



WHAT WORKS - A PKAL ESSAY

ACADEMIC SCHIZOPHRENIA AND STEM LEADERSHIP

The Problem

Scientists in academe are schizophrenic. That diagnosis is not a formal psychiatric assessment of their mental states, but a factual statement about academic scientists' behavior. When they deal with scientific research and when they work on educational projects, faculty members display totally different personalities.

Research Behavior vs. Teaching Behavior

Let me use my own behavior as an example; when I recently started a research project modeling the dynamics of stellate neurons in the hippocampus— a totally new area of research for me— I did the following:

- ◆ conducted an extensive literature search to find out what is already known about these neurons
- ◆ talked to other scientists who had done work in the area
- ◆ developed some theoretical models and tested them against the evidence presented in the literature
- ◆ analyzed data from recent experiments on stellate neurons
- ◆ thought a lot about what my work would add to the growing body of literature on these cells.

About the same time, I began thinking about one of the courses I will soon be teaching. My behavior in planning for the course, though typical of academicians, was entirely different from my research behavior:

- ◆ I found my notes from the last time I had taught the course (six years ago), did a quick scan through Amazon.com to check out the latest editions of possible texts. I chose a text (the same one I had used six years ago) because it felt the most “comfortable.” (It is also a very good textbook.)
- ◆ I, however, did not talk to my colleagues who had taught the course more recently, except briefly to review the topics that were expected to be covered in the course
- ◆ I did not do a literature search about who was doing what in teaching this type of course
- ◆ I made no plans (at least initially) to evaluate the effectiveness of the approach I was going to use.

Then it struck me: why was I behaving so differently in these two endeavors, both critical and important parts of my job as a researcher and teacher?

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THE PRESCRIPTION

- ◆ Encourage faculty members to set explicit goals and to find ways to assess student learning and student attitudes.
- ◆ Provide means for faculty members to become familiar with the literature on the scholarship of science teaching.
- ◆ Begin locally and encourage STEM faculty members to engage in reflective practice of their teaching.
- ◆ Encourage departments to tackle teaching collectively by jointly setting goals for courses and working together to understand which courses are effective and which are not.
- ◆ Provide support for faculty members to attend educational sessions of their professional societies.
- ◆ Set up Teaching and Learning Centers that provide assistance and resources for faculty members in setting explicit goals for their teaching and implementing assessment of the effectiveness of their teaching.
- ◆ Take advantage of national efforts to promote the scholarship of teaching and learning.



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Acculturation

This schizophrenia is not entirely irrational. Our scholarly communities have acculturated us to behave differently when doing research and when teaching. For example, I know from my experiences in scientific research that if I wrote a research proposal to the National Science Foundation without references to what had already been done in the field and if I indicated that I would not bother to evaluate the validity of my research results nor publish them in journals, I would be dismissed as a lunatic or a fraud (or perhaps both).

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Not wishing to be thrust into either category, I do my homework and acknowledge previous research work and write explicitly about what my work will add to the body of scientific knowledge and how I will communicate my results to the scientific community.

But our community standards and expectations for teaching have evolved differently: my teaching might be viewed as perfectly fine, and indeed exemplary (as long as the students are happy), without any of the scholarly attributes that are viewed as a necessary part of research.

Diagnosis

I do not know of any definitive study of this kind of schizophrenic behavior, but most of us recognize it in ourselves and in our colleagues.

Here is my amateur analysis of what is happening:

- ◆ we most often teach alone
- ◆ we are not expected to justify our teaching practices in terms of the evidence for what works best
- ◆ we are not expected to evaluate the effectiveness of our teaching (what students have actually learned and how their attitudes have changed)
- ◆ even if we do evaluate the effectiveness of our teaching, we are not expected to communicate the results of that evaluation, even to our departmental colleagues, let alone the broader scientific community.

Our teaching behavior descends to meet these (low) expectations.

Why Has This Behavioral Duality Developed?

The Academic System

Certainly, the academic system often works against our developing a more scholarly approach to teaching. We often don't know our teaching assignments until a few weeks before classes begin, leaving little time for preparation.

It is difficult (though getting easier with the Internet) to find out what others have done in developing and assessing innovative content and pedagogy. Even if we explore what others have not, we often have little time for the necessary adaptation of those materials for our local situation.

