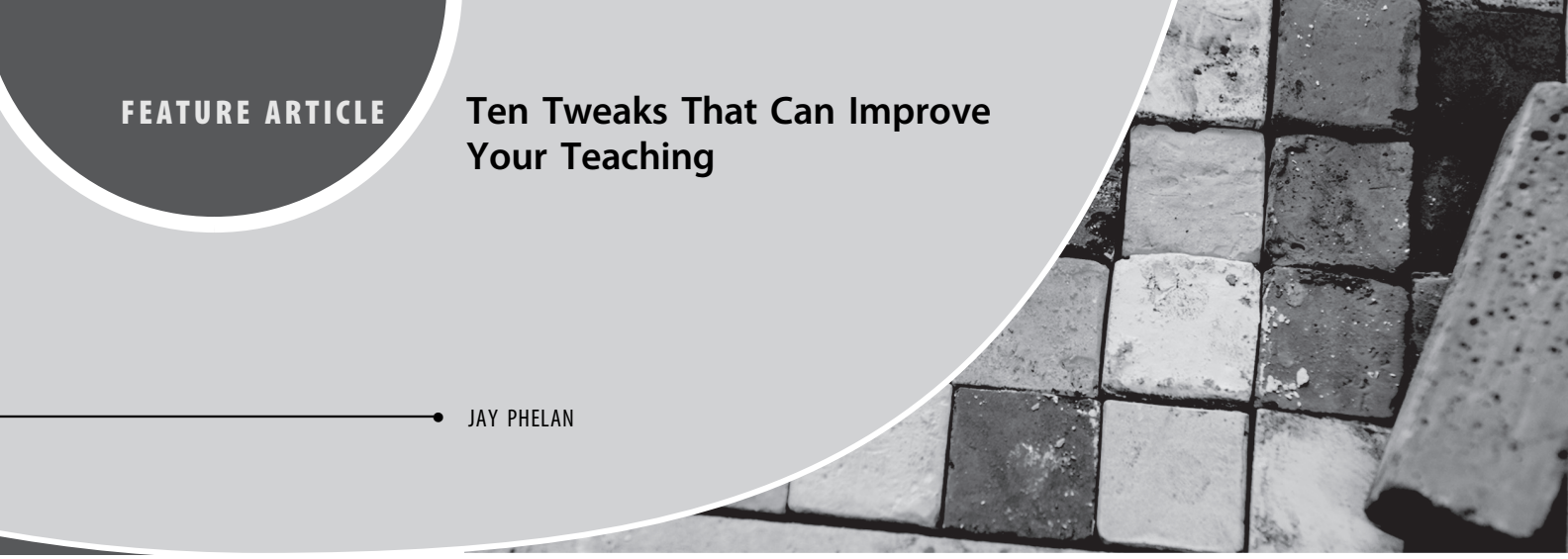
FEATURE ARTICLE

Ten Tweaks That Can Improve Your Teaching



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Abstract

Many recommendations for improving teaching are valid and important but may be prohibitively challenging for instructors. I describe 10 teaching techniques – "tweaks" – that are more easily implemented, and evidence of their value for increasing student engagement and learning: (1) Have a class outline visible at all times. (2) Use hand-written PowerPoint slides. (3) Help your students encode and review more complete notes. (4) Use in-class exercises that require commitment. (5) Incorporate "transfer" questions. (6) Focus on misconceptions. (7) Include photos that inspire and provoke. (8) Create the right test and teach to it. (9) Incorporate self-disclosure. (10) Reinforce the "take-home messages."

Key Words: *Teacher effectiveness; self-disclosure; assessment; note taking; transfer; student misconceptions.*

○ Good Teaching Is Deceptive

It looks easy. Consequently, it can make you believe that it is occurring without any particular effort or special plan. And it can lead you to assume that some people are just born good teachers, that others are not, and that this explains all the variation from one teacher to the next. For many, this also serves as a convenient way to absolve themselves from the effort of trying to improve.

To be fair, there is considerable variation in teacher quality (Nye et al., 2004; Rockoff, 2004; Harris & Sass, 2007; Hanushek & Rivkin, 2012). With training, however, teacher effectiveness – measured as student learning – increases significantly (Gibbs & Coffey, 2004; see also Hake, 1998; Udovic et al., 2002; Knight & Wood, 2005; Smith et al., 2005; Armstrong et al., 2007; Freeman et al., 2007; Beichner, 2008).

