

**ENGAGE YOUR STUDENTS.
A STARTER'S GUIDE FOR MATH TEACHING ASSISTANTS**

JAMES OXLEY

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PREFACE

Many of us can point to one of our teachers as a source of inspiration, perhaps even as the reason we are where we are today. When, as a graduate assistant, each of you takes on the role of a teacher, you become, to your students, that person who was so important to shaping you. As you read my words about teaching, I hope you will reflect on this responsibility.

For over thirty years, I have been watching the classes of Mathematics graduate assistants at Louisiana State University and giving them advice about teaching. The students have mainly taught college algebra, trigonometry, calculus I, or calculus II, though some have taught differential equations or some math education courses. Class size has primarily been between thirty and forty-five with just a few classes up to about eighty.

After observing over three thousand classes, I have developed some quite strong views about what does and does not work in these classes. I have shared these views with the graduate students I have observed, always being mindful of the fact that, for them to become successful teachers, they need to develop confidence in their teaching ability. That confidence is usually fragile and is sometimes almost non-existent; helping it to grow has been a major focus of my endeavors. The rare cases of overconfident or indifferent graduate students have posed alternate challenges. With all students, my goal has been to develop in them a recognition of their significant responsibility as teachers.

I have wondered whether my observations are worth sharing with others. But I've always been held back by a variety of factors: I have no formal training in education; I have read very little of what others have written about mentoring math graduate assistants; and, most importantly, none of my thoughts is likely to be original. My thinking on these matters received a jolt during a conference with a graduate student following my observation of his class. That student, Mostafa Hayajneh, suggested that a record of my experiences may be valuable to both graduate students and their teaching mentors; and he made the novel suggestion that I write this record in the form of a series of anecdotes. This approach appealed to me and it is the one I have followed here. I hope that my long tenure as a mentor gives credibility to my insights both into nurturing young teachers and into sound ways to achieve good outcomes for their students. I have observed the positive effects of my suggestions in the classroom. Although, I have done no experimental studies to validate my ideas, at the end of each section, I have provided references to publications that generally endorse the ideas presented in the section although some present counterpoints to my suggestions. While the ideas expressed in this guide are probably of less significance than the natural talent of the LSU Mathematics teaching assistants, it a source of some pride to my department that, in the period from 2015–2024 inclusive, eight of the ten winners of the LSU Alumni Association Teaching Assistant Award for STEM subjects were from our department.

I am aiming my comments not only at graduate assistants who are just beginning to teach, but also at more experienced graduate assistants who are seeking to hone their teaching skills. In addition, I hope to reach professors across all levels of experience who are responsible for mentoring new teachers. Let me address a few remarks here to these mentors. When I began my mentoring assignment, I had not taught college algebra or trig, two of the basic classes that are assigned to many of our graduate assistants. To learn how these classes are taught, I observed the classes of some of my department's dedicated, accomplished teaching professionals. The benefit of watching others teach cannot be underestimated especially when the observer is given a checklist to help focus attention on key techniques that, when done well, are often almost

invisible. (Such a checklist can be found in Section 3.) Novice teachers, and even experienced ones, can feel vulnerable to feelings of humiliation when others critique their teaching style. To try to put these students at ease in the aftermath of one of my classroom observations, I always talk to them privately, in my office or in a corridor away from where their students can hear or see our interactions. I begin by asking them how they felt about the class and what they'd like to change. Then, after praising them for what they have done well, I try to gently nudge them toward a better approach in the areas of most urgent need. Providing them with a long list of deficits can only further undermine their confidence and tends to be counterproductive.

One crucial feature of my mentoring is that my comments to individual graduate students have been tailored to what I have seen in their particular classes. The nature of this guide is that it is directed to a broad audience, so I have lost probably my most potent mentoring tool, the opportunity to interact with individual graduate assistants. Nevertheless, my observations have taught me that there is some basic advice that I have found myself repeating again and again. It is this advice that is presented in the first section. The second section extends the principles developed in the first section to give concrete advice about implementing some of these principles. These first two sections contain the core of my advice. The third section is focused around an observation report I complete after each class. It highlights various things for you to consider in relation to your manner in the classroom, your method of presentation, and some issues relating to the mechanics of your presentation. The fourth chapter is about testing and gives guidelines on how to write, administer, and grade a test. Section 5 discusses more about classroom management, focusing on maintaining control and eliminating distractions. There is also a brief discussion of teaching evaluations. The final section discusses how to ensure that your students get the most from office hours.

If you have read this far, it suggests that you are interested in becoming a better teacher. This willingness, accompanied by the effort of following a perhaps prolonged, trial-and-error journey, should ensure that eventually you will achieve your goal. My aim here is to share my observations of what has helped others with a view to accelerating the process for you. Astute readers will notice certain ideas appearing again and again throughout the book. This follows standard pedagogical practice that recognizes the value of repetition.

Although this guide records a series of anecdotes relating to my experiences, to protect the anonymity of the graduate students involved, I have changed their names and often their genders. All tales relating to my family or me are accurate to the best of my memory. A number of characters in this narrative are composites of several individuals who have exhibited similar tendencies. The one totally fictitious character I introduce is Sarah (you'll find her) and, while her story is a pure metaphor, all of the other stories reflect actual events and make significant pedagogical points. I have quoted verbatim from the student evaluations of a number of LSU graduate assistants. I find that these quotes powerfully illustrate a number of key points. Most of them are very positive, but some are quite critical. I hope that the latter help to remind you of the fact that your students are relying on your guidance to get through their course. Although you may be inexperienced, you can certainly work hard to overcome the three types of instructor misbehavior identified by Kearney et al. [37]: incompetence, offensiveness, and laziness.

To address the value of this guide, I note that Speer et al. [64] make the following rather bold claim: "Though written accounts of collegiate mathematics teaching exist (e.g., mathematicians' reflections and analyses of learning and teaching in innovative courses), research on collegiate teachers' actual classroom teaching practice is virtually non-existent. We advance

this claim based on a thorough review of peer-reviewed journals where scholarship on collegiate mathematics teaching is published.” This guide is intended to provide practical teaching advice based on many years of in-person observations of the classroom practices of TAs at LSU.

Many friends and colleagues have been involved in the preparation of this guide. I am most grateful to Carolyn Chun, Christine Cho, Pattie Doody, Dylan Douthitt, Tara Fife, Mostafa Hayajneh, Allan Mills, Bogdan Oporowski, Judith Oxley, Simon Pfeil, Jagdeep Singh, Geetanjali Soni, Avery St. Dizier, and Jesse Taylor for their invaluable assistance. I also thank several anonymous reviewers for their comments designed to improve this guide.

This document has undergone repeated rewriting and, going forward, I expect that process to continue. The version of the document you are viewing can be determined from the date at the bottom of the first page.

TALKING TO THE TREES

I learned an important lesson about communication from my daughter, Margaret, when she was just five. One day, when Margaret and my wife, Judith, were at home, Margaret was talking incessantly to her mother, as was her custom. Judith was attending to some household chores and, while usually very willing to engage in endless exchanges with our daughter, felt the need for a break, so she sent Margaret out into the back yard to “talk to the trees.” Obediently, but reluctantly, Margaret did indeed go outside only to return rather quickly, too quickly for her exasperated mother. The following exchange ensued.

JUDITH: Margie, I thought I told you to go and talk to the trees.

