How Teaching Can Help You Be a Better Student (and Scientist!)

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Outcomes: By the end of this session, participants will be able to…

- Create effective study strategies that use distributed practice and formative assessment
- Apply effective lecture styles to oral research presentations
- Appreciate the value of TAing to their learning and research

Why should I read through this document?

Teaching well requires commitment, and sometimes it's easier to convince yourself to invest in your own learning rather than in the learning of others. However, this document will show that there is harmony, rather than a trade-off, between your learning and your teaching. Knowing how to train others to think like experts will help you build your own expertise in graduate classes and inspire you to communicate your own research more effectively. Learning to teach can improve your learning and your research as well!

Before reading:

▪ Multiple choice ▪

Which of the following is the best study strategy?

A) Memorization of relevant information and facts
B) Quizzing yourself or others with flashcards and practice problems
C) Rereading relevant notes and textbook
D) Highlighting key phrases and concepts in notes and articles

Think ▪ Pair ▪ Share: Consider a very challenging assessment (exam, project, presentation) you have faced. How did you prepare, and was your preparation effective?

In this activity, think of some answers to the above question before pairing up with someone and discussing your answers. Share your answer or your partner's answer and relevant observations from your discussion with your partner with the class.

How we teach and learn

Effective teaching strategies provide a model for how to train yourself or someone else to think like an expert.

We all have a general idea of what should happen in a classroom, but the experience of being a teacher can feel very different than being a student. Everyone sits somewhere on a continuum from novice to expert in various subjects. When we teach something, we usually sit closer to the expert side of that continuum. As students, we may be absolute beginners!

As teaching assistants or teachers, we can be subject to expert amnesia, the inability to explain a concept in a way that makes sense to a novice. We forget what it was like to be a beginner! Similarly, as students, some concepts may be difficult to understand because your teacher does not remember what is hard for beginners. Research has shown that experts and novices organize knowledge about their field differently, explaining the ocassional disconnect between teacher and student. To advance your knowledge of a field, you should try to think and organize information like an expert.

▪ Knowledge organization ▪

Take one minute to memorize the following sets of letters:

C I A C B S A B C F B I I R S

Now turn to a neighbor and discuss the strategy you used to memorize these letters. What did your partner do differently?

Becoming an expert requires careful knowledge organization and deeper thinking styles.

To think like an expert, we need to employ good study habits that build towards solid knowledge organization. Good study habits and teaching practices should pave the way from novice to expert. As teachers and students, we should think about scaffolding, building up to new concepts using the information someone already has mastered, to make our way to an expert understanding of something.

What strategies should we use? Instead of thinking of learning strategies as separate methods or as individual styles, we can place them on a continuum. On this continuum, we progress from memorization to deeper understanding. While a basic understanding of a topic is a good starting point, as scientists, our end goal is typically to be able to create something with our knowledge.

We want to become experts, which means we should be doing tasks that take us farther up the hierarchy (commonly called Bloom's taxonomy and represented by a pyramid) of abilities, or learning domains. In the same way, a good teacher should take their students from understanding to creation.

*Teachers guide students to deeper thinking with **practice** and **feedback**.*

One of the difficult choices teachers must make is what to include in an actual class, both what content is chosen and how it is presented. These choices usually boil down to questions about practice, feedback, and performance. Overall, class can be defined as an opportunity for practice (learning opportunities such as practice problems, and lecture) and feedback from your teacher and your classmates before performance based on what you've learned in a class (problem sets, quizzes, tests). Teachers and classmates can then provide further feedback (comments, grades, etc.), which can lead to better performance in the future. The two main ways you improve during a course are through practice and feedback.

Research-tested approaches to practice and feedback

Practice: Distributed practice leads to long-term retention.

Whatever method you choose, research shows that you should try to learn over a longer period of time for good retention of information. The longer the length of time, the better your overall learning.

How do I use distributed practice techniques in the classroom?

- Don't be afraid to teach the same topic twice or in two different contexts (this may even help students understand the value of the topic!)
- Create multiple opportunities to interact with material (in class, during recitation, office hours)

How do I use distributed practice techniques as a student?

- Engage with difficult concepts when you first realize that they are hard and seek out practice problems in your text
- Attend office hours to hear and practice the same material in different ways
- Use several strategies to learn the material (quiz yourself, review with friends, use flashcards, do practice problems)

Feedback: Formative assessments provide meaningful feedback on understanding and retention.

You may be most familiar with assessments in the form of problem sets and exams during a course. These are known as summative assessments. They test the total knowledge you have retained over the course of the class.

Good teachers also use formative assessments to determine what their students know and where their deficits are. These assessments happen throughout the quarter and determine what material a teacher may need to review or reteach. Formative assessment is a great way to catch misconceptions or correct mistakes before an exam.

Before a lesson, formative assessment reveals prior knowledge and misconceptions.

As mentioned in the previous section, formative assessments can also help you understand what your and your students' initial understanding of a subject is. Just because we have learned something before does not mean we have learned it correctly. Every student enters the classroom with prior knowledge, information or background in a subject that they have before taking the course. However, not all prior knowledge is created equal. Experts also may assume that novices entering a course have the prior knowledge they need to succeed, when that may not be true!

Video ▪ College students explain the seasons
The video shown during the session can be found on YouTube (Harvard graduates explain seasons).