Furthermore, our teaching assignments often change every year, giving us little chance for the refinement of content and techniques.

Finally, and perhaps most importantly, teaching is viewed as a solitary effort. We are not expected to discuss our teaching plans with others, and with the exception of standard end-of-the-semester student evaluations, we need not share any of the results of our teaching.

Of course, many of us spend some time talking with others about teaching. The conversations, however, often focus on the poor job our students are doing or on specific features of our teaching like a really neat demonstration experiment or a nifty exam question. Rarely do we bother, perhaps because it is so difficult, to focus on the overarching goals for teaching and the means of assessing the effectiveness of our teaching in helping the students meet those goals.



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Scientific Community At-Large

Our disciplinary and academic communities re-enforce this schizophrenic behavior by giving rewards for one kind of behavior and effectively ignoring the other.

The scientific community publicly recognizes and rewards success in research, perhaps because it is easy to measure: we count the grants received and the papers and books published.

On the other hand, we are just beginning to figure out how to recognize and reward success in teaching. For example, at the national level the National Science Foundation's Distinguished Teacher-Scholar Awards recognize outstanding researchers who have also made excellent contributions to science education.

Teaching Goals vs. Research Goals

Another cause for this schizophrenia is the recognition that the goals of teaching and research are different. The aim of research (putting aside the crass rationale of just bringing in more research dollars) is the creation and dissemination of new knowledge. The goals for teaching more often focus on the student and the transmission of knowledge.

We base our teaching on what has already been done in science, with perhaps a brief introduction to current scientific research. We rarely let students experience the actual doing of science. The distinction is akin to that between basic medical research and the clinical practice of medicine.

Let's pursue that medical analogy. Would you be satisfied if your local physician gave the same array of pills to patients year after year? After all, those pills worked twenty years ago. Why change? Our attitude toward teaching says that it is just fine to teach today the way we taught twenty years ago.

On the other hand, we expect (and the medical societies require) our physicians to keep up-to-date about the latest medications and treatments. And we also expect that a good physician helps a patient understand the patient's physical condition and what the patient can do to help maintain a healthy body.

I argue that we need to approach our teaching in the same spirit. We need to keep our knowledge of the practice of teaching up-to-date and we ought to work with our students to help make them better (more self-aware) learners.

As teachers we play many roles:

- ◆ the enthusiastic expert who inspires and motivates our students
- ◆ the experienced scientist who helps the students learn both specific knowledge and the big picture
- ◆ the mature learner who helps our students become better and more sophisticated learners.

All of these roles are important for effective teaching.

Resistance to Change

Even if there is little motivation to develop and participate in a scholarly approach to teaching, why is there often open resistance?

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Part of the answer is just inertia: I am busy enough with teaching, research, and college committees and, if lucky enough, a minimal family life. I have no time for the additional effort, and even if I did have the time to develop a scholarly approach to teaching, no one will reward me for my efforts.

A second response often leans on academic freedom. I should be able to teach any way I want and no one can tell me how or what to teach.

To take a radical stance, I argue that academic freedom should not include the freedom to "screw up" by using teaching practices that have been shown to be ineffective. For example, physics education research has shown with studies of thousands of students in many different kinds of institutions [R. R. Hake, (1998), Ref. 2] that straight lecturing does little to build conceptual understanding of basic physics ideas.



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All physicists would agree that developing that kind of conceptual understanding is important both for future physicists and for others. But the usual attitude is the following: After twenty years of absolutely clear and admirably organized lectures about Newton's Laws of Motion, my students still can't apply them to even the simplest cases without considerable coaching.

What worked for students in the 1960s or 70s, for example, may not work today.

So this year's lectures will be really clear and really organized. It rarely dawns on me that just lecturing about Newton's Laws is not an effective way to get students to be able to use them. Telling is not teaching! Should academic freedom protect demonstrably ineffective teaching?

Yet another argument against a more scholarly approach to teaching is that it is difficult, if not nearly impossible, to determine the effectiveness of different approaches to teaching.

There are two parts to this argument:

- ◆ First, we have to admit that one reason effective evaluation is difficult is because we generally do not explicitly specify what we expect students to learn and what we expect students to be able to do with what they have learned. But that aspect is under the control of the individual faculty member and can be straightforwardly addressed.
- ◆ The second aspect is more problematic. It is in fact difficult to develop good assessment tools even if teaching and learning goals are clearly stated. We all know that standard student evaluations of teaching are often little more than popularity ratings and have almost nothing to do with actual student learning.