MARGARET: But Mommy, I can't talk to the trees. *They've got no eyes.*

If even a five-year old knows that eye contact is fundamental to communication, it tells you something profound about its importance. You will learn from your students' eyes whether they are bored or engaged and whether they are following your lesson. Making eye contact with students can be intimidating for all of us. Practice doing it when students come to your office for office hours. Practice it in your conversations with strangers. Learning to read the reactions of your students is crucial to actively engaging them and thereby to successfully teaching them.

HOW TO USE THIS GUIDE

Just read the first section. It focuses on three simple skills to work on when you start teaching. Once you have mastered these you can concentrate on developing more complex skills. Some of these are discussed in the second section. The precise issues that will be troublesome for you will vary, so I have tried to make this guide as versatile as possible by having a collection of short sections that deal with specific issues, a buffet from which you can pick what you like, remembering that none of us enjoys being exposed to our weaknesses but confronting them is the only way that we improve.

As a graduate assistant, when you first begin teaching, there are so many things to worry about that it is easy to be overwhelmed by worrying about all of them. Don't let this guide intimidate or overwhelm you. Most of you would eventually learn the lessons it contains by yourself. The hope is that, by dipping into the guide from time to time as needed, you will learn these lessons a bit faster than you might on your own.

1. FIRST STEPS

I used to be an avid swimmer. I spent so much time in my swimming goggles that one of my colleagues called me “Goggle Man”. With the exception of synchronized swimming, I love all things pool-related and every Olympic year, I witness the same amazing spectacle that I’m sure most of you have also seen. A young diver stands atop the ten-meter platform, her back to the water, wrist guards on to protect her when she hits the water travelling at over thirty miles per hour. She settles herself on the very end of the platform with only her toes touching it, her heels over the edge. Then she raises her arms into the air and launches herself upwards and backwards. After an astonishing array of twists and somersaults, she enters the water with barely a splash.

How did this young athlete learn to take care of so many variables simultaneously? How could she launch herself backwards into the unknown and not be afraid? How long did it take for her to perfect such a complex maneuver? Teaching is a similarly difficult process that takes a long time, some would say an infinitely long time, to master. You are about to launch yourself into the unknown, into a classroom in which the students will look to you as the expert, the one who can help them to understand sophisticated ideas, can respond to their individual needs, and can help them to get a good grade. Your assistantship requires this and you should know that, even if you get a college job, you will need to do a good job as a teacher to get tenure. In fact, you will need a strong teaching recommendation to even be considered for that precious job. But you probably have almost no experience as a teacher. It is scary. Indeed, if you are not nervous about it, then you are not taking the job seriously enough.

Your first class is coming up soon and you want to make a good impression on your students. You know you can’t possibly perform at the elite level of that young diver who had years of training to get there. Right now, your main goal is to get through that first class without drowning. Your next highest priority is to avoid looking foolish or incompetent. What do you do?

I will begin with three things to focus on. If you work on these three things first and develop your mastery of them, then my experience strongly suggests that the other pieces of the complex puzzle that is teaching will fall into place much more easily for you, in part because you will have gained confidence.

- (1) Learn and use your students’ names.
- (2) Involve your students in the lesson.
- (3) Prepare thoroughly.

Before discussing in detail the three suggestions above, let me add a word of encouragement. Things may not go as well as you hope or they may be even worse than you imagined. Even our expert young diver has had disasters. She has broken both her wrists at different times. She clipped her head on the platform once. She dislocated her shoulder. And that does not count the thousands of times she hit the water so hard she had bruises that lasted for weeks. But she never gave up. The disasters became less frequent. She mastered her craft. After more than forty years of teaching, I still have bad days in the classroom. The trick is to continue to strive to improve. I have never mentored a graduate assistant whose teaching did not improve with time, with guidance, and with genuine effort from the student.

1.1. Names!

- “He is extremely nice and considerate, and got to know all our names.”
- “I enjoyed that the instructor took time to learn names and get to know us.”

- “The thing I enjoyed most about my professor, is he took the time to know each student’s name in which most professors cannot say they did.”
- “He was very personable and knew everybody’s names.”
- “The fact that she was able to know all of our names made it easier to learn from someone who saw me as a person.”

Verbatim comments from undergraduate-student evaluations of six different graduate assistants at LSU.

Of course, you must know the material you are teaching well enough to explain it to your students in a way that they can understand. Most teaching assistants recognize that. What most teaching assistants (TAs) do not do automatically is to learn and use their students’ names. This is the message that I repeat most often to TAs. Indeed, I view it as the most important recommendation I can make to teachers. Why? Because the mathematics we teach is not difficult for us; nor does it change when we teach the same course multiple times. What does change are the collections of students in our classes. The real challenge of teaching them is not the difficulty of the subject matter, but rather the dynamics of the personal interactions we have with our classes. For a shy person, these interactions can be particularly confronting. There is no way to succeed as a teacher without embracing and overcoming this challenge. It is a challenge that could well push you out of your comfort zone. I will offer some strategies to try to minimize the stress this creates for you. Should you need further convincing of the importance of learning and using your students’ names, imagine taking a course with two different professors, one who clearly demonstrates a goal of attending to your individual needs by communicating with you by name, and one who does not even appear to know who you are. Which professor would you prefer?

This suggestion about learning and using the students’ names has been met with resistance from many graduate assistants. I am not sure precisely why. The following is a list of some of the responses I have received when, following a classroom observation, I have encouraged a graduate assistant to follow this suggestion.

- “I learn them when I give the tests back.”
- “I usually know most of them by the end of the semester.”
- “It’s not fair to the other students if I only use some of the names.”
- “I am bad with names and I don’t want to make a mistake by using the wrong name.”

Let’s deal with these objections. The first two indicate a willingness to at least learn the names, which is admirable. But they speak to a lack of urgency in the process. When I say, “Learn and use your students’ names,” I mean do it in the first class and keep doing it until you know and use all of the names regularly. The goal of doing this is to create an atmosphere in the class where the students feel comfortable speaking up and you feel more relaxed as a teacher because you are not addressing a roomful of strangers.

While the third objection reveals respect for the fundamental principle that you should try to treat all students equally, I believe the benefit of learning and using the names is worth a temporary minor violation of this fairness principle. I say “temporary” because, ideally in a class of size forty or fifty, you should be using most of the names by the end of the first week or so. I have witnessed graduate assistants who, in their first classes for the semester, had already learned and were using half a dozen or so names. If you have hundreds of students, learning all of their names is essentially infeasible. This means the implication of the third objection is that

you should use no names at all. A consequence of this is that students who come to office hours or who answer questions in class or who need your help as a mentor do not deserve to be called by their names. I hope these examples help to show that this third objection is indefensible.

The final objection says that I, the teacher, do not want to look foolish in front of my students by making a mistake so I will not make myself vulnerable by putting myself in a situation where I may be wrong. But, as I have learned from my observations, the willingness of teachers to make themselves vulnerable sends a very powerful signal to their students.

As teachers, we all make mistakes. We say one thing and write another; we say things are obvious when they are false; we make errors in logic; we fail to connect with our students. I have found that, in order for me to succeed as a teacher, I have to be prepared to make myself vulnerable not only by potentially calling a student by the wrong name but also by, say, trying a novel approach to induce student involvement from a reluctant class. Among the many errors I have made with names over the years is to totally mispronounce numerous names, to call a female Chinese student by a name that is reserved for men, and to forget some names despite having been told them multiple times. On most occasions, the students will correct these errors, and I cannot recall a negative interaction over names. Fundamentally, I think that most students appreciate the message that is being sent by my willingness to learn and use their names: I care both about you as an individual and about your success in my class.

