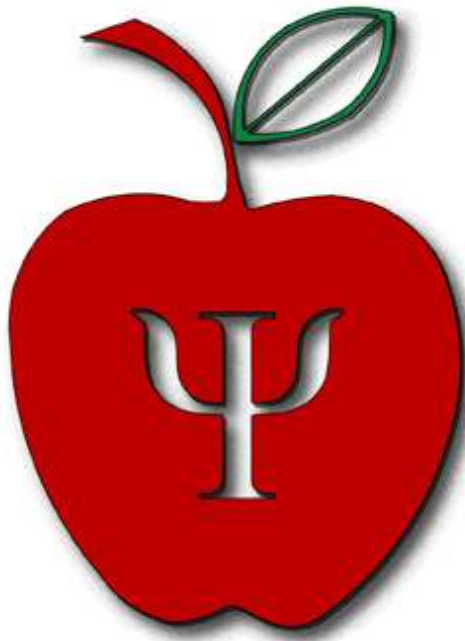


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Chapter 3

Four Simple Strategies from Cognitive Psychology for the Classroom

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Scientists focusing on educational research questions have a great deal of information that can be utilized in the classroom. However, there is not often bidirectional communication between researchers and practitioners in the field of education as a whole (see Roediger, 2013). In this article, we describe the science behind four evidence-based teaching strategies: (1) providing visual examples, (2) teaching students to explain and to do, (3) spaced practice, and (4) frequent quizzing. Below, we provide concise overview of these strategies and examples of how they can be implemented in the classroom before describing the science behind each strategy:

1. Providing visual examples
 - Relevant cognitive concepts: Dual coding
 - Description: Combining pictures with words.
 - Application examples (using social psychology topics):
 - Students can draw examples of factors determining liking or loving. For example, two people who are close vs. far away, two people who are similar vs. different, or a visual depiction of reciprocity
 - Instructors can make sure to provide video depictions of experiments where available to go with verbal descriptions (e.g., Milgram, misattribution of arousal)
2. Teaching students to explain and do
 - Relevant cognitive concepts: Elaborative interrogation; Levels of processing; Enactment effect
 - Description: Asking and explaining why a factor or concept is true; asking students to perform an action.

- Application examples (using social psychology topics):
 - Students can ask and explain what factors contribute to whether one person helps another person.
 - Instructors can provide students with example scenarios of a person in need of help and ask students to describe and explain why they think a passerby may or may not help.
3. Spaced practice
- Relevant cognitive concepts: Spacing; Interleaving; Distributed practice; Optimal lab
 - Description: Creating a study schedule that spreads study activities out over time.
 - Application examples (using social psychology topics):
 - Students can block off time to study for 30 minutes each day rather than only studying right before a test or exam.
 - Instructors can assign online quizzes that interleave questions from various chapters.
4. Frequent quizzing
- Relevant cognitive concepts: Testing effect; Retrieval practice; Retrieval-based learning
 - Description: Bringing learned information to mind from long-term memory.
 - Application examples (using social psychology topics):
 - Students can practice writing out everything they know about a topic, for example conformity, obedience, and bystander effects.
 - Instructors can give frequent low-stakes quizzes in the classroom or online to encourage retrieval practice.

Instructors can find free teaching materials for each of these strategies on the Learning Scientists website (www.learningscientists.org/downloadable-materials).

We focus on these strategies because they were highlighted in a recent policy report from the National Council on Teacher Quality (Pomerance, Greenberg, & Walsh, 2016), which identified key teaching strategies based on evidence from the science of learning. The report found that few of the 48 teacher-training textbooks they examined cover any of these learning principles well—and that *none* covered more than two of them (but see Thomas & Goering, 2016). These strategies also reiterate recommendations made in an earlier guide commissioned by the U.S. Department of Education (Pashler, Bain, Bottge, Graesser, Koedinger, McDaniel, & Metcalfe, 2007; also see Dunlosky, Rawson, Marsh, Nathan, & Willingham, 2013). Thus, there seems to be a gap between the research – converging evidence from controlled laboratory studies and classroom studies – and practical use of the strategies in education. While there are in-depth reviews on each of these strategies, here we provide a concise, teacher-ready overview of these strategies and how they could be applied in the classroom.

