Kostas Pagiamtzis’s experiences as a student motivated him to be an effective teaching assistant. “I was actually a big critic of teaching assistants when I was an undergraduate,” says Pagiamtzis. “I had both really good ones and really bad ones.” The bad ones didn’t even seem to be trying. Then he had to take on the role himself, while studying for a PhD in electrical and computer engineering at the University of Toronto in Canada. “I thought I’d better not be one of the bad ones”, he says. At the time, the University of Toronto had no formal training for teaching assistants.

So Pagiamtzis looked to his adviser, his colleagues and the Internet for advice. His diligence paid off: Pagiamtzis won three departmental teaching awards and gained interpersonal ‘soft skills’, such as communication and time management, that prepared him for a career as a microchip designer with Gennum in Burlington, Canada.

Making the time and effort to teach can be difficult for young scientists — especially when mentors, advisers and other faculty members tell them to concentrate on their research. Training varies wildly in content and quality. Some institutions mandate training only in topics such as sexual harassment and ethnic discrimination. Others offer voluntary courses on how to teach. Some provide course- or topic-specific instruction. And a few, such as Emory University in Atlanta, Georgia, and, now, the University of Toronto, mandate detailed training, in which teaching assistants or young instructors learn to teach first during discussion sessions with small groups of students, then in lab courses and, finally, in large lectures. Whether they are autodidacts like Pagiamtzis or have had formal training like graduate students at Emory, good teachers learn the iterative process of preparing relevant lessons and presenting information effectively, then assessing the effectiveness of their efforts (see ‘Pedagogical pointers’).
CAREERS

EXPERT TIPS

Pedagogical pointers

Early-career researchers are often unpractised at teaching, and can get distracted by their lab responsibilities. Here, experienced teachers offer some tips to help novices and their students get the most out of the classroom experience.

Prepare
Send your syllabus to your peers for feedback. Ask others who have taught a similar class to share their materials.

Set aside time to develop course materials — it often takes longer than you think.

Find a mentor whose philosophy and teaching style you would like to emulate. If possible, visit their classes before you begin teaching, to understand how they structure time, interact with students and promote learning. Talk to your mentor about what works and what doesn’t.

Think about the skills and knowledge that you want your students to gain — and make sure that you are allowing time for your students to practise using them.

Interact
Focus less on content mastery than on skill mastery. You can’t expect your students to think critically in an exam if you haven’t asked the same in class.

Don’t do for students what they can and should be doing for themselves. Teach them how to find the answers to their own questions, either alone or in groups.

Don’t feel that you have to cover every topic that falls under the heading of your course. What does it matter that students know every definition in the textbook if they can’t do anything with that information?

Assess
Make sure to provide students with ample feedback, so that they and you recognize when they need improvement.

Make sure you and your students have clear, measurable goals. Write them down and provide copies to your students. Revisit these goals throughout the teaching period and assess whether you’ve attained them.

Be transparent with your students. Let them know what you expect, what you are doing and why you are doing it. Honesty will go a long way towards building a successful learning community. P.S.

Teaching can benefit an academic’s career whether or not it is their main focus. Bouncing between teaching and research can help to identify research questions, improve academic writing and hone presentation skills — particularly those required for audiences with varying knowledge and skill levels. Teaching can also be a laboratory in which to learn the soft skills that will be vital to a professional career.

PREPARATION

One of the most important aspects of teaching is also one of the most misunderstood: preparation. Many new teachers think that preparation means having a basic understanding of the course material, but mere familiarity is only the beginning. “I aimed to understand the material one level deeper than what I was teaching,” says Pagiamtzis. “But go as deep as you can in the time you have allotted for preparation.”

To prepare course materials, Diane Ebert-May, a plant biologist at Michigan State University in East Lansing, suggests thinking about the core skills or knowledge that teachers want their students to gain, then reverse engineering the syllabus to ensure that pupils get the desired benefits. “Then you have to practise those competencies with them,” says Ebert-May, who also trains biology postdocs in scientific teaching through an inter-university programme called FIRST IV.

Students are often told to put in two hours of work outside the classroom for every one they spend in it; teachers should devote at least as much time to their own preparation, says Ebert-May. And that doesn’t include marking work, advising students or other administrative tasks.