Even when I try to convince graduate assistants to follow this suggestion, many remain very resistant. Below, I record a series of anecdotes relating to my experiences with students' names. I hope that these brief recollections will convince you to at least try to learn and use the names. Once you see the effect this process has on your class, it is unlikely that you will doubt this advice again.

When I was a postdoc, I was sharing an office with an experienced professor. I saw him one day staring at the list of names of his students and I asked him what he was doing. When he said he was learning his students' names, I asked him why and he said that he felt he got better results from his students when he did that. It took me many years to recognize the wisdom of his words. At that age, in my twenties, I thought of myself as bad with names, which was strange because I had a good memory. Years later, I realized the only reason I had ever been bad with names was that, because I was shy, I found meeting people stressful and the name of a person I'd just been introduced to disappeared into a fog of embarrassment. The other thing I realized was that I had not really viewed learning names as being important. Once I changed my attitude, the learning process was simpler and, while I still made some mistakes early in the semester, these were soon eliminated.

One semester, one of our conscientious TAs, call him Tom, took to heart my advice about learning and using his students' names, and he did this before the first class of the semester. These days, students' pictures often accompany their names in online course rosters and this can be helpful in the learning process. When I observed Tom's first class, he began using his students' names without ever asking the students to identify themselves. The class was slightly unnerved by this. You could almost see them thinking, "What else does this guy know about me?" With his future classes, Tom learned the names during the course of his classes in the ways I will describe below. The online availability of your students' pictures next to their names can help jog your memory when you know you have been told a name but have forgotten it. I have printed out these pictures for several classes to help me get the names correct.

As a footnote to this, after Tom had graduated, he emailed me that he was teaching classes with over a hundred students so could not possibly manage to learn all of the names. My response was that, by learning ten or so names in each class, he would give an impression of knowing their names. More importantly, the signal he sent by making the effort to learn and use names was the same powerful signal he was trying to send when teaching a small class: you are not some random collection of nameless individuals, you are my students, and I want to help you learn.

How do you go about learning and using the names? You can start by using naturally occurring opportunities. A student asks or answers a question. You praise her and then ask her for her name. A student comes up to you after class or comes to your office hours to ask a question. You ask the student his name. You walk into class a few minutes early, as you routinely should, and you chat briefly to some of the students sitting near the front, finding out their names. This may feel like a difficult process if you are a bit shy. But the payoff can be immense. Your students will appreciate that you are making an effort to relate to them as individuals and this will help you to build an environment in which the students feel comfortable asking and answering questions. It will also help you to overcome the awkwardness that everyone experiences around new people. A common technique to familiarize yourself with your students is to distribute index cards, one to each student, during the first class. You can then have the students write their names on the cards along with what they like to be called and various other things about themselves such as their majors, their last math classes, any special needs they have, or any particular hobbies or outside interests they have. As a teacher, you will often be in situations where your students turn to you for advice that goes beyond the course content. By building the trust the students have in you, you can help to develop their confidence. This can have far-reaching consequences for their lives well beyond the demands of a math class.

Note that the principle, “Learn and use the students’ names,” has two parts. One semester, I observed an international student, let’s call her Ting, teaching her own class for the first time. Her first class was poor but that was explained when she admitted that she had not prepared well enough. Her second and third classes were better. These had been thoroughly prepared and Ting was starting to get her students involved. After each of these classes, I urged Ting to seek more involvement from her students. I noted that learning and using her students’ names was a useful aid here. With the improvement I had seen in the second and third classes, I was surprised that Ting’s fourth class was significantly worse than the previous two. When I asked about this, Ting said that, just before I had arrived in the classroom, some of the students had been laughing about something. Ting believed that the laughter had been directed at her and it embarrassed and hurt her, affecting her teaching for the rest of the class. Again, after that fourth observation, I asked Ting about the students’ names and she said that she had learned them. Unfortunately, she was still not *using* them. If she had been, she may have been able to prevent the situation that embarrassed her that day.

All TAs whose undergraduate training was not in the US enter an American college classroom with an immediate disadvantage. I have seen an Asian-looking TA walk into the first class of a semester and several undergrads get up and walk out even before the TA had said anything. As an international student, how do you overcome the prejudice held by many undergraduates that you are incapable of teaching? Learning and using your students’ names prevents them from being anonymous. We are less inclined to be rude to people who know us. The signal that you send by taking the time to learn (and use) the students’ names is a very powerful one.

Until I speak, my students do not know that I am not from the US. As an Australian, I have an accent that is different from those of my American students, but I always acknowledge it in the first class, telling the students that if what I say or how I say it confuses them, they should ask me about it. I also make a deliberate effort when teaching to speak more slowly than I ordinarily do and to avoid using Australian expressions that may not be familiar to the students. Incidentally, it is the American custom to use the students' personal, rather than their family names. This personal name is usually called the "first name" in the US. Thus, you should call William Smith "William" rather than "Smith" or "Mr. Smith." Note, however, that William may prefer to be called by some variant of his first name like "Will", "Willie", "Bill" or "Billy"; or he may go by some other name like "Junior". When you ask him, he'll tell you what he prefers.

One common task in many classes is the checking of attendance by calling names. Here in Louisiana, this is a tricky business because the French influence in the state means that a name like "Robert" may be pronounced with a French accent by one student but without this accent by another. Review your roster before class. On this roster, the names will be ordered alphabetically based on the last names. In your review of the names, make a note of when two students have the same first name. Then, when you call the roll, you can call out just the first names except when you need to distinguish between, say, Mary Bourgeois and Mary Thibodeaux. First names tend to be easier to say and to be more familiar. In addition, as the students know where their last names occur alphabetically, you can often avoid having to pronounce most of their last names. I have observed that this short cut is particularly useful for international students because this whole process of checking attendance can draw a lot of negative attention to their accents.

One of our international students had an excellent approach to the accent problem. He would always say to his students at the beginning of the semester that he would help his students learn math if they would help him improve his English. Pairing the acknowledgement of his accent with a request for help from his students proved to be very effective in gaining his students' acceptance of him. I have observed that students will forgive a foreign accent if they believe that its owner cares about their learning. The most striking example I can recall of this concerns an international student who, when he joined our department, had very limited English and had a strong accent. After a short time here, his vocabulary grew but his accent remained strong. Yet his students loved him. Why? Because he was a very passionate teacher who really wanted his students to learn. They recognized that and responded very well to his teaching. His accent became irrelevant. So talented was he as a teacher that, towards the end of his time in our graduate program, he was hired by our Academic Center for Athletes to tutor some of our student-athletes. In a school like LSU, where the importance of football cannot be overstated, this was perhaps the strongest endorsement his teaching could have received.

1.2. Involve your students.

- "I thought [my teacher] was a very effective and enthusiastic calculus teacher. I really liked the interactivensess of the class and he is always willing to help."
- "He is very helpful & would always welcome questions. I could tell he enjoyed teaching & was very enthusiastic about the subject."
- "He kept us very engaged and attentive, and even went the extra mile to take time to talk to each of us and make sure we knew the content during class."

Taken verbatim from the undergraduate-student evaluations of some LSU graduate assistants.

