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LETTERS

edited by Jennifer Sills

Teaching and Learning Strategies That Work

FOR MORE THAN FOUR DECADES, WE HAVE TAUGHT CHEMISTRY. AS WE STRUGGLED TO BECOME better teachers, we developed (and borrowed) a number of effective strategies. Learning and teaching are a double flame—each feeds the other. We begin with some suggestions for instructors.

Foster the mentor-apprentice bond you have with your students. Once established, this relationship helps students learn in two ways: First, the student admires the mentor and wants to attain the mentor's level of understanding. Second, the mentor can help the learner navigate boring or tough stages on the way to mastery.

Teach students how to learn. Students may not realize that learning progresses through stages, with memorization being only an early one (1). Bloom and colleagues identified levels of learning, now labeled as remembering, understanding, applying, analyzing, evaluating, and creating (2, 3). Making students aware of different kinds of learning can transform them from rote memorizers into independent, self-directed learners (4). We have also found that when students learn about metacognition (thinking about your own thinking) (5) they change their attitudes about learning and begin to implement effective study strategies.

Grade on a combination of dominant absolute performance (examinations and quizzes) and minor "curved" components (such as labs). A clearly defined contract is best, in which performance at a certain level ensures a grade, with adjustments only to increase the grade. With this system, students are empowered—the outcome of their course grade is dependent on their work alone rather than their work relative to the work of others. For this to be effective, you will need to construct exams for which the level of mastery of the material is accurately reflected by the grade (6).

Do as many demonstrations as possible. Demonstrations are somewhere between magic and science (7), and they cross the bridge from entertainment to learning. Ideally, they also incorporate content and thus enhance learning.

We disagree about "cheat sheets"—allowing each student to bring to a test one page on which he or she can write anything. On one hand, the sheet serves as a learning tool; in composing it, the student organizes what he or she has learned. On the other hand, students may spend time looking for information to copy onto the sheet instead of working to understand concepts.

More generally, let these ideas shape your teaching: (i) Empathy. Students will respond when they know that you genuinely care about them. (ii) Active learning. Student participation will facilitate learning. (iii) Judicious interplay of groups and individuals. Learning is a solitary activity, yet it can be enhanced by group work. (iv) Empowerment. Encourage students to feel that they are responsible for their own learning successes.

We have found that students can improve their learning through the following strategies:

Take notes by hand, even if the class notes are provided. As soon as possible, condense and extend the notes, paraphrasing them into your own words. Taking notes is active engagement, which is imperative for learning (8). The process of paraphrasing notes helps transfer information from short-term to long-term memory (9, 10).

If you miss a class, get notes from a fellow student instead of downloading them from a Web page. Discussing class notes facilitates learning, both for the student who asks questions about the notes, and for the student who engages in teaching by answering the questions.

To maximize learning from homework problems, first study the text and lecture information relevant to the problems. Next, work through the problems without looking at an example or the solutions in a solutions manual. Finally, compare your approach—not just your answer—to the text's. (Instructors should always provide ways to work through each problem, not just the answers.) Focusing on methods, rather than final answers, helps you develop agile, flexible thinking.

To make the most of group learning, the alone-together-alone sequence is crucial. First try to do the homework problems or prepare for the exam alone. Then, access the collective wisdom of a group, watchful for the pitfalls of group dynamics. Finally, return to solving the problem set or facing the exam on your own. Social constructivist learning theorists have shown that meaningful learning results from study groups with two crucial features: discussion and problem-solving activities (11). Tips for forming effective groups are available (12).

Individually and in groups, make up practice tests when preparing for examinations. This exercise involves the selection and organization of all the material and fosters discussion of what material is important enough to be on the test. This is the only way to get into the teacher's mind.

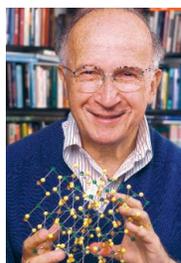
Finally, we provide a suggestion for both teachers and students:

Recognize that students have different learning styles. Learning style can refer to a person's preferred modality [visual, auditory, verbal, or kinesthetic (13)], Myers-Briggs personality type (14), or other learner characteristics. People do disagree about these (15), but we think they are useful. Students should work to understand their individual learning preferences in order to become more efficient learners. Teachers need to recognize that there are different ways to learn and try to accommodate a variety of learning styles in their classes. Instructors should resist the temptation to teach only as they were taught or in a manner that suits their own learning style.

Our suggestions are not prescriptive; we just want to share with you some of the strategies we



Saundra Y. McGuire



Roald Hoffmann

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have improvised and developed over the years to facilitate learning for, rather than to deliver instruction to, the students we have taught. We hope that you will find them useful tools in your teaching and in your students' learning (16).

ROALD HOFFMANN^{1*} AND SAUNDRA Y. MCGUIRE²

¹Department of Chemistry and Chemical Biology, Cornell University, Baker Laboratory, Ithaca, NY 14853, USA.

²Center for Academic Success and Department of Chemistry, Louisiana State University, Baton Rouge, LA 70803, USA.

*To whom correspondence should be addressed. E-mail: rh34@cornell.edu

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Science-Savvy Physicians

IN THEIR EDITORIAL ("SCIENCE FOR FUTURE physicians," 5 June, p. 1241), S. Long and R. Alpern mention the release of a major report on medical education arguing for increased emphasis on basic scientific competence. However, they fail to note the report's relevance to the broader arena of biomedical science and innovation. Beyond the obvious need for clinicians to understand the scientific underpinnings of disease mechanisms when treating patients, a sound scientific education is critical to training physicians who translate research findings to a clinical setting.

A key factor fueling these new recommendations is the desire for more students to enroll in physician-scientist (M.D./Ph.D.) programs in the United States. A commonly held belief is that these physician-scientists will use both their clinical and scientific training to facilitate the translation of discoveries to the clinic. More often, physician-scientists either become pure clinicians or focus all of their energies on basic sciences, thus playing the same role as Ph.D.-trained biomedical scientists (1).

Whether due to time constraints or intent, physician-scientist programs have generally failed to fulfill this dual role and have focused excessively on basic research. This creates unnecessary redundancy and also discourages and even deceives medical students interested in more applied research. While I support the findings of this report, maximal value from the recommendations can only be derived by training and allowing physicians with a sound scientific foundation to play a more downstream and enabling role in facilitating the delivery of innovation to the clinic.

Recently, several medical schools in the United States and internationally, including the University of Toronto, have recognized this

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