1. Providing visual examples

Learning can be substantially enhanced if verbal information is accompanied by visual examples. This coupling of verbal and visual information is supported by the ‘dual-coding theory’ (Paivio, 1986). This theory attributes the mnemonic benefits of providing visual examples to different cognitive processes associated with processing words and images, or even words that describe concrete ideas.

This can be particularly useful when teaching abstract concepts (see Figure 1 for an example, <http://www.learningscientists.org/dual-coding-example>), as associating concrete and abstract terms can improve memory for the abstract information (Madan, Glaholt, & Caplan, 2010).

Additionally, there is clear evidence that memory for pictures is superior to memory for words (Paivio & Csapo, 1969; 1973). However, this effect is fundamentally distinct from the notion of “learning styles”, where information to be learned is presented in a learner’s preferred modality. This type of differentiation is not supported by cognitive research (Rohrer & Pashler, 2012) and has often been described as a myth or urban legend (Coffield, Moseley, Hall, & Ecclestone, 2004; Hattie & Yates, 2014; Kirschner & van Merriënboer, 2013). Rather than diagnosing each student’s style and matching instruction for each individual, teachers can couple visual examples with text for all students.

2. Teaching students to explain and to do

One of the most effective methods to improve learning of information is to have students engage with the material more ‘deeply’, also known as elaboration (Craik & Lockhart, 1972; also see Lockhart & Craik, 1990). Elaboration has been defined in many ways, but most simply it involves connecting new information to pre-existing knowledge. Perhaps William James said it best: “The art of remembering is the art of *thinking* [...] our conscious effort should not be so much to *impress* or *retain* [knowledge] as to *connect* it with something already there. The connecting *is* the thinking; and, if we attend clearly to the connection, the connected thing, will certainly be likely to remain within recall” (James, 1899, p. 143). Two forms of elaboration are readily applicable to classroom learning: having students explain why something is the case, and having students perform actions.

Elaborative processing can be fostered by having students question the material that they are studying; for instance, by asking them to produce their own explanations for why a fact is true, rather than just presenting them with a complete explanation (Pressley, McDaniel, Turnure, Wood, & Ahmad, 1987). This elaboration technique is flexible enough to work in a variety of different learning situations (e.g., for students working alone or in groups, Kahl & Woloshyn, 1994). However, work on elaborative interrogation outside of the lab is just beginning (Smith, Holliday, and Austin, 2010) and we need stronger evidence from the classroom before we can confidently claim that this technique is helpful (Dunlosky et al., 2013). Another relevant technique is that of self-explanation, where students walk themselves through the steps they take during learning. This technique is helpful both when students engage in it spontaneously (Chi, Bassok, Lewis, Reimann, & Glaser, 1989), and also when teachers prompt students to produce the self-explanations (Chi, De Leeuw, Chiu, & LaVancher, 1994).

When feasible, the most elaborative way to process information is by ‘doing’. When information could either be learned by hearing about an action, watching someone else do the action, or having the student themselves perform the action, retention was best in cases where the student performed the action themselves (Cohen, 1981; Engelkamp & Cohen, 1991). This action component can build upon the previously described dual-coding theory (Engelkamp & Zimmer, 1984; Madan & Singhal, 2012). In the classroom, this type of learning could be supported by hands-on activities (e.g., science experiments, or getting students to draw their own diagrams; Wammes et al., 2016) or field trips to museums or nature sites.

3. Spaced practice

We often tell our students that cramming “doesn’t work”. That is good advice—but is not entirely true. As many students have discovered, “cramming”—an intense study period that occurs shortly before one’s memory is to be tested—sometimes does work. Cramming often produces adequate performance on an imminent exam (Roediger & Karpicke, 2006); unless the cramming is done instead of sleep, in which case the sleep deprivation outweighs any gains from cramming (Gillen-O’Neel, Huynh, & Fuligni, 2013). The information learned through cramming, however, will subsequently be rapidly forgotten (Bjork & Bjork, 2011). In order for information to be retained more sustainably and over longer periods of time, it needs to be revisited on multiple occasions spaced out over time. This is known as distributed practice, or the spacing effect, which has been in the literature since Ebbinghaus first discovered it in the late 19th century (Ebbinghaus, 1885/1913). Despite much converging evidence over the past 100 years (see Cepeda, Pashler, Vul, Wixted, & Rohrer, 2006), this practice has not made its way into mainstream education (Kang, 2016).