As teachers, we are constantly tempted by the thought that if we say just one more thing, then our students will get it. But mathematics is not a spectator sport. It is a full-contact sport. We learn it best when we do it ourselves not when we watch others doing it. The larger your class is, the more challenging it becomes to engage your students. But, if you don't try, wouldn't your students be better off watching an online video featuring a very experienced teacher? You can learn to engage your students using a few straightforward steps that are illustrated in the following anecdotes. Your students own the keys to their understanding of mathematics. Your role is to ensure that they get as much practice as possible working with those keys so that they can indeed unlock their understanding.

Bill: Day 1

As we sat in my office discussing his first class, I asked Bill to reflect on how the class went. Bill had been well-prepared; he had presented the material clearly; he didn't stumble or get confused; he gave an excellent lecture. Indeed, the teaching style mimicked that of the graduate classes Bill was currently taking. Why might I be concerned for Bill's students after such an accomplished lecture?

The keyword here is "lecture". By not deviating from a well-prepared script, Bill was able to give a very clear presentation but he didn't once try to involve his students. Despite his smooth presentation, Bill had been worried about the class. In particular, he was concerned about getting through all of the required material. There were so many variations in the types of examples that arise, he needed to go fast to cover them all. But his writing on the board was clear and neat, and his students seemed to be taking notes. Asking questions would have slowed him down. Also, he may have had to make up an explanation on the spot and he knew that such an explanation would not be as polished as those in the notes he'd prepared. It was safer for him to rely on the conscientiousness of the students. Many teachers take the view that those who are responsible will succeed and the rest will get what they deserve. But one of the reasons many students are in low-level classes is that they have not learned to be sufficiently responsible to take care of, for example, doing homework. For such students, part of what can be taught in a math class is responsibility.

I managed to convince Bill that he needed to involve his students in the lesson, to ask questions that probe whether his students are following, and to accept that he may not get through quite as much material as he'd planned. He even acknowledged that the goal of exposing his students to every single variation on a problem was unattainable.

Bill: Day 2

In preparing his second class, Bill had accepted that he needed to involve his students. Observing this class, I saw Bill work part of a problem and then, reluctantly, pause to confirm that the students were following by asking, "Right?" This question yielded a few nods from students so Bill felt able to go on. Indeed, he probably asked about thirty of these yes-no questions in class so he was certainly getting student involvement. He still didn't ask whether his students had any questions.

After class, I explained to Bill that yes-no questions reveal little or nothing of the students' understanding. Moreover, asking for confirmation of what you have already done reveals even less. To get the students genuinely involved in such a situation, it is far more effective to draw the students into doing the calculations.

Bill: Day 3

In Bill's third class, I saw him trying to use questions to engage the students. But the questions were rather unfocused so the students were unsure about how to answer. Instead of putting in stepping-stone questions, that is, questions designed to help the students move towards answering an original question, Bill panicked about the precious class time that he felt was being wasted and so he answered his own questions. Pretty soon, the students had learned that they just needed to wait when Bill asked a question and he would eventually answer it himself. Indeed with several of Bill's questions, the students did not even have enough time to pause from catching up with their note-taking to give the question any thought.

After this class, Bill was frustrated with me because he didn't get through as much material as he had hoped, and because his students didn't respond the way he wanted when he asked questions. We discussed the types of questions to use to start the students on the path to responding. Questions like "How does this simplify?" or "What does this give?" usually yield responses. Sometimes the students need a bit of gentle nudging, "Come on guys, I know you know how to do this." Putting in stepping-stone questions here is fine. As long as you establish in the minds of the students that you will not proceed until they answer, you will have succeeded. Once you have trained the students to respond, they will continue to do it with appropriate prompting. But, at the very beginning of the semester, you must invest the small amount of time that is needed for this training. As you struggle to engage the students, it will not seem like a small amount of time. But if you believe, as I do, that the students need to be involved to learn, then you will invest that time.

Bill: Day 4

In Bill's fourth class, I could see him tense up a little when the students were initially slow to respond to his questions. Of course they were. He had already trained them that he was going to answer his own questions and now he had changed the game by expecting them to respond. But Bill persevered. He asked questions at the right level, he praised the students when they responded, he used the students' names and maintained a positive spirit and gradually the responses began to flow more freely. Bill relaxed visibly and the students, who had inevitably picked up on the stress Bill was feeling, relaxed too. The interactions became more natural and Bill was getting the kinds of responses he needed to enable him to gauge whether or not his students were following and whether he should do another example of the same type or could skip to the next topic. The correct and incorrect responses he was getting were enabling him to react to the needs of the particular group of students in front of him. His presentation lacked some of the polished flow of his initial lecturing style. He stumbled in response to some of his students' questions. He misunderstood some questions and, although his students struggled to clarify what they meant, eventually their confusion was resolved. By getting his students to actively engage with the material, Bill had learned that teaching is a lot messier than lecturing. He also learned from his students' responses what parts of the lesson his students had grasped and what parts were difficult for them.

In our discussion after the class, I complimented Bill on his success. He was happy because he sensed the change in the mood of the class when it became clear to them that he cared about their answers to his questions and that these answers would guide how he proceeded. He was still worried that he had not been able to cover quite as much material as he had hoped.

The tension between having to cover a certain amount of material and trying to ensure that your students grasp what you are doing is present in every class. With low-level classes, there tends to be a syllabus that needs to be covered. Failure to complete the syllabus means your students are inadequately prepared for the next course. One response to this tension, Bill's initial inclination, is to try to expose the students to everything in the hope that they will be hard-working enough to review the material themselves and will develop understanding during this review. But the students have a textbook and all of the material covered in class is in the book. For TAs who follow this all-inclusive approach, my question is always, "For an average student who may not be all that well-motivated, how is your class different from having the students copy out large parts of the book?"

Another response to this conflict between coverage and understanding is to take the view that you will try to think of class as guided preparation for doing the homework. As teachers, we frequently help our students to construct the framework for solving a problem and then let them fill in the details. Often, building this framework is a demanding challenge for our students. Yet it is one that they must eventually master. Most of this mastery will be acquired through working homework exercises. But exposing the students to some of this during class can stretch the students and involve the better students who may otherwise find class boring.

1.2.1. *Why not just ask direct questions?* Perhaps it has occurred to you that one obvious way to involve the students is just to ask questions of particular students. At least initially, I advise against this. In the low-level classes that TAs typically teach, many students are not at all confident in their mathematical ability, some even suffer from what is known as "math anxiety". Asking such a student a direct question has the potential to cause embarrassment or, worse still, to humiliate the student in front of the class. This will do further damage to the student's confidence, so is best avoided. As the semester proceeds and you get to know your students well, you may feel able to call on particular students. But that is an individual judgement. A rough guideline here is that the higher the level of the course, the more confident the students tend to be in their mathematical ability so the more reasonable it is to call on specific students. But beware! I called on a student once in a large lecture and the student collapsed into tears.

When you are nervous in front of a class, it is natural to revert to something familiar and to follow the format of the graduate classes you are currently taking. But graduate algebra and college algebra are vastly different subjects taught to totally disjoint audiences. One is composed of highly skilled, well-motivated students who have confidence in their mathematical ability. The other consists of students most of whom are being forced to take yet another math course although they have always hated math and have never been able to master it. Whenever we teach, we need to recognize the make up of the audience and respond to the individual needs of the members.

1.3. **Be prepared!**

- "He did not seem to have his lesson plans completely planned before class, and had difficulty in explaining concepts most of the time."
- "I liked that she was always ready to teach, and also ready to help out students."
- "One problem was the instructors seeming lack of lesson plan on certain days . . ."
- "She is always prepared for the each class [sic] before coming. She is also a great help with a lot of homework."