Some students do reflect on how aspects of the course have helped or hindered their learning, but in most cases they have little basis for comparison since they have not had the same course elsewhere.

Given these difficulties, why bother with formal assessments? Why not do what teachers have done for generations: base our teaching on what we think is working without bothering to find any evidence to support our conclusions?

While chastising the traditional approach to teaching, we should recognize that there are in fact important differences between scientific research and a scholarly approach to teaching.

Research Problems vs. Pedagogical Problems

In scientific research once we know why certain ceramic materials become superconductors at relatively high temperatures, or how a set of three base-pairs in DNA codes for a specific amino acid, that knowledge becomes part of the fabric of science. We can use that knowledge as the basis for further investigations and applications.

But solving an education problem is different. As the late Melba Phillips, a distinguished theoretical physicist and the first woman President of the American Association of Physics Teachers, noted: "The difficulty with education problems is that they do not stay solved."

What worked for students in the 1960s or 70s, for example, may not work today.

Why not? The subject matter we are teaching today has changed, the tools (notably computers) available for learning are different, and the preparations, backgrounds, and interests of our students are different from those of the students of 1960s.

Today's students are not necessarily better or worse than those of previous generations, but they are certainly different. Effective STEM leaders know this, good teachers know this, and they work with their colleagues to build a culture of scholarship that continues to revisit these educational "problems" and to solve them anew for each generation.



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Treatment and Clinical Trials

I would not worry about our schizophrenic behavior if we knew that students were learning what we wanted them to learn. Lots of education research, however, indicates that our students are not in fact learning as much as we hope they would learn [John D. Bransford, Ann L. Brown and Rodney R. Cocking, (1999), Ref. 1].

Moreover, our traditional teaching behavior does not lead to continuing improvements and progress in education. Even teachers who develop exemplary methods and materials often do not communicate them beyond their own classrooms.

Our scientific research behavior, on the other hand arguably does lead to a growing body of knowledge and a sense of progress in both facts and understanding. Scientific research is a communal, scholarly activity. Teaching should be as well.

STEM Education Leadership

So what has all of this to do with leadership in STEM education enhancement? (I avoid the use of the term “reform” because it implies that what we are doing now is totally ineffective and wrong. That is simply not true; students do learn with “traditional” teaching techniques; they just don’t learn as much as we would like them to.)

One of the characteristics of an effective STEM education leader is the ability to get colleagues to think “off the blackboard.”

Effective leaders help their colleagues cure their schizophrenia by:

- ♦ recognizing that there is a problem
- ♦ helping them see that teaching is (or at least should be) a scholarly, communal activity to which we should apply the skills we have honed in research.

Some of these skills include:

- ♦ finding out what others have done
- ♦ working collaboratively to define problems and seek solutions
- ♦ learning how to find and evaluate evidence for what is effective
- ♦ recognizing that what works for one group of students may not work for another group.

The Scholarship of Science Teaching

We call this collection of attitudes and skills the scholarship of teaching [Randy Bass, (1999), Ref. 3]. STEM education leaders ought to be the prime movers behind the scholarship of science teaching in colleges and universities.

How do we know the scholarship of teaching works to enhance college-level science learning?

Let me describe one piece of evidence from the physics community. In 2003, the National Task Force on Undergraduate Physics finished a study called Strategic Programs for Innovations in Undergraduate Physics (SPIN-UP).

To find out why some physics departments increased the number of undergraduate majors during the 1990s while the physics community as a whole saw a 25% decline in the number of majors, the Task Force and some 40 additional volunteers carried out site visits to 21 “thriving” undergraduate physics programs.

Scientific research is a communal, scholarly activity. Teaching should be as well.

The departments visited were chosen because they exhibited several features of what anyone would call a thriving program: a large number of majors compared to other similar institutions, a lively undergraduate research program, and a strong sense of community among faculty and students. The visited departments were universally viewed as “model” departments on their campuses in serving students from other departments as well as the physics majors.

