Helping Students Learn Knowledge

When *CEE* received a copy of Lang's new book,[1] I volunteered to review it because I had found his earlier book[2] useful. Lang's idea of small teaching is to use proven short interventions that are based on learning sciences. To increase readership, the book review was converted into *CEE* Teaching Tips on knowledge, understanding, and motivation.

Chemical engineers analyze, solve problems, and design; why is knowledge first? Factual knowledge and how to use it are required for the higher-level cognitive activities. The brain's memory storage is essentially infinite—the challenge is retrieval of useful knowledge. The internet and Google have only increased the challenge of retrieving useful knowledge. Lang's first prescription: have students practice retrieval from their brains, not from Google or the textbook. For example, give a five-minute, closed-book, ungraded quiz asking students to recall parts of the previous lecture or of reading, and then have students self-score their papers as you provide immediate feedback. Another option is to give weekly graded, but low-stakes, quizzes with rapid feedback. Both methods increase student retention of knowledge and result in higher grades. My experience with weekly quizzes is students who persistently take the quizzes do better on tests, even if their quiz grades are low, than students who skipped quizzes.

The second principle is "making predictions about material that you wish to learn increases your ability to understand that material and retrieve it later."[1, p. 43] In research we call this hypothesis testing. One example is to spend a few minutes in class first having students predict from their conceptual knowledge (no calculation and without looking at the textbook or notes) the behavior of a complicated function or of a unit operation (*e.g.*, if pressure of a distillation column is increased, what happens?). Immediately provide feedback by showing a plot of the function or a simulation of the operation. Predictions of this type can easily be developed into excellent clicker questions. If a little more time is available ask questions that induce reflection: Why did they make the prediction? What actually happened? Why was prediction correct or incorrect?

A second example of making predictions is to give students an ungraded pretest *before* a lecture. Although many of the student answers will be guesses, the act of guessing prepares their brains to seek connections. During the lecture, provide the answers and be sure students do not leave believing their wrong answers were correct. Pretests also provide students with clues of what parts of the lecture are most important. However, Lang cautions that if you do not explain why you are giving pretests, students may rebel.

Lang's third principle for increasing student learning is *interleaving*, which is combining blocked and spaced learning with spiral coverage. Blocked learning consisting of a long, concentrated period of learning is often useful initially. However, blocked learning does not require students to access long-term memory; thus, retrieval is not practiced. Spaced learning, relatively short and separated periods, does require retrieval and relearning material that has been forgotten. The best approach is often to combine blocked and spaced learning. Spaced learning can be introduced by including review questions in assignments and tests and by giving a comprehensive final exam. Strongly encourage spaced study instead of cramming by staggering due dates of a number of short assignments.

Spiral learning, which requires changes in course structure, involves moving on to the next topic before the current topic is exhausted and eventually returning to the topic but at a different level. Spirals automatically space learning, provide opportunities to review previous material, and show connections between topics.

REFERENCES

1. Lang, J.M., *Small Teaching: Everyday Lessons from the Science of Learning*, San Francisco, Jossey-Bass, 2016
2. Lang, J.M., *Cheating Lessons: Learning from Academic Dishonesty*, Cambridge, MA. Harvard University Press, 2013❒

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This one-page column presents practical teaching tips in sufficient detail that others can adopt the tip. Focus on the teaching method, not content. The column should be maximum 600 words, but subtract 50 words for each figure or table. Submit as a Word file to Phil Wankat <wankat@ecn.purdue.edu>. Subject: CEE Teaching Tip.