- “The part I like most about the class was that it was very well structured. She had a plan and she stuck to it.”

Taken verbatim from the undergraduate-student evaluations of some LSU graduate assistants.

Sarah was one of our students who had learned to hunt with a bow and arrow when she was young. When she moved to a new town to start high school, she decided to try out for the archery team. A popular series of books and movies had made archery very popular. The team practiced in an old barn with the targets set up at one end in front of some bales of hay. The prospective team members gathered at the other end of the barn with the remnants of last year's team looking far more confident than Sarah and the other new students. Practice could not begin until the coach arrived. When he did, he chose Sarah to shoot the first six arrows. Just as Sarah was preparing to shoot, the coach told her that the team tradition was to shoot your first arrow in the dark. He turned off the lights and ordered Sarah to fire. The barn was very dark. Because Sarah had turned around slightly to listen to the coach, she was not even sure that she was facing in the right direction to have any chance of hitting the target. She'd forgotten exactly how far away the target was. How was she going to judge the height at which to aim? Wasn't there a cute couple over to the side watching? What if she hit one of them accidentally?

When you teach your first class, you do not want to be shooting arrows at a target you cannot see. Here are three questions that you should try to answer before that first class so that you can identify your target audience.

- (1) What did your students learn in their previous mathematics courses, which may have been in high school?
- (2) What was the last mathematics course your students had and when did they do it?
- (3) What kinds of mathematical issues are going to trouble your students?

As in any situation where you need to communicate something, you need to *know your audience* so that you will be able to reach them at their level. If you did high school and undergraduate studies in the US, then personal experience will give you a pretty good way of answering the first question. But if your high school or undergraduate experience was somewhere else in the world, then you probably will not know the answer to that question. Surely all basic mathematics courses are the same? Not so. But, when the topics covered are the same, surely the students' understanding of the concepts will be the same? Again, not so. To illustrate this, most undergraduate students in Louisiana and across much of the US will know what it means to FOIL something. Do you? FOIL is an acronym that stands for “First Outer Inner Last”. It is used to describe how you expand $(a + b)(c + d)$. Multiply the first terms to get ac , the outer to get ad , the inner to get bc , and the last to get bd . Add these four terms to get the result. Another common technique for performing this process is called the Box Method. While you may find it most natural to describe the expansion of $(a + b)(c + d)$ as arising from two applications of the distributive law, that is not the way that many students have learned it. If you are not familiar with what your students know, they can get frustrated. Why all the fuss about two processes that are equivalent? Because, for typical students in a college algebra class, this equivalence may not be obvious.

Let's consider the second and third questions with which this section began. How do you find out the answers to these questions? For the second, you can obtain quite a lot of information from your class roster. This will tell you each student's major and year of study. This information may enable you to infer an approximate answer to the question. If you hand out index cards in

your first class for the students to record their names, majors, and other important information, you can explicitly ask them the second question. You can get the answer to the third question from the course coordinator but you may prefer talking to one or two senior graduate students who have already taught the course successfully. You may even be lucky enough to be able to borrow the lecture notes of someone who has taught the course before. This does not mean that you can avoid making your own notes. It just means that these notes will give you some guidance as you prepare your own notes by highlighting what needs to be emphasized. Why prepare notes at all? It is all there in the book. Why not just use the book as your notes?

In my first semester at LSU, I taught a combinatorics course. In the teaching evaluations at the end of the semester, I received the comment: “Does exactly the same examples as in the book.” I wondered why this was a criticism. Surely that was my job, to present the examples from the book. By covering exactly the same examples as in the book, I was depriving the students of a second valuable source of examples from which to learn, their notes from class. Also, when I asked a question, how did I know whether the response was deduced by the student or just read or remembered from the book? If you do different examples from those in the book, your students will have a bigger library of examples from which to learn.

Where do you get the different examples that you will use? Sometimes, the variation is natural. If the book considers $\lim_{x \rightarrow \infty} \sin(\frac{1}{x})$, why not do $\lim_{x \rightarrow \infty} \cos(\frac{1}{x})$ to illustrate the same point? Another good source of examples is those at the end of each section of the book; or you take worked problems from a calculus book other than the class text. Many Math departments have spare copies of such books. Wherever you get your examples, working them out in preparation for presenting them in class is always advisable. It ensures you are illustrating the point you are aiming at and it also serves as insurance for eventualities such as the following. Thirty years ago, when I was being reviewed for tenure, a colleague observed my calculus class. A student asked me a fairly routine homework problem, which I had not worked in advance. I flailed around trying to do the problem and failed. I could see how to do it but the stress of being observed blocked me from thinking clearly. Finally, I gave up and moved on to two other homework problems that the students had asked about. After managing to solve them both, I decided to have a final try at the original problem. At last, I managed to finish it, salvaging some pride. But the twenty minutes I usually reserved for homework problems swelled to fifty minutes on that day and I learned a valuable lesson about preparation: before class, do the homework problems you assign. As more than one TA has found out to their embarrassment when I was observing them, it may not be enough to just glance over the problems without working them out in detail.

When you are in front of a class, there is nothing quite like the terror you feel when you realize that you are confused. Veteran teachers can usually draw on their experience to calm their nerves but novices have nothing but the prospect of certain humiliation to look forward to. Recognizing this, for at least my first ten years of teaching, I would always write out exactly what I was going to say, not because I intended to just read my notes but because it gave me something to fall back on when I did get lost. More importantly, I tried to write my notes in a way that made explicit a clear thread of motivation for why I was doing what I was doing. I used that thread to weave the lesson. A well-written set of notes means that the second time you teach a course, your preparation time will be dramatically reduced and will consist mainly of revising your old notes along with reading through the appropriate sections before each class.

When I observed Don teaching one of his first classes, I noticed that he had not used any notes. After class, I asked him about this and he admitted to not having any. Despite recognizing that

all of his teachers had used notes, it had not occurred to him that he needed to prepare his own set of notes. On another occasion, I watched Sveta struggling to explain the basic concept of a limit. When I asked to see her notes, she showed me half a page that contained just the numbers of the book examples that she intended to cover. It was clear that she had not considered how to convey the fundamental concept of a limit to her students; for her, confidence in her understanding was enough. A follow-up observation of another of Sveta's classes soon afterwards again saw her unprepared. This time, she claimed to have been too busy with her research to have had time to prepare. I was stunned that a teacher could have so little respect for her students and urged Sveta to take more time to prepare. I would like to say that Sveta responded as I had hoped but, although her teaching did improve, whenever she felt under pressure from her research, the quality of her teaching fell alarmingly.

A set of class notes provides you with an outline of what you are aiming to cover in class. Once you involve the students in the lesson, you will frequently be drawn away from the safety of your notes into uncharted territory. A student will suggest that you proceed in a certain way that may differ from your original plan. Will that suggestion take you too far off course, or is the diversion worth following even though it may not be the most efficient path to the solution? In each class, you will make numerous decisions like this. If you stick rigidly to your notes, the students will learn that you do not intend to deviate from your preset path and will feel as if their answers mean nothing to you. If you allow yourself to be pushed too far off course, you will not cover enough material. As with all these things, there is a middle ground. You can meet a suggestion that takes a very slow path to the answer with a response like, "Yes, we could do that, but can anyone see a more direct path?" A suggestion that deviates just a little from the shortest path is often worth following. Then, when you have solved the problem, you can briefly observe that a part of the argument was not needed or that there is another quicker method, which you may then briefly discuss.