I pursue the more modest strategy of evaluating and "tweaking" each element of the presentation to increase student engagement and learning.

○ What Does Improved Teaching Entail?

Improvements to teaching should incorporate education about learning, should increase active participation in lectures, and must be based on and evaluated with rigorous, systematically tested scientific thinking (Handelsman et al., 2004, 2007; DeHaan, 2005; Freeman et al., 2007; Wood, 2009). Many of the recommendations, however, can be difficult to implement for individual instructors, particularly adjunct faculty. Consider, for example, this valid but broad recommendation made in the journal *Science*: "Research universities should overhaul introductory science courses for both science majors and non-majors using the principles of scientific teaching" (Handelsman et al., 2004).

Setting aside complete curriculum overhaul, even incorporating many of the other valid and useful recommendations can require an almost prohibitive time commitment. Acting on many of these recommendations, nonetheless, is absolutely advisable. Extensive and rapidly accumulating evidence supports their significant positive impact on important student outcomes compared to "passive" lecture methods. These instructional strategies for increased active learning include "Just in Time Teaching" (Novak et al., 1999), blended learning (Stockwell et al., 2015), the use of PORTAAL, a classroom observation tool for assessing teaching practices (Eddy et al., 2015), collaboration with embedded education experts within departments (Wieman et al., 2013), and others (see Fraser et al., 2014; Freeman et al., 2014; Waldrop, 2015).

Often, however, implementation of these innovations requires the acquisition of new educational skills, such as

- development of active-learning activities;
- identification of student misconceptions;

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- creation of formative and summative assessment items addressing higher levels of conceptual understanding;
- validation and reliability testing of such assessment instruments;
- preparation of strategies, activities, and assessments to utilize – on the fly – in response to all possible student performance on formative assessment tasks;
- learning the skills for facilitating small-group work; and
- development and validation of transfer tasks and associated assessment items.

Keep in mind, too, that after developing all of these new methods and materials, instructors ought to fully incorporate them into curricula only following rigorous, systematic, controlled studies evaluating their efficacy. Designing and implementing even one such study is hugely challenging, if not impossible, for an individual instructor.

Challenges notwithstanding, there remains significant desire among instructors to improve their effectiveness, as a pathway to growth on the job and improved competence and satisfaction (Guskey, 2002). Schuetz (2002) for example, reported that 83% of full-time faculty and 76% of part-time faculty expressed a desire to take part in professional development activities to enhance their content knowledge and instructional effectiveness. Importantly, however, in a recent survey of faculty members at 269 colleges and universities, Eagan et al. (2015) noted that only 13.5% of adjunct faculty had access to professional development resources.

○ What Are the Routes to Improved Teaching for Individual Instructors?

In auto racing, there are two chief ways to improve performance: increase the car's power or decrease the car's weight. And among race-car designers, the consensus is that the best way to reduce a car's weight by a hundred pounds is to find a thousand places to shave off a tenth of a pound. I employ this strategy when trying to design increasingly effective lectures. Rather than searching for some radical change that completely transforms my teaching, I pursue the more modest strategy of evaluating and "tweaking" each element of the presentation to increase student engagement and learning. No single improvement produces a dramatic transformation. Cumulatively, however, the changes can become significant. And, importantly, this strategy can (and should) be used concurrently with developing larger-scale, longer-term improvements.

My goal here is not to present the methods that will lead to the *greatest* improvement in your effectiveness. Rather, I aim to present some methods that can spur *immediate* improvements in your effectiveness, concrete changes you can implement as soon as your next class meeting.

○ Ten Tweaks That Can Improve Your Teaching

1. Have a class outline visible at all times as a road map. Refer to it explicitly.

A written class outline provides an explicit cue of the organizational structure of a class period. This outline should be presented not simply on an opening slide. It should be written in a location where it will be visible throughout the class period. Students arrive late, they zone out, they get lost. The always-visible outline illuminates the path back, salvaging the remainder of the class. This road map serves several additional important purposes.