Committing to that level of preparation means mastering time management, especially for graduate students or postdocs doing their own research. “Academic expectations keep going up. There just isn’t enough time,” says Alison Roark, a biologist at Hood College in Frederick, Maryland, who is a former teaching assistant and a participant in FIRST IV. To deal with the crunch, she reverse engineers her schedule in the same way as she does her syllabuses — by setting goals, then carving out time to meet them. What works best, she says, is to set aside blocks of time for specific activities: academic writing, teaching preparation and correcting her students’ work.

“It gets better,” Roark tells new teaching assistants. “I was a big critic of teaching assistants when I was an undergraduate. I thought I’d better not be one of the bad ones.” Kostas Pagiamtzis

“I was a big critic of teaching assistants when I was an undergraduate. I thought I’d better not be one of the bad ones.” Kostas Pagiamtzis

PRESENTATION

Part of being an effective teacher involves being able to grab students’ attention — even being a showman of sorts. Young teachers should look at the day’s lesson as a story, with a beginning, middle and end, says Pagiamtzis. For example, he traces the history of computing from the invention of the transistor to the formation of technology giants such as Intel and Google by talking about how William Shockley, co-inventor of the transistor, “was a jerk”. Pagiamtzis interweaves the story of how transistor technology morphed into microchips with tales of how Shockley’s abrasive personality drove away eight top scientists, some of whom went on to form a venture-capital firm that funded Google, Amazon and others. Intermingling science with the personalities behind it helps to hold students’ attention, says Pagiamtzis. Nanda Dimitrov, associate director of the Teaching Support Centre at the University of Western Ontario in London, Canada, agrees. “A lot of great researchers know the material very well,
but do not know how to engage the students,” she says. “You need to understand the learner, understand the learner’s prior knowledge and understand how to motivate the learner.” The best teachers, says Dimitrov, use various approaches, including active learning and frequent assessments. That philosophy sums up a technique called ‘scientific teaching’, which builds on the standard lecture format.

“The notion that ‘If I cover it, they learn it’ is fatally flawed,” says Ebert-May. Her research shows that students retain more when lectures are enhanced by interactive lessons and lots of feedback (D. Ebert-May et al. Bioscience 47, 601–608; 1997). The best way for researchers to teach science, says Ebert-May, is to treat the classroom as if it were a lab, getting students to ask research questions, do literature reviews, conduct research, analyse data and present results. “You want to have people working together to solve complex problems,” she says.

**EXERCISING THE BRAIN**

Roark uses this approach when teaching about how nerves drive muscle-cell function in her introductory biology course. She gives each student a ‘neuron token’ with a voltage value, then arranges the students into ‘neural networks’. They must work out whether a particular muscle cell in that network will contract. “The students have to turn on their brains in my classroom,” says Roark. “They can’t just sit there and take notes.”

Pagiamtzis likes to challenge his students with problems that have unexpected solutions. For example, as part of the standard electronics curriculum, he asks them to calculate the level of amplification of a two-pole amplifier. They usually use a simplified formula called the Miller approximation, and most come up with the wrong answer. But with enough prodding, students come to understand that the usual formula is not valid at high frequencies. They will remember the lesson better for having discovered it for themselves than they would for having been taught it directly, says Pagiamtzis.

Although coming up with challenges requires a lot of effort, the work pays off — and not just for the students. Pagiamtzis has found that searching for special cases and exceptions to use in exercises deepens his own knowledge and understanding of the subject. His experience agrees with the conclusions of a study published last month, which quantitatively shows that teaching helps to enhance graduate students’ scientific skill sets (D. F. Feldon et al. Science 333, 1037–1039; 2011). The authors suggest that coming up with multiple study designs and research premises for use in the classroom honed the graduate students’ own thought processes.

Tobias Langenhan, a physiologist at the University of Würzburg in Germany, finds that teaching and testing his students helps him to think about where to put his future research efforts, as well as how to refine his teaching. “You realize that some of the principles you teach are very well substantiated in terms of experimental results and that others are not,” says Langenhan. “Flipping back and forth between teaching and research tells me where I should invest more time in explaining, and also where the pieces in the dogma we are trying to explain to the students are missing.”

Not only did Pagiamtzis’s classroom experiences force him to gain technical mastery of his subject matter, but the interpersonal skills that he learned have been invaluable to his industry job. He uses those skills when he explains the intricacies of computer chips to marketing people, or technical problems to managers. An important part of that exchange, he says, is being a good student by actively listening. “In essence,” says Pagiamtzis, “we are always learning from and teaching each other.”

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