"But how did you know to do that?" is a frequent question from students. Seeing you working every problem apparently effortlessly can establish unrealistic expectations in your students' minds. It may help them if you compare the process of learning to recognize the subtle patterns in math problems with acquiring such physical skills as learning how to swim, how to ride a bicycle, or how to shoot a jump-shot. The need to spend time practicing may not be a welcome message in an increasingly impatient world, but helping your students to recognize the one proven path to success does them a valuable service.

When you make a mistake, how you deal with it will teach your students a lot. Glenn, an award-winning TA in our program, used to offer his students \$1 for every error they spotted. This was an excellent way to keep the class alert, and Glenn had the confidence in front of the group to prevent it from becoming a distraction. I had a high school teacher, Mr. Brown, who called his errors "teaching tricks". My classmates and I were not fooled and we lost some respect for him because of his lack of honesty with us. When you make a mistake, as you inevitably will, acknowledge it. You may enlist the students' aid in correcting it. On the board, put the correction in a different color to help the note-takers. If you cannot see how to correct the error, don't panic. Just say that you will correct it via email or in the next class, and make sure that you live up to your word or you will lose your students' trust. Frequently, a mistake will reveal a genuine misconception that it is worth taking time to address.

If you are not a native English speaker, you may be worried about how a departure from your notes will test your English. There is no question that it will. But to teach your students, you

must be willing to engage in two-way communication rather than the one-way communication that is a lecture. That means you should not try to avoid the students' questions. Such avoidance will frustrate your students, and I have seen this frustration escalate into disruption of the class. If you are struggling to understand what you are being asked, don't be afraid to admit it. Every teacher misunderstands some questions. Many students know they are confused but cannot identify precisely the source of their confusion. One possible response is to offer to do another example. An alternative response is some variant on: "I'm sorry I am not quite sure what you are asking. Can you help me to understand by restating it?" Be patient with these interactions. They will take time and will often be messy but resolving them is very important to the questioners. When you think you have found a resolution, check with the student: "Have I answered your question, Simon?" You always have an escape from such an interaction. For example, "I am sorry Mary, I am just not getting this. Let's talk about this after class or in my office hours." In this instance, be sure to follow up with Mary at the end of class. This strategy can also be used if Mary is taking up too much class time with something that seems only to be an issue for her and not for any other students. When an individual student seems to be getting a disproportionate amount of the teacher's attention, the other students can quickly become restless.

When you teach, you tend to recall how you learned the material you are teaching. You remember what helped you to understand a topic and what gave you difficulty. It is natural for you to present the material in the best way to understand it, that is, in the way that you understood it. But is that really the best way for your students to learn the material? Does it make sense to teach as if a younger version of yourself represents a typical student in your class? Compare yourself with such a typical student. You have reached graduate school in mathematics whereas an average one of your students will get a C in this calculus or college algebra class. You were always good at math, among the best in your classes; math was rarely a struggle for you probably until you reached graduate school and perhaps not even then. Many of your students may have had struggles with math throughout their schooling. You always felt confident in your math ability while large numbers of your students have always approached math with fear and dread.

Although the most natural thing for you to do is to teach to a younger version of yourself, such a person does not represent a typical student in your class. By teaching to such an imaginary student, you are ignoring the basic principle of knowing your audience. If you were in a high school program that separated out the mathematically talented from the other students, then you may never have had a fellow student who struggled with math so your experience as a student does not help you to relate to your students. Perhaps you have done some tutoring in the past. The struggling students you tutored are representative of many of your students, particularly in college algebra and trigonometry classes. It will help you to keep such things in mind when you teach. Certainly some of the things you learned as a student give you insight, but many will lead you up a path that is too steep for your students to manage.

When I meet our international students as they are entering our program, I urge them to take every available opportunity to use their English. This suggestion is usually met with resistance. I recall an international student, call him Bo, who came to me once with a form he needed me to sign. He was so afraid to make a mistake with his English (which was actually much better than he recognized) that he just shoved the form at me without saying anything. I pretended not to know what Bo wanted. This forced him to speak. I continued to challenge Bo to use his English and gradually he did so more and more. At the time Bo graduated, he seemed quite comfortable using his English. He still had a strong accent, he still made mistakes, but he had no difficulty

at all making himself understood. Indeed, he was actually a very energetic teacher and his students responded very well to him. The real barrier for Bo had always been his fear of making mistakes. I think math grad assistants, with their training in the precise use of language, can feel this fear quite deeply. No one likes to feel foolish by saying the wrong thing. As a twelve-year old boy, meaning to refer to closed-circuit television, I had said “short-circuit television” in front of my whole class and my classmates had roared with laughter. We all have embarrassing moments when we speak. But Bo’s technique of saying nothing is not an option when you are teaching. Accept the fact that you will make errors in grammar, you will mispronounce words, and you will sometimes use the wrong words. All teachers do. What your students care about is whether you can look beyond such trivialities and help them to understand the material. Such an outward-looking view should prevent you from obsessing over your own shortcomings.

In response to my suggestion to practice your English, I hear such objections as:

- “Why spend time on my English when I am here to study math?”
- “I am already required to take a course in spoken American English. Isn’t that enough?”
- “My fellow graduate students understand my English just fine.”

Let us look at these objections beginning with the last. Your fellow graduate students are more mature than your undergraduate students; they have had more experience dealing with foreign accents; and they are prepared to make allowances for your mistakes. Moreover, they are not relying on you to guide them through a low-level class. Returning to the first objection, note that any seminars you give will be in English; your general exam will be an oral exam in English; when you give conference talks, they will usually be in English; and clear English exposition will be needed to publish your research results. In summary, you need English as a tool to convince people, both your professors and your students, of your understanding of mathematics. For the second objection, you should be aware that, when you graduate, your command of English will often be a determining factor in whether or not you get a job in the US. When you begin your graduate program, you have perhaps five years to improve your English before you graduate. The more time you spend using English, the better your English will become and the more successfully you will communicate with your students.

Below are some quotes taken verbatim from the teaching evaluations of LSU undergraduates concerning their TAs, all of whom were international students.

- “Overall was a good teacher and cared about our understanding of the material. He just needs to keep practicing his english so communication will be better.”
- “Great teacher, and for not being perfect English speaker he was very understandable.”
- “This teacher is awesome! Best teacher ever I am serious! The first day I was going to drop & change my major bc of how hard I thought this class would be. But he is AMAZING he really helps me understand.”
- “He was available any time you needed him and was always willing to help you understand the material. He made calculus fun every class session which kept me very entertained in the course. Again a definite A+ instructor!”
- “This man seriously wanted us to understand the material. He was extremely helpful and enthusiastic.”
- “Honestly, this class was BYFAR my favorite class of my college career. Unlike other classes, this class forced me to learn instead of memorize.”

- “As a bilingual speaker, his English was perfect and his talking was very clear. He was able to communicate the concepts clearly to me.”
- “I’ve always struggled with math but this class has been extremely helpful. This class made math actually enjoyable and the professor is extremely helpful and skilled in the content.”

These quotes illustrate an important principle. Your students want to learn from you. Your job is to convince them that you care about their learning. To emphasize this point, consider two further quotes from teaching evaluations.

- “He was really concerned with helping his students learn.”
- “The teacher was very concerned about student learning and helped out whenever possible, which made the class a lot easier.”

