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Feature
Book Review

A Manual for the Scientific (Teaching) Revolution

Review of: *Scientific Teaching*, by Jo Handelsman, Sarah Miller, and Christine Pfund; 2007; 184 pp.; W. H. Freeman and Company (New York); ISBN-13:978-1-4292-0188-9

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The headline from the National Science Teachers Association (NSTA) e-mail update said it all: "Research Universities Resistant to Proven Science Instruction Methods." NSTA was reporting on an article published in the *Chronicle of Higher Education* that discussed the perplexing and frustrating finding that research universities are reluctant to embrace and implement proven teaching methods in their science classrooms (Brainard, 2007). A major repercussion of this reticence to change is the loss of a diverse group of students who could succeed if given the chance. As a result, the continued growth and expansion of our scientific efforts are in peril.

What needs to be done? How will we address this challenge to our discipline? One authority cited in this article proposes that more emphasis be placed on developing resources and disseminating the rich body of knowledge that exists on effective teaching strategies. To be most effective, such resources should be practical, enabling implementation of these strategies. *Scientific Teaching* is just such a resource. As stated by the authors of *Scientific Teaching*, "none of the methods in *Scientific Teaching* are entirely new." Nevertheless, the authors have consolidated the major findings and philosophies of the emerging field of science teaching and learning into a handbook that incorporates the findings from the science education research community. As such, it deftly guides the transformation of our teaching efforts to align with scientific evidence about learning.

Scientific Teaching began its life as an Education Policy Forum article in *Science* (Handelsman *et al.*, 2004) and has grown and matured into a book that should be on the bookshelf of every life science faculty member and be required reading for all graduate students (get them while they are young and impressionable!). Handelsman, Miller, and Pfund propose that the changes needed to transform the science classroom from teaching centered to learning centered are not really as great as most might imagine. They argue that the principles and skills scientists use to guide their work in their laboratories are the same ones needed to guide their activities in their classrooms. This insight is encapsulated in the term "Scientific Teaching." Few of us would begin an experiment without first determining the purpose of the experiment. After determining the purpose, we would develop the experimental protocol and assays, carry out the experiment, analyze the data, and then go back and modify the protocol or refine the purpose of the experiment. Facilitating learning in the classroom follows the same path. In a classroom designed for learning, learning goals/objectives are formulated from the outset; learning strategies are designed to help students construct their understanding; student learning is assessed and outcomes are reviewed; and this information is used in an iterative manner to further refine teaching. *Scientific Teaching* provides a systematic, reasoned, and very readable guide through the process of transferring the laboratory mind-set to the classroom and thereby maximizing meaningful learning for students.

The first chapter on scientific teaching provides a great overview of the literature on student learning. The chapter does not contain an exhaustive review of the research on learning but rather highlights the seminal work in this field. Various models of learning are discussed, including those proposed by the National Research Council's *How People Learn*. This chapter also helps faculty get up to speed on the terminology used by educational researchers. Key terms, from constructivism to metacognition to rubric, are defined and given a conceptual framework. In this sense, the book is very good at "walking the talk," as it has been written in a style that promotes active learning in its readers.

Subsequent chapters deal with the three main components of a transformed classroom: active learning, assessment, and diversity. The chapter on active learning presents examples of how faculty have infused the spirit of science into their classrooms by designing class activities that require active participation by the students. In each case, faculty find that normalized learning gains are significantly greater in the active-learning classroom when compared with traditional lecture courses. Key guidelines for getting the most out of active learning are discussed and numerous specific active-

learning exercises, from minute papers to "clickers," are detailed. The discussion of each active-learning technique includes practical tips on how best to get it to work in your classroom.

Assessment is critical to understanding what students are learning, and Chapter 3 presents a wealth of assessment types, from informal, in-class activities such as think-pair-share or minimap activities (i.e., formative assessments) to formal testing formats (a.k.a. summative assessments). In each case, the authors highlight how the instructor can use assessment to better gauge student learning while simultaneously using it to engage the student in their own learning. To capture this dual purpose of assessment, the authors coin the clever term "EnGauge." Also very useful is the description of how to develop and use rubrics, both to assist in setting clear expectations for your students and to ease the grading load for yourself.

Because of the foundations in the laws of the natural world, natural and physical sciences may seem to be immune from issues of diversity. Instead, diversity may appear to be solely the purview of the social sciences and humanities. Chapter 4 points out the many benefits of addressing the issues of diversity in the science classroom, for the practice of science, the process of learning, and increasing our competitiveness in the world. Unfortunately, the numbers that depict the reality of diversity in college science classrooms are bleak and the authors don't pull any punches while confronting "these emotionally charged and intellectually challenging issues." They do, however, offer sound and practical methods to help us become aware of unconscious bias and how it affects how we teach.

Having helped us learn the lexicon of the field and the key elements required for transforming our classroom, the authors provide us with a framework for change. This framework is a four-step process that is as straightforward and easy to follow as a commercial miniprep kit: setting learning goals, determining evidence for learning, planning learning experiences, and checking alignment of the elements. Key questions to guide faculty easily and successfully through each step of the process are provided as are ample examples pertinent to science courses. Completion of this four-step process produces what the authors call a "teachable unit," a manageable and meaningful beginning to changing the learning environment of the science classroom.

Acknowledging that, although change needs to start in the classroom, sustained change requires a campus-wide effort, the final chapter in the first half of the book tackles the critical topic of institutional transformation. Again, the authors provide a very pragmatic approach, suggesting various strategies and reminding us that institutional change is behavioral change and, as such, takes time and goes through established stages. For those of us impatient for change, this reminder helps us confront the seemingly glacial pace of change. The second half of the book is a detailed manual of how to run workshops on each of the elements of scientific teaching. Again, the authors are thorough, organized, and have done all the leg work so that you are free to focus on the major concepts and make each workshop successful.

Science is an evidence-based discipline of exploration and discovery, and *Scientific Teaching* offers a compelling argument for embracing this same standard of rigor and excellence in our classroom. It also provides a systematic and reasonable protocol for implementing the changes in the classroom in a time-efficient manner that should appeal to life science faculty. In *Scientific Teaching*, Jo Handelsman, Sarah Miller, and Christine Pfund have created the manual for the Scientific (Teaching) Revolution. Read, enjoy, and come join the revolution. Your students will appreciate it!

REFERENCES

Brainard, J. (2007). The tough road to better science teaching: proponents of new methods encounter resistance, especially at research universities. *The Chronicle of Higher Education*, August 3, sec. A15. Available at: http://chronicle.com/weekly/v53/i48/48a01601.htm.

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