The report [Robert C. Hilborn, Ruth H. Howes and Kenneth S. Krane, (2003), Ref. 4], available on-line at <http://www.aapt.org/Projects/ntfup.cfm>, gives a detailed analysis of what makes these thriving departments different from those departments that, to put it generously, are less than thriving.



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One of the key features is, not surprisingly, departmental leadership— leadership characterized not as dictatorial or flamboyant, but as focused and realistic. The successful leader is one who keeps the department’s attention focused on its undergraduate program, not a trivial task in a research university physics department.

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In keeping that focus, the leader works with colleagues to develop:

- ◆ a realistic sense of what is working and what is not working
- ◆ a clear-eyed vision of who their students are and what their aspirations and goals are.

Teaching is viewed as a collaborative and scholarly enterprise, perhaps a bit more complicated and fuzzy than research in nuclear physics, but an enterprise that must be approached using the same demands for evidence that we use in our scientific research.

The SPIN-UP report provides evidence that can be viewed as an existence proof: this scholarly approach to teaching does work. It is more fun and intellectually rewarding for faculty to approach teaching as a scholarly activity and students seem to thrive in departments that practice the scholarship of teaching.

Although most of the site-visit departments would not use the phrase “scholarship of teaching” to describe what they are doing (mostly because they are not aware of that phrase), all of these departments in fact are engaged in a scholarly approach to teaching.

To be honest, I must acknowledge that the Task Force did not attempt to measure directly what students in these departments had learned. We had neither the time nor the tools to do so.

However, the students did seem to learn a lot. They participated in sophisticated research projects, were admitted to fine graduate schools in physics and related fields and found excellent jobs. Even if each student did not learn more than a student in a traditional program, more students learned physics in these departments. So more student learning certainly did occur.

The Prescription

What can STEM leaders do to promote the scholarship of teaching? There are several straightforward steps:

- ◆ Encourage faculty members to set explicit goals (teaching quantum mechanics is not sufficiently specific) and to find ways (not developing them ourselves) to assess student learning and student attitudes.
- ◆ Provide means for faculty members to become familiar with the literature on the scholarship of science teaching. The National Research Council report *How People Learn* [John D. Bransford, et al., (1999), Ref. 1] is a good place to begin.
- ◆ Begin locally and encourage STEM faculty members to engage in reflective practice of their teaching. Encourage faculty members to keep a course “lab notebook,” in which they keep track of what they do in the course along with reflections about what is working and what is not.
- ◆ Encourage departments to tackle teaching collectively by jointly setting goals for courses and working together to understand which courses are effective and which are not.
- ◆ Provide support for faculty members to attend educational sessions of their professional societies.



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- ◆ Centers that provide assistance and resources for faculty members in setting explicit goals for their teaching and implementing assessment of the effectiveness of their teaching. The Teaching and Learning Centers can also provide community resources for talking about teaching on campus.



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To promote the scholarship of teaching, we need to change the behavior of both individuals and the scientific community.

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- ◆ Use the bully pulpit of authority to promote the scholarship of teaching.
- ◆ Take advantage of national efforts to promote the scholarship of teaching and learning. For example, the Carnegie Foundation has established the Carnegie Academy for the Scholarship of Teaching and Learning, CASTL. (<http://www.carnegiefoundation.org/CASTL>)

Ultimately, the issues I have raised in this essay are questions of behavior: the behavior of individual faculty members and the collective behavior of the scientific community.

If we want to promote the scholarship of teaching, and I have tried to argue why we need to do so, we need to change the behavior of both individuals and the scientific community— not an easy task, but one essential to the future of science for us both individually and collectively. ■

References

¹*How People Learn, Brain, Mind, Experience, and School*, edited by John D. Bransford, Ann L. Brown, and Rodney R. Cocking (National Academy Press, Washington, D. C., 1999).

²R. R. Hake, "Interactive-engagement versus traditional methods: A six-thousand-student survey of mechanics test data for introductory physics courses," *Am. J. Phys.* 66, 64-74 (1998).

³Randy Bass, "The Scholarship of Teaching: What's the Problem?," *Inventio* 1 (1999). (<http://www.doit.gmu.edu/Archives/feb98/randybass.htm>)

⁴Robert C. Hilborn, Ruth H. Howes, and Kenneth S. Krane, *Strategic Programs for Innovations in Undergraduate Physics: Project Report* (American Association of Physics Teachers, College Park, Maryland, 2003).