Class outlines – among other organizational cues – serve as signals to students, helping them *select* the relevant material for note taking, *organize* it, and *integrate* it with their prior knowledge (Mayer, 1996). Further, the appropriate organizational framework serves as a scaffold that enables students to better learn the associated details (Ausubel et al., 1968). With the outline, students take better notes, which significantly improves their performance on exams and in courses overall (Kiewra, 1984; Kiewra & Fletcher, 1984; Kiewra & Benton, 1988).

Beyond simply having the outline visible on a board, supplementing the written outline with verbal references to it further increases its impact on student learning. In a well-controlled study, Titsworth & Kiewra (2004), for example, demonstrated that spoken organizational cues increased fourfold the number of the organization points included in student notes and doubled the number of details included. And with improved note taking, the students significantly improved their performance on tests of lecture details.

2. Use hand-written, hand-illustrated PowerPoint slides.

It is faster and easier to produce lecture slides by typing them and including professionally drawn illustrations. Often, these are more aesthetically pleasing as well. To improve student note taking, however, it can be beneficial to write and draw them by hand (such as by using a tablet computer or even an overhead projector).

Why not use uniform typefaces and figures professionally drawn by an artist? First, by drawing and writing lecture slides, you signal to students that they, too, can do so. And by writing their own notes, students actively develop the skills of encoding and presenting ideas – something they must do if they are to be able to express complex ideas to others.

And second, evidence from several studies suggests that when the difficulty of encoding information is increased ("disfluency"), cognitive processing of the material is altered, and subsequent memory and learning may be improved (Diemand-Yauman et al., 2011; Sungkhasettee et al., 2011; French et al., 2013; Lee, 2013; Weltman & Eakin, 2014). Disfluency appears to act as a "desirable difficulty" (Bjork, 1994); confronting such difficulties can enhance learning, inducing engagement and promoting more active processing (but see Yue et al., 2013; Meyer et al., 2015).

3. Help your students encode and review more complete notes.

This may be the most difficult of my recommendations to implement. Note taking is an activity that requires significant cognitive effort (Piolat et al., 2005). In fact, if we measure just how much effort it requires – as the degree of interference (in milliseconds) that performing it causes in completing a secondary task – note taking requires more than twice the cognitive effort of copying text or reading sentences, and more than the cognitive effort required of an expert playing chess (Britton & Tesser, 1982; Piolat, 2007). It's hard. And so it is something students would prefer not doing, if you'll allow that.

Further, as a consequence of the high cognitive effort they must expend in note taking, students will typically experience difficulty

in keeping up with the lecture and taking complete notes (Hartley & Marshall, 1974; Kiewra, 1985a, 1985b). In this context, their request may seem reasonable: "If you give us your notes, we can focus more on what you're saying." Because note taking activates brain processes involved in learning and memory, however, when students take notes, they become attentive to numerous important signals that aid in comprehension (Isaacs, 1994; Titsworth, 2001; Williams & Eggert, 2002). This demands active, rather than passive, participation in the instruction and so leads to significant learning, not just when reviewing notes at a later point, but when taking the notes as well (Carter & Van Matre, 1975; Foos et al., 1994). For this reason, simply providing students with the instructor's lecture notes can be counterproductive – and, in a way, that is not immediately obvious to students (Barnett, 2003). Listening alone just isn't as effective as listening with note taking – even taking into account the time pressure of note taking and the coordination of listening, comprehending, and note production.

Taking together the findings that students recall more of their own notes than those given to them by the instructor (Thomas, 1978), but that performance is increased with review of more complete notes (Knight & McKalvie, 1986), it can be beneficial to make "skeletal notes" available. Skeletal notes contain the lecture's main points while providing space for note taking and can then help students learn to take more complete, better notes (Kiewra et al., 1991; Armbruster, 2000).

4. Use in-class exercises that require commitment to a position.

To learn course content, most students use a strategy of listening in class and taking notes, supplemented by reading required texts and reading and highlighting their notes. If they have additional time, they read again. They gauge their readiness by how familiar they feel with the material. But they will not be assessed (or graded) based on their ability to read and highlight material. The skill they will be tested on is their *retrieval* ability.