An excellent way to improve your English is to find some social activity that you enjoy where you need to use everyday English with non-mathematicians. A number of our graduate assistants used to play at a local ping-pong club. Near most campuses, you will find free conversational English classes. Many international students have told me that they just do not have the time to spend on improving their English when the demands of their graduate courses are so great. There are opportunities to practice your English that do not involve the commitment of any extra time on your part. All you need to do is look for them. For example, you can eat lunch in the department lounge and talk to others there. You can try to speak only English when you are on campus. I have talked to international students who have told me that they speak English for less than half an hour a week apart from when they are teaching. Improving your English will help you to understand your students better, it will help you when you are writing your dissertation, and it will make you more employable when you graduate.

1.4. Notes.

- (i) In the paper *What’s in a name? The importance of students perceiving that an instructor knows their names in a high-enrollment biology classroom*, Cooper et al. [15] identify the following nine reasons why having their names known is important.
 - (a) Student feels more valued.
 - (b) Student feels more invested in the course.
 - (c) Student feels more comfortable getting help.
 - (d) Student feels more comfortable talking to the instructor.
 - (e) Student feels enhanced performance in the course or confidence in the material.
 - (f) Student feels an instructor cares.
 - (g) Student feels it builds student-instructor relationships.
 - (h) Student feels it builds classroom community.
 - (i) Student feels that instructors are more likely to provide student with letter of recommendation or mentoring.
- (ii) In the post *Getting names right: Its personal*, Nichole Igwe [35] presents some excerpts from the book *To My Professor: Student Voices for Great College Teaching* [52] that focus on the importance of learning students’ names. The following two quotes from students appear there.

“I spend a lot of money to go to school here. It would be nice if a professor knew my name.”

“I appreciate the fact that you asked me what I wanted to be called because my name has various pronunciations in different languages.”

- (iii) O'Brien, Leiman, and Duffy [55] write about *The power of naming: The multifaceted value of learning students' names* in law school. They note that "Intentionally learning and using student names has potential to humanise the law school experience, build community, and positively impact upon the wellbeing of students and staff."
- (iv) Malcolm and Feder [46, p.84] write that "The most comprehensive meta-analysis to date illustrates that students learn more in STEM classrooms where instructors use active learning strategies rather than traditional lecturing (Freeman et al., 2014 [22])."
- (v) Goodboy and Myers [29] wrote in 2015 that "The current generation of college students, known as Millennial students, prefer to receive individualized attention from instructors and expect to be actively engaged by their instructors (Becker, 2012 [6])."
- (vi) As noted by Sidelinger [63], "Tinto (1997) [68] stated that student involvement matters and leads to greater acquisition of knowledge and development of skills. . . . students who participate in classroom discussions develop higher level cognitive skills (Wade 1994 [75]). Students who are willing to talk in class and engage in class discussions contribute to their own learning (Frymier & Houser, 1997 [23]) and to the learning of their peers (Webb, 2009 [77])."
- (vii) Two studies by Frymier and Houser [24] "challenge the long-held assumption that oral participation is unquestionably a good thing." They add that "If participation is the desired outcome, there may be other ways to encourage it." Noting that other behaviors that are indicators of engagement include "note taking, eye contact, and an attentive posture." To achieve the goal of student involvement, Frymier and Houser "recommend encouraging a broad array of engaged behaviors rather than focusing only on oral participation."
- (viii) Another word of caution concerning the level of participation you seek comes from Frymier and Houser [24] again: "There are also cultural differences in expectations for oral participation. Asian cultures in particular do not expect frequent oral participation in the classroom (see, for example, Lee [41])."
- (ix) As Weaver and Qi [78] note "Students who actively participate in the learning process learn more than those who do not."
- (x) "Be Prepared" is the motto of the scouting movement. It was introduced in 1907 by the founder of the movement, Robert Baden-Powell. It seems a self-evident motto for all teachers. Although I write my lecture notes for each class well in advance of the class, if I miss the 10-15 minute period just before class when I usually read over those notes, I am invariably uncomfortable during that class.
- (xi) "I was busy, okay!" responded one of our graduate students when she was criticized for repeatedly failing to properly prepare her classes.
- (xii) Vos et al. [74] note that "Math anxiety is widespread and affects both children and adults. For instance, results of the Program for International Student Assessment (Organization for Economic Cooperation and Development, 2016 [56]) indicated that 33% of the students experience helplessness while doing mathematics. Interestingly, about 14% of the variation in mathematical performance can be explained by variations in math anxiety. It is often assumed that individuals with high levels of math anxiety are attending to both performing mathematics and their worries and, in turn, this negatively affects their mathematical performance (Ashcraft & Kirk, 2001 [4]; Eysenck et al., 2007 [18]). Consequently, individuals with high levels of math anxiety show worse performance

on math achievement tests than the performance predicted solely by their mathematical abilities.”

- (xiii) The above study of Vos et al. [74] deals with gender differences in mathematical performance of young adults. The authors note that “Several studies examining gender differences in math anxiety have found that women report higher levels of math anxiety than men (Hart & Ganley, 2020 [33]; Luttenberger et al., 2018 [45]; Suárez-Pellicioni et al., 2016 [66]; see Else-Quest et al., 2010 [16] for a meta-analysis).”
- (xiv) Fleisher et al. [21] write concerning a study of theirs that “The authors assess the impact of foreign graduate teaching (GTAs) on undergraduate economics instruction where the standard language for the majority of students is English. They find little evidence that foreign GTAs adversely affect grades in economics principles courses or students’ choices of additional economics courses. In some cases, the impact of a foreign GTA is significantly positive. . . . Their findings suggest that when foreign GTAs are properly screened and trained in spoken English and in teaching skills, they are at least as effective in providing economic education as GTAs from the United States.”
- (xv) Beginning in Fall, 1994, the LSU Mathematics Department introduced an award scheme for graduate student teaching. Each semester, the Department chooses students to receive both the Graduate Student Teaching Award and Certificates of Teaching Excellence. The first award carries a monetary prize and can be shared by two students. Winners in the spring semester are students in the first three years of their graduate program; winners in the fall are students who have been in the program for more than three years. A graduate student can win the award at most once in the spring semester and at most once in the fall semester. At most five Certificates of Teaching Excellence are awarded each semester and a student can win at most one such certificate each academic year. The Graduate Student Teaching Award has been given on 70 occasions; 16 of the winners were international TAs. A total of 228 Certificates of Teaching Excellence have been awarded with 97 of those winners being international TAs.
- (xvi) A study by Subtirelu [67] considered “whether mathematics instructors with Korean and Chinese last names at institutions of higher education in the United States were evaluated differently on RateMyProfessors.com than their colleagues with US last names.” The author “found that instructors with Chinese or Korean last names were rated significantly lower in Clarity and Helpfulness.” A study by Kang et al. [36] suggests that exposure to international TAs lessens the negative reactions that some American undergraduates have towards such TAs. These studies and my observations suggest that if you are an international TA, much of the concern that your students may have about your accent can be reduced by actively demonstrating to them that you genuinely care about their learning.

2. SECOND STEPS

By now, you have learned and are using many of your students' names, you are trying to involve them in each class, and you are preparing each class very thoroughly. Some of you may still feel like an impostor in front of the class and you may not be completely happy with all of your interactions with your students. Are you more assured than when you began teaching? Or are you even more nervous about the next time you have to teach? What do you do next? If you feel that the lessons learned from the first section are becoming ingrained in your teaching persona, your confidence is probably rising. If things don't seem to be going the way you want despite your best efforts, you are probably looking for more help.

