Six Strategies for Effective Learning

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The Learning Scientists: http://www.learningscientists.org

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Cognitive psychologists have made significant advances in applying cognitive processes to education in the past few decade (Dunlosky, Rawson, Marsh, Nathan, & Willingham, 2013; Weinstein, Madan, & Smith, in press; Smith, Madan, & Weinstein, in press). From this work, specific recommendations can be made for students to maximize their learning efficiency. Specifically, six key learning strategies from cognitive research can be applied to education: spaced practice, interleaving, elaborative interrogation, concrete examples, dual coding, and retrieval practice. However, a recent report (Pomerance, Greenberg, & Walsh, 2016) found that few teacher-training textbooks cover these principles; current study-skills courses also lack coverage of these important learning strategies. Students are therefore missing out on mastering techniques they could use on their own to learn effectively.

We recently synthesized these 6 strategies in a new framework that involves the following three stages: planning (spaced practice and interleaving); reinforcement (retrieval practice); and development of understanding (elaboration, concrete examples, and dual coding; Smith & Weinstein, in press).

What follows is a heavily abridged version of:
Weinstein, Y., Madan, C. R., & Smith, M. A. (in press). Teaching the science of learning. *Cognitive Research: Principles and Implications.*

Planning

Spaced Practice

The benefits of spaced (or distributed) practice to learning is arguably one of the strongest contributions that cognitive psychology has made to education (Kang, 2016). The effect is simple: repetitions spaced out over time will lead to greater retention of information in the long run than the same number of repetitions close together in time (known as massing). Teachers can introduce spacing to their students in two ways. (1) by creating opportunities to revisit information throughout the semester, or even in future semesters; and (2) by helping older students to create their own spaced study schedules.

Interleaving

Interleaving is another scheduling technique that can increase learning efficiency. Interleaving occurs when different ideas or problem types are tackled in a sequence, as opposed to the more common method of attempting multiple versions of the same problem in a given study session (known as blocking). For example, students might interleave different types of problems during learning, which

is particularly applicable to subjects such as math and physics (Rohrer & Taylor, 2007). Interleaving can be helpful in other situations that require discrimination, such as inductive learning (Kornell & Bjork, 2008). Another type of interleaving involves the interleaving of study and test opportunities (Trafton & Reiser, 1993).

Reinforcement: Retrieval Practice

What should students be doing when they sit down to study? While tests are most often used for assessment purposes, a lesser known benefit of tests is that they actually cause learning by strengthening the memory of the tested information (Karpicke, Lehman, & Aue, 2014). Testing was shown to strengthen memory as early as 100 years ago (Gates, 1917), and in recent decades there has been a surge of research in the last decade on the mnemonic benefits of testing, or what we now call *retrieval practice*. The act of retrieval itself is thought to strengthen memory, making information more retrieval later (Roediger & Karpicke, 2006). In addition, practicing retrieval improves higher-order, meaningful learning, such as transferring information to new contexts or applying knowledge to new situations (e.g., Butler, 2010; McDaniel et al., 2013; Smith, Blunt, Whiffen, & Karpicke, 2016). Practicing retrieval is a powerful way to improve meaningful learning of information, and it is relatively easy to implement in the classroom. When students sit down to study, their primary strategy should always involve retrieval practice.

Development of Understanding

Elaboration

Elaboration involves connecting new information to pre-existing knowledge, and describing things in many details. In practice, elaboration could mean many different things, but the common thread is that elaboration involves adding features to an existing memory. Elaborative interrogation is a specific technique under the umbrella of elaboration that has received ample evidence in terms of effectiveness. This technique is called elaborative interrogation, and involves students questioning the materials that they are studying (Pressley, McDaniel, Turnure, Wood, & Ahmad, 1987). To use this technique, students must ask "how" and "why" questions about the concepts they are studying, and then try to answer these questions – either from their materials, or, eventually from memory (McDaniel & Donnelly, 1996). The process of figuring out the answer to the questions – with some amount of uncertainty (Overoye & Storm, 2015) – can help learning.

Concrete Examples

Providing supporting information can improve the learning of key ideas and concepts. Specifically, using concrete examples to supplement content that is more conceptual or abstract in nature can make the ideas easier to understand and remember (Paivio, Walsh, & Bons, 1994). Concrete examples can provide several advantages to the learning process: (a) they can concisely convey information, (b) they can provide students with more concrete information that is easier to remember, and (c) they can take advantage of the superior memorability of pictures relative to words (see Dual Coding). However, care must be taken when selecting the examples (LeFevre and Dixon, 1986), and many examples will need to be provided so that students can deepen their understanding of abstract concepts rather than focusing on surface features (Gick & Holyoak, 1983).

Dual Coding

More information can be conveyed through a simple illustration than through several paragraphs of text (e.g., Barker & Manji, 1989; Mayer & Gallini, 1990). In addition to being able to convey information more succinctly, pictures are also more memorable than words (Paivio & Csapo, 1969, 1973). Paivio (1971) proposed that verbal and pictorial information is processed through separate channels or information 'codes'. This dual coding theory (Paivio, 2007) suggests that providing both verbal and pictorial representations of the same information enhances learning and memory. Clark and Paivio (1991) provide a thorough review of dual coding theory and its relation to education. Given that pictures are generally remembered better than words, it is important to ensure that the pictures students are provided with are helpful and relevant to the content they are expected to learn. If students are provided with useful visual examples, this can decrease conceptual errors; however, visual details can at times become a distraction and hinder performance (McNeill, Uttal, Jarvin, & Sternberg, 2009).

Warning: Learning Styles

Dual coding theory is distinct from the notion of 'Learning Styles,' which describe the idea that individuals benefit from instruction that matches their modality preference. While this idea is pervasive and individuals often subjectively feel that they have a preference, evidence indicates that the learning styles theory is not supported by empirical findings (Pashler, McDaniel, Rohrer, & Bjork, 2008). That is, there is no evidence that instructing students in their preferred learning style leads to an overall improvement in learning. Learning Styles have become an urban legend in education (Hattie & Yates, 2014); the evidence-informed teacher must remain skeptical of this fad in the absence of reliable evidence for teaching to preferred Learning Styles (Kirschner, 2017).

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