Can they recall the appropriate content and use it in response to a question? If that is a skill they'll be tested on, that is a skill they should use during class. Practicing retrieval promotes not only better learning, but long-term retention as well (Roediger & Karpicke, 2006; Karpicke & Blunt, 2011). Without such practice, students often mistake recognition of the material for mastery of the material. Moreover, with reading and rereading, students express a confidence in their knowledge of the material that is not supported by their performance on exams.

Because many students spend little (or no) time self-testing when studying, in-class exercises in which they must commit to a position by writing down an answer are valuable. Clickers can be useful for in-class exercises, but they are not necessary. Pen and paper are sufficient. The important feature is that the exercise requires the student to recall the material and use it in some way as they commit to an answer. Confronted with their own wrong answer, students can get a wake-up call about deficiencies in their understanding in a low-stakes setting.

5. Incorporate "transfer" questions on each topic during class.

I don't want to be a fire hose of information for my students. They have an accurate and comprehensive 1100-page textbook. They have a study guide with practice exercises and self-test questions. They have websites with animations, outlines, and more.

My goal – and the greatest value I can provide for students – is not to deliver content faster or more efficiently. Rather, I want to teach them ways of thinking and to help them develop skills to answer novel questions that I or they can't currently imagine. This is a skill referred to as "transfer." During class, I present questions to which I have not given the answers, but that, based on ideas they are learning, students should be able to answer (for excellent examples of transfer questions, see D'Avanzo, 2003). I present the questions when students have been given enough of the conceptual framework to reason their way to an educated response. I embellish these questions with a big red Q when I present them, two to four times per class meeting.

For these questions to help students develop transfer skills, it can be beneficial to not give answers or to provide only delayed feedback, particularly with concept-formation tasks (Corbett & Anderson, 1989; Schroth, 1992; Kluger & DeNisi, 1996). This is difficult. And it is generally met with disappointment or confusion by students trained to receive and remember content, particularly because, although transfer is facilitated, the initial learning time may be increased (Kulhavy et al., 1985; Schroth, 1992). But the point of the "Red Q" questions is *not* for them to get the answer to that specific question. Otherwise, I am simply delivering more content. Instead, I am helping them develop critical-thinking skills that will help them long after they have forgotten this or that specific fact, as they are called upon to reason their way through the new territory and novel problems relevant to their lives. I want to help them see that sometimes you're learning things you don't realize you're learning.

There is a large and persuasive literature on the importance of transfer skills (see, e.g., Catrambone & Holyoak, 1989; Alexander & Murphy, 1999; Bransford et al., 1999; Billing, 2007) as well as evidence that transfer abilities can be taught (Stokes & Baer, 1977; Covington, 1987; McKeough et al., 1995; Mayer & Wittrock, 1996). Without instructional intervention, however, transfer is significantly less likely to occur (Perfeto et al., 1983; Bransford et al., 1986; Perkins & Salomon, 1988, 1992).

6. Focus disproportionately on misconceptions.

Selecting the topics to cover in a class period is challenging because only a tiny subset of all relevant material can be covered. Focusing on student misconceptions rather than just laying out an outline and delivering the appropriate content is a powerful and effective response to this constraint.

Student misconceptions can be deeply held and can interfere with the acquisition of scientifically valid ideas (Ausubel et al., 1968; Lawson, 1988). Further, they are unlikely to be replaced with scientifically accepted conceptions unless addressed and challenged explicitly (Hewson et al., 1998; Tanner & Allen, 2005). Students often hold misconceptions about topics in biology, particularly topics that have elements that are nonintuitive, such as genetics (Lawson & Thompson, 1998), evolution (Greene, 1990; West et al., 2011), molecular ecology (Karl et al., 2012), cell metabolism (Storey, 1991), and phylogenetic trees (Meir et al., 2007).

Often, student misconceptions are viewed as obstacles to learning (Larkin, 2012). Increasingly, however, evidence supports the idea that identifying and addressing misconceptions directly – even as a focal point of a presentation – can actually be effective at

improving student learning (Abraham et al., 2009; Armbruster et al., 2009; Andrews et al., 2011). For these reasons, identifying common misconceptions related to each topic in a course and developing class instruction around these is valuable. Good places to start on this include thinking about where your students tend to have difficulties, as well as the research literature.

