Catching the new wave of teaching

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Many graduate students teaching introductory labs find themselves dissatisfied with conventional lessons that fail to ask the student to participate actively in the learning process. Research suggests that students do not use higher-order thinking skills (e.g., application, analysis, synthesis, and/or evaluation) in many of these introductory courses (Handelsman et al. 2004). As a result, some universities are already switching their science courses to an active-learning approach (Handelsman et al. 2004; Ebert-May and Hodder 2008). By the time current graduate students are job hunting or seeking tenure, they will probably be expected to know how to teach using active-learning strategies. As a graduate student assigned to teach a lab course, you can leverage this opportunity to become a better, more marketable teacher by demonstrating your ability to incorporate active-learning techniques in the classroom. Here, we offer practical advice and resources to graduate students for catching this new wave of teaching.

The traditional (passive) teaching model is best described as “teaching by telling” (e.g., lectures and cookbook-style labs), where the instructor is responsible for giving students the information they need to know and the students are responsible for recalling that information at exam time. Active learning, by contrast, draws on students’ preconceived notions about a subject and places the new materials within their own model of understanding (i.e., a conceptual framework). Thus, active learning focuses on connecting what the student already knows with what we want them to learn. It improves students’ ability to apply their knowledge in novel situations (Bransford et al. 2000; Handelsman et al. 2004). It can also help foster connections that enrich the students’ college experience, by strengthening relationships with peers and instructors (Smith et al. 2005).

As teachers, we may worry that if we replace time spent covering content with reinforcement activities, students will not perform well in upper-level courses and on standardized tests (e.g., Medical College Admission Test or MCAT). In reality, the questions that students face on the MCAT and the Graduate Record Examination (GRE) Subject Test in Biology are primarily applied or analytical questions, as opposed to content-only questions (Zheng et al. 2008). We should therefore view time spent using active learning as a complementary component, in preparing students for these future challenges.

As a teaching assistant, you will likely have limited scope for making sweeping changes to existing courses; however, some minor changes may be possible, with little resistance from the lead faculty and minimal time commitment from you. Below, we offer examples of active-learning strategies that we have found particularly useful, and to which our students have responded positively.

Question and answer (Q&A). An easy way to start using active learning is to involve students in a guided Q&A session with open-ended questions. This allows students to place the current topic into a wider perspective. For example, at the beginning of class, ask students what they expect to learn from the current class, given what they know about the topic. Toward the end of the session, ask what new thoughts they have on the topic (e.g., if the lab focused on mitosis and students were observing onion root tip cells in each phase of cell division, ask how their new knowledge could apply to understanding cancer and potential solutions, such as chemotherapy).

Minute papers. These very short, in-class writing assignments can be used to achieve multiple goals quickly, including: (1) revealing what students already know about a subject; (2) ascertaining if they learned what you thought they did; and (3) engaging students in self-reflection on their own learning. In this way, each student personalizes the class discussion, and the instructor can assess student learning at an individual level. Some example subjects for such papers include, “What is the most interesting thing you learned in lab today?”, or “Write an example short-answer question for the next test. Explain why this question is important.”

Jigsaw. Jigsaw activities have students work on specific pieces of a complex problem; students then share their specialized knowledge with other students who worked on different pieces of the same problem (Smith et al. 2005). Dissections are one example of a jigsaw activity: students break into small working groups to investigate a specific part of a biological system (e.g., digestive, circulatory) and then switch groups to share their knowledge with students working on other components of the system.

Problem-based learning. Science is about testing hypotheses, so why not emulate the scientific method in class, by framing the lab topic in the form of an interesting problem? For example, “Are the Great Lakes being influenced by the global greenhouse effect?”. Introduce the students to tools they can use (e.g., online water temperature datasets), and then allow them to develop their own testable hypotheses and the methods needed to test them. Your job is to guide the students through this process and refrain from telling them what to do, even
when they may appear to be struggling. The ideal outcome is that students will use critical thinking skills and gain a better appreciation of the scientific method, while learning about the topic.

To transition to active learning, we must learn to step back and allow students to follow their own path to learning. We need to recognize that this is when students use their higher-order thinking skills and remind ourselves that, in the end, they will have a better understanding of material through active learning than if they had just followed the step-by-step lab instructions.

By thinking critically about teaching and trying new active-learning strategies, you will be better equipped to discuss your teaching experience in future job interviews and may be a more marketable, well-rounded candidate. You can also use active learning when communicating your own research to lay audiences (e.g., through educational outreach activities). Many universities are already transitioning toward active learning, and we believe there is every reason to start trying it now as a graduate student.

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Faculty response

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During the past decade, professional development programs for improving undergraduate science instruction by graduate students, postdocs, and faculty have increased in number and quality. Martin and Horst provide clear, compelling evidence that some of these programs are catalyzing the way we teach undergraduate science. At Michigan State University, they both participated in National Science Foundation-sponsored, cutting-edge projects on teaching and learning. Evidence of how their thinking about teaching has evolved is reflected in this article. Their perception that many universities are switching to active-learning approaches in their courses is optimistic, and will likely occur only through the efforts of the next generation of faculty. Recent data indicate that faculty who implement active learning in introductory biology courses are early in their careers, whereas established faculty are less likely to change their teaching habits.

Martin and Horst offer practical advice to their peers for incorporating active learning into labs, regardless of the limited autonomy most graduate students have within a curriculum. All of the instructional strategies described are useful and applicable to both lab and lecture settings, and there is evidence that students do gain a deeper understanding and integration of concepts through active learning.

In the future, when graduate students and postdocs have opportunities to design and teach their own courses, knowing only how to do activities is not enough. Knowledge and use of “backward design” to construct courses and daily lessons are critical (Wiggins and McTighe 2005). Backward design involves establishing student learning goals first – what do we want students to know and be able to do? – and then developing assessments that will determine the degree to which students accomplish those goals. Finally, we select, create, or adapt appropriate active-learning activities that will enable students to achieve those goals. This approach requires establishing active-learning communities in class, so that all the students have the opportunity to achieve the goals of the course.

A key variable that influences what instructors do in a course is their personal belief in what constitutes the roles of the learner and the teacher. How a teacher views students’ demands continuous reflection and analysis of their characteristics and performance. Thoughtful evaluation will drive subsequent instruction. Belief that students have the potential to achieve higher cognitive levels influences where we place the bar for learning outcomes – low or high. If we design instruction that enables students to demonstrate complex thought processes in the context of the course, they will achieve that goal.

Graduate students have the ability to become agents of change. Martin and Horst were willing to experiment and reflect on their instructional practice and learning outcomes. In effect, they did not accept the metaphor of teaching as “sage on the stage”. Graduate students and postdocs have the opportunity to set the standard, so that their future students “teach as they were taught” in an active, learner-centered way. Faculty should nurture their ideas and provide the encouragement and mentoring necessary to help them do so.

References


