procedure. Hence, although mixed review is more demanding than blocked practice, because students cannot assume that every problem is based on the immediately preceding

lesson, the apparent benefits of mixed review suggest that this easily adopted strategy is underused.

CPM has been using mixed, spaced practice for 24 years, and virtually all of our teachers believe that this practice is central to improving long-term student learning.

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