7. Include photos that inspire and provoke (as well as illustrate).

Words are not enough. Images can inspire and provide an alternate modality for understanding and remembering ideas. A powerful route to improving teaching is the incorporation of photographs into each lecture. Using photos can accomplish two goals. The images can illustrate and teach specific information, for example, by showing bacterial cells in the process of exchanging genetic material or demonstrating the impact of a high-cholesterol diet on artery walls. Photos can also – perhaps more importantly and less obviously – engage and inspire students. And they can challenge students to see ideas in new ways.

If possible, separate your images from the existing linear narrative of your presentation. Instead, present two simultaneous visual narratives: photos and overhead notes/slides. Students can consume written words quickly – much faster than we can describe and discuss them. With a second screen always showing a related, compelling, and provocative photo, their attention is less likely to drift from the topic. They experience the ideas concurrently from different perspectives, make new connections, and can form unexpected associations.

Consider this: a ridiculous photo of a child staring at a big plate of pasta. How could that possibly be relevant to our discussion of cell division? Or a familiar picture of John F. Kennedy with his wife, Jacqueline, in which she wears an iconic pearl necklace. How might that inform our lecture on intra-gene recombination and development of our idea of what a gene is? These are visual challenges that can nudge students toward a deeper appreciation of subtleties in seemingly irrelevant phenomena. (During most of the cell cycle, chromosomes don't really look like the tidy, compact X-shaped structures in textbook photos. Unwound, diffuse, and tangled, they more closely resemble a tangled mass of pasta. And prior to work demonstrating that recombination of genetic material could occur within genes as well as between them, biologists viewed genes as indivisible units, much like beads on a string – or pearls on a necklace. A stretch, perhaps, but a stretch that can help students reconstruct in their mind the evolution of an idea, as scientists reconciled the reality of DNA with the concept of genes.)

In several experimental studies, researchers have reported improved learning outcomes, particularly with respect to comprehension, when instruction made use of images in addition to narration (Mousavi et al., 1995; Tindall-Ford et al., 1997; Mayer & Moreno, 1998; Mayer, 2001).

8. Teach to the test (after first creating the *right* test).

"Teaching to the test" is commonly denounced as a practice signaling a failing educational strategy. This sentiment, however, is misguided and can undermine effective teaching and thoughtful implementation of assessment in curriculum design (Phelan & Phelan, 2013).

There are some generally accepted elements of good curriculum design (e.g., Toohey, 1999; Biggs, 2011; Waldrop, 2015). Broadly speaking, *Step 1* is to decide what we want our students to learn: the learning goals. *Step 2* is to devise ways to determine whether (and how well) our students are accomplishing these goals. And *Step 3* is to design our courses and teaching strategies to help our students accomplish the learning goals. Proceeding according to this plan, it becomes easier to see that "teaching to the test" can be valuable.

Have you ever waited until a day or two before a midterm to begin writing the exam? I have done this – only to realize that for many topics, I am unable to ask the questions I want, because my instruction did not present the material in ways that adequately prepared my students to write the complete and precise responses such questions require. Or I have struggled to remember whether or not I included all of the essential ideas and details in a class many weeks earlier.

What are the features of a good test? Validity and reliability are at the top of the list. Validity measures how well items correspond to learning goals, and reliability reflects the consistency with which a test measures what it is supposed to be measuring when given to different groups of students, in different environments. We must keep these in mind as we select or create our assessment items. Ideally, test design begins with content expertise and is supplemented by an understanding of student misconceptions. Questions must then be revised and improved – preferably in response to quantitative analysis that reveals an item's power to discriminate between students with differing degrees of mastery of ideas. Further, good tests maximize the information provided about student performance across the entire range of the established learning goals.

Developing informative, valid, and reliable assessments that are properly aligned to our learning goals is definitely challenging and time-consuming. It cannot be an afterthought, done in isolation from the rest of your curriculum design (on the night before an exam). Fortunately, we are not alone when it comes to creating assessments. Assessment items from multiple sources are valuable – including the concept inventories developed and published by content experts in many fields. And the payoffs of using high-quality assessments in conjunction with the development of learning goals are great. Only when we have articulated the learning goals and designed tools specifically for assessing their attainment can we determine how well our curricula and teaching strategies are "working."