Common misconceptions can be hard to avoid, especially if you're only ever tested once on a concept. Formative assessment is one way teachers and students can catch these misconceptions before they become ingrained.

After a lesson, formative assessment gauges understanding and retention.

In the classroom, common formative assessments (that you might not have considered a true assessment in the past!) are sharing out results from group work, multiple choice questions posed to the class, or perhaps anonymous feedback at the end of each class.

Outside the classroom, research shows that study methods that involve testing and retesting are some of the most effective ways to retain information (i.e. flashcards, mock quizzes, quizzed by a friend, etc.). These self-quizzes can be formative assessments. If you fail a self-given quiz, you may need to spend more time mastering a topic.

How can you use formative assessment in the classroom as a TA?

- Take this session as an example! Provide active learning opportunities to students (multiple choice questions, think-pair-share, etc. Find more on the CTLO website!) and have them report out their results. Are they reporting what you expect to hear? If not, reteach and review the material.
- Provide opportunities for anonymous feedback. For example, you can solicit the unclear point from a lecture or recitation by giving students forms with the question, "What is still unclear?" or "What was the muddiest point from this session?"

How can you use formative assessment as a student?

- Find opportunities to get feedback from your professor or TAs. Find out what's confusing before turning in a problem sets!
- Attend and participate in class to receive feedback from your professor in real time.
- Go to office hours and ask questions. Come with examples you may struggle with and ask for help.
- Quiz yourself or your classmates and correct each other when you struggle.

▪ Multiple choice revisited ▪

Which of the following is the best study strategy?

A) Memorization of relevant information and facts
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While one strategy is the best, is there still value to other strategies?

When combined with distributed practice, many of methods can be used to improve your retention, and maybe even your grade on a final!

Applying these ideas to our research

In conference presentations and candidacy exams, you are effectively teaching your audience to think about your data like an expert.

A key part of research is communicating our results. An audience that understands our research well is more likely to provide useful feedback, propose new and fun ideas, and (perhaps most importantly) let us graduate. Ensuring that your audience understands your research is very similar to ensuring that your students understand course material well. Much of the advice for effective presentations (see *PLOS*'s "Ten simple rules for short and swift presentations") can be understood in the context of an effective teaching technique.

Good talks have clear objectives and a main message.

Often, we plan a talk by listing the pieces of evidence that we will include, rather than what core message those pieces of evidence will support. With this approach, the main message becomes lost to the audience, or we forget to have a clear objective!

Instead, we can prepare "backwards" by first listing what the audience should understand or think differently about by the end of the talk. Then, what pieces of data should be included, as well as the big ideas that appear on introductory and conclusion slides, becomes more clear. This is simply an application of backwards design, frequently used to improve homework, exams, or lectures. In backwards design, explicitly stating the goals of a course helps determine what assessments will show whether students achieved those goals, and what kinds of practice are needed to perform well on those assessments.

Objectives for a talk may include:

- Understand the main results of the work: "Material A has desirable properties X, Y, and Z," "Algorithm Q predicts movie preferences better by metrics P and R because of features X and Y."
- Understand the context of the work: Michael Ernst says the main points of every technical talk are that the problem is worthwhile, the problem is hard, and you solved from the problem (from Michael Ernst's "How to give a technical presentation").
- Effectively engage with the data: "We're experts at knowing what a good talk is because we know what we want delivered as an audience member…We're interested, obviously, in learning some about interesting and novel science…We want to be able to see the data, understand it, interpret it, and then make our

own decision about the science." (from Sue McConnell's "Designing effective scientific presentations")

Good talks unite the main ideas in a logical flow.

Remember that an expert often has deeper insight and understanding because of how they organize information in a web of knowledge. The structure of your talk is the first way your audience will organize your ideas. Both the order in which your present your results and the time you take to emphasize connections will build their web of knowledge. You can help your audience think about your project like you, the expert, do! Consider providing an outline that you frequently return to, pausing with slides that summarize the main conclusions up to that point, and practice transitions that show clear connections between adjacent parts of your talk.

Good talks repeat the main ideas, perhaps in different forms.

As we discussed above, distributed practice leads to long-term retention. Restating your main idea many times, and in many different ways, is essentially a form of distributed practice, as the audience reviews the material at many different points throughout your talk. Frequently pausing to summarize, or just repeating the main finding at the beginning and end of your talk, can achieve this.

Good talks can incorporate aspects of active learning and assessment.

Active learning gives students space to interact with new material before additional material is presented. Similarly, including elements of active learning in your talk can increase audience engagement and retention. While traditional active learning techniques may not be appropriate at a conference presentation, you can simulate them, perhaps by framing your talk as a series of questions and resopnses, asking the audience to silently anticipate a result before you show the data, or even including QR codes that link to figures or interactive data.

▪ Minute paper ▪

Think about a current or former research project. If you were to present on this project, what is one thing (or two or three) you would want someone to remember, even a week after your talk? How could you design your presentation to increase the audience's ability to understand or remember that one thing? Consider using any of the ideas from this workshop as a starting point!

▪ Final reflections ▪

What is one strategy you learned about in this session that you found interesting? How will you apply it as a student? As a TA?

If you're looking for more helpful strategies for studying, check out the article "What Works, What Doesn't" from Dunlosky *et al.* in *Scientific American*.

For more information on backward design, see "Backward Design: Targeting Depth of Understanding for All Learners" from Childre *et al.*