In the cognitive literature, a distinction is made between spacing and interleaving, i.e., switching back and forth between different topics or question types within a topic (Rohrer & Taylor, 2007). That is, Storm, Bjork, and Storm (2010) showed that interleaving produces benefits that cannot entirely be accounted for by spacing. However, in practice, it is hard to imagine an educationally relevant situation in which spacing and interleaving would be dissociated. We propose, then, that the theoretical distinction between spacing and interleaving may not be critical in terms of practical applications. Instead, teachers can focus more generally on trying to provide students with opportunities to space their studying.

One implementation issue is that spacing hurts performance in the short-term, which makes it less appealing. Students typically feel overconfident when they cram, while spacing out learning leads them to feel relatively less confident (Bjork, 1999); but this is a “desirable difficulty”, which helps learning in the long-term (Bjork, 1994). When making predictions about future performance based on different study schedules, students tend to underestimate the benefits of spacing (Logan, Castel, Haber, & Viehman, 2012). Another reason why spacing might not be used by students as often as we’d like was recently suggested by Kang (2016): this strategy may require more advance planning than simply studying one topic until a saturation point is reached. More research is necessary to fine-tune implementation of spaced study schedules, and would preferably involve teachers in classrooms.

4. Frequent quizzing

The use of retrieval practice to aid learning has been a major focus of the applied cognitive literature in the past decade. As with spacing, the finding that testing strengthens memory is not new (Gates, 1917). However, the message that testing helps learning is somewhat politically charged and often lost when teachers hear the word “testing” because this activates ideas related to high-stakes standardized testing. It’s important to note that frequent testing does not have to be presented as a formal quiz; any activity that promotes retrieval of target information should help (e.g., Karpicke, Blunt, Smith, & Karpicke, 2014).

Although the mechanisms behind the retrieval practice effect are not yet fully understood, the findings are quite clear: when preparing for a test, practicing retrieving information from memory is a much more effective strategy than restudying that information (Roediger & Karpicke, 2006). This is true even when there is no opportunity to receive feedback on the quiz (Smith, Roediger, & Karpicke, 2013), as long as performance on the practice quiz is not too low (Kang, McDermott, & Roediger, 2007). The only notable exception to the retrieval practice effect is when the final test is occurring immediately after study, in which case restudying can sometimes be more effective than testing (Smith et al., 2013). However, unless students are reviewing their notes before walking into the exam room, in general it is quite rare for students to be anticipating an immediate test situation while studying. Thus, in regular exam preparation situations, a strong recommendation can be made from the literature: students ought to practice retrieval.

A good way to integrate quizzes into regular teaching is to provide opportunities for retrieval practice during learning; quiz questions interspersed during learning produce the same benefit to long-term retention as quiz questions presented at the end of a learning episode such as a lecture (Weinstein, Nunes, & Karpicke, 2016). In addition to providing retrieval practice, this method also boosts learning by maintaining test expectancy throughout the learning experience (Weinstein, Gilmore, Szpunar, & McDermott, 2014). A combined benefit of retrieval practice and spacing can be gained from engaging in retrieval practice multiple times. Creating the specific spacing schedule for a particular educational situation is tricky because it depends how strong the original memory is, and how quickly forgetting is going to happen for that information (Cepeda, Vul, Rohrer, & Wixted, 2008). Without the use of sophisticated software to schedule spacing, a more practical suggestion may be for teachers to include quiz questions from previous topics throughout the semester, in order to facilitate a reasonable amount of spaced practice.

Conclusion

There is an unending supply of suggestions on how students can learn information more effectively. Here we draw from established cognitive psychology research and distill four simple strategies to enhance classroom learning. These four strategies are: (1) providing visual examples, (2) teaching students to explain and to do, (3) spaced practice, and (4) frequent quizzing. More specifically: (1) Try to present information with both text and pictures; (2) Get students to explain the information they are learning, or if possible, have them act things out; (3) Create opportunities to revisit information over the course of a semester; and (4) Include low-stakes quizzes throughout learning to provide retrieval practice. Critically, each of these strategies is strongly supported by extant research and can be readily implemented in the classroom.

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