9. Integrate anecdotes and revelations about your path toward understanding.

Virtually all effective teachers incorporate personal anecdotes, stories, and other revelations about themselves into their classroom instruction. Within the educational research literature, this is referred to as "self-disclosure" (see, e.g., McCarthy & Schmeck, 1982; Nussbaum et al., 1987; Downs et al., 1988; Sorensen, 1989; Cayanus, 2004). On the surface, this might seem inefficient. Far from being a simple, irrelevant break from learning, however, "self-disclosure" in your classroom can have several extremely important benefits that promote student learning, including

- increased student focus, interest, and motivation (Labov, 1972; Goldstein & Benassi, 1994; Wambach & Brothen, 1997; Cayanus et al., 2003);
- increased teacher clarity in presentations (Andersen et al., 1981; Downs et al., 1988);

- increased out-of-class communication (Cayanus et al., 2003); and
- a more active role taken by students in the classroom (Goldstein & Benassi, 1994).

Self-disclosure in your teaching can take many forms. As with most teaching techniques, planning your strategy – even for self-disclosure – can significantly increase effectiveness. First, you can determine which points best lend themselves to self-disclosure. Second, focus on maximizing the relevance of your disclosures to the course content (Cozby, 1973; Frymier & Shulman, 1995; Frymier et al., 1996). While self-disclosures unrelated to course content can still establish a high level of immediacy in the classroom (McBride & Wahl, 2005; Cayanus & Martin, 2008), they can negatively influence student affect and the learning environment (Kearney et al., 1991). And third, make sure to vary the timing and topics addressed with self-disclosures; when they are too consistent and predictable, teacher self-disclosures can reduce student interest and motivation (Cayanus, 2004).

The range of topics for which effective self-disclosure is possible is broad (Javidi & Long, 1989). General topics include your friends, family, and colleagues, as well as your education and teaching experience. More specific topics depend on the course itself but may include

- your own struggles (and failures) in trying to conduct a study;
- analogies that you particularly hate (such as "ATP is like currency") or love ("ATP is like a rechargeable battery");
- explanatory phrases that you find annoyingly overused ("the powerhouse of the cell," "building blocks of proteins");
- reflections on where the textbook goes wrong ("reliance on a phrase, 'scientific method', that casts the whole enterprise as more rigid and less adaptable and creative than it actually is"); and/or
- revealing your scientific heroes and why they inspire you.

To the extent that students can see how ideas in your course have meaning for your own life and experiences, their learning will be enhanced. From your personal revelations, they may see a path toward understanding that can work for them.

10. Reinforce the most important ideas with take-home messages.

In a world of information overload, it is more important than ever to learn how to distill ideas, examples, and implications, forming hierarchies of importance. A valuable service you can provide for your students is to include in your instruction "take-home messages" that concisely and precisely highlight and reinforce the lectures' most important ideas.

Expertise within a domain does not come simply with the acquisition of some critical level of factual knowledge. Rather, experts utilize a small number of organizing concepts and principles. It is this conceptual understanding of "big ideas" that enables experts to think flexibly and productively as they incorporate new information and address new problems (Bereiter & Scardamalia, 1986; Chi et al., 1988; Glaser & Chi, 1988). Across numerous different subject areas, novice–expert research has demonstrated the power of this approach in teaching (e.g., Larkin et al., 1980; Chi & Ceci, 1987; Niemi, 1996).

Toward this end, you can help your students – novices – toward expert mastery of the material by structuring your presentations around "take-home messages." Include three to five concise and precise summaries of the big ideas on a topic – and identify them with a consistent presentation style.

○ Conclusion

There is no one "secret" to teaching. The tweaks I have described here can help you make incremental improvements in your teaching. But they're just the beginning. There are many routes to discovering your own tweaks. As you work actively toward improving your own effectiveness, watch and dissect great teachers. Watch and dissect video of yourself teaching. Talk to your students. ("Tell me about a terrible class and how it might have been improved.") Be methodical in your changes. Evaluate the benefits. Find a community of people who understand the challenges and the value of inspired teaching. Explore the education research literature.

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