In this second section, we discuss some extensions of the principles from the first section. In particular, we consider the following four topics.

- (i) The art of questioning.
- (ii) How should you interact with your students?
- (iii) The importance of examples.
- (iv) The art of listening.

2.1. Questions (and answers).

- “He paid attention to the students and their questions when there are other instructors who don't do that.”
- “He passionately encouraged participation and questions of all kinds.”
- “It felt like if you ever asked him for help he would either make it more confusing or make you feel bad for not getting it right away.”

Taken verbatim from the undergraduate-student evaluations of some LSU graduate assistants.

Chris, like many of our beginning TAs had had a lot of experience working one-on-one with students as their math tutor. That experience was immensely valuable to him when he began teaching. Recognizing that much of a tutoring session consisted of him asking questions to determine what his student did and did not understand, Chris resolved to use the same model when he was teaching. It would be harder to detect individual levels of understanding within a class of size forty but the flow of responses or lack thereof would serve as a gauge as to whether the group was following him or not. How could he stimulate that flow? What worked for him as a tutor was to praise and encourage his students when they responded, so he would try that. He knew that, as a tutor, he failed when he did not address the needs of his students. He reasoned that the same must be true when he was teaching. But there are differences as he soon found out. The first time he asked a question, a student, whose name he found out was Tasha, answered it correctly. As he would have done when he was tutoring, Chris immediately fired back with, “Why?” Tasha couldn't answer that and stayed quiet for the rest of the class. Indeed, throughout the class, Chris struggled to get the level of response he wanted from his students.

“Raise your hand if you don't understand,” said Ann echoing a directive I have heard from numerous TAs over the years. The motivation for Ann's directive was good. Her aim was to get the students involved in the lesson and to identify and eliminate potential sources of confusion. Compare Ann's directive with the following two variants of it.

- “Have I made this clear?”
- “Should I do another example?”

Each of the last two questions transfers responsibility for the students' understanding of the material from the students to the teacher. Ann's original directive asked the students to, in front of their classmates, admit to being slow to grasp something. That directive and the two variants noted above all seek an answer to the question "Do you understand?" Why should it matter how you ask this question? While many of us like standing out from the crowd for a success that we've had, very few of us enjoy being distinguished for a failure. Of course, students need to learn that the ultimate responsibility for their learning rests with themselves. But, initially, while their understanding is shaky, the teacher can absorb the burden of guiding them to firmer ground. Of course, Ann wants to know what is confusing her students. Once she has established an environment in her classroom where the students feel comfortable responding, if she asks numerous questions of the class as the lesson progresses, the responses to these questions will provide her with a much better indication of her students' level of understanding than the invitation to admit failure, "Who doesn't understand?"

Initially, both Chris and Ann had failed to recognize that, with students whose confidence in their mathematical ability is lacking, the potential for humiliation in front of their peers is a very powerful force. In a one-on-one tutoring session, this situation does not come up. As soon as I pointed out to Chris that, if a student who answered a question in his class was immediately to be hit with a follow-up question, the flow of responses would diminish, he changed his questioning style. When his first question was correctly answered in his next class, he acknowledged the correctness of the response praising the responder, Jenny, and then he reworded his follow-up question to, "Now can someone tell us why Jenny is correct?" Of course, Jenny is free to answer this question but she is no longer obligated to do so. This simple change to his questioning style helped Chris to achieve the level of response from his students that he needed to guide how he proceeded through the lesson.

Chris had to alter his style of questioning again when he was helping to prepare the department's Math Contest team. These students were very sharp and they trusted in their math ability. They needed that ability honed so that they could respond not only correctly but also rapidly. For such students, the "Why" follow-up question was totally appropriate. Challenging such talented students was a necessary part of their preparation. Different audience, different approach. *Know your audience!*

2.1.1. *Ask, don't tell, but confirm and reinforce.* Compare the following two questions.

"Can anybody tell me what we should do first?"

"What do we do first?"

The second is direct and carries the expectation that the students should be able to respond. The first, which may seem more polite, conveys a sense that the issue being discussed may be beyond the capabilities of the students. It also invites the response "No". As a teacher, an important goal for you is to engage your students in the lesson. You are also trying to build their confidence. Sending them the signal that what you are asking them to do is within their grasp can encourage them to reach beyond their comfort zones. You certainly don't want to signal to them that you don't expect much from them.

Even if you ask the second question, you may get no response. While it is sorely tempting to answer your own question, that will just train your students to believe that, if they do not respond within a certain time, you will do the work for them. Instead of telling them the answer, ask them a stepping-stone question, perhaps several such questions, designed to help move them toward

the answer to your original question. Ultimately, you want your students to be independent of you. By guiding them with well-chosen questions, you can accelerate the development of this independence.

Simply telling your students things casts them as passive spectators to your performance as a lecturer. It also perpetuates their dependence on you. But crafting your classes so that your students are engaged participants requires you to prepare in a different way. Following this model, you need to prepare questions that nudge your students along the path of understanding. Of course, the unpredictability of their responses poses additional challenges for you since it can force you away from the path that you had planned to follow. Preparing thoroughly before class and then constantly practicing asking rather than telling will make you more adept at this skill and it will eventually become your natural mode of interaction with your students. It will also help you towards the goal of guiding your students to become independent learners.

The last part of the title of this subsection is important and relates to the timing of how to present the material. Once you have guided your students by your well-chosen questions to discovering the key ideas, you should confirm the correctness of their responses and reinforce the core points of the concept. The point is that this confirmation follows the contributions of the students rather than precedes them. Sometimes you will find yourself in a position where you feel that you cannot avoid initially leading the discussion. One advantage of being in a graduate program is that you are surrounded by peers many of whom have taught or are teaching the same course as you. Take advantage of this wealth of experience to help you. You may feel embarrassed to ask for help. That feeling will help you to appreciate an all-too-familiar situation for many of your students. Recognizing that your primary goal is to help your students to succeed should assist you in overcoming any hesitancy that you may have.

2.1.2. *“Right” is wrong.* “So, $(\sqrt{4x - x^2} - 7x)^2$ is $4x - x^2 - 14x\sqrt{4x - x^2} + 49x^2$, right?” said Fred to his college algebra class, who looked stunned. Then one student tentatively asked, “Why is it 14?” Fred responded with, “Remember that $(a - b)^2$ is $a^2 - 2ab + b^2$, so it follows from that formula.” Enlightenment did not follow, just more confusion. Fred, recognizing the confusion, said, “What is a in our example?” Still there was confusion. Fred responded with, “ a is $\sqrt{4x - x^2}$, right? So, what is b ?” One student responded with “ $-7x$ ”. “No,” said Fred, “Remember that the formula is for $(a - b)^2$, so b is $7x$, right?” The discussion continued as Fred attempted to help his students recognize the power of the formula for $(a - b)^2$. He told his class that they would be doing many calculations in this section that would require them to expand expressions of the form $(a - b)^2$, so learning this formula would help them. In Fred’s mind, this formula had been really helpful to him over the years and he wanted his students to learn it. But Fred had forgotten who his audience was.

Fred’s students were taking a basic algebra course in college because they had shown themselves to be uneasy with abstraction. How could Fred have handled this? One thing he had learned from his students was that they were very good at FOILing. He could have guided them to do this problem by FOILing by saying, “ $(\sqrt{4x - x^2} - 7x)^2$ means $(\sqrt{4x - x^2} - 7x)(\sqrt{4x - x^2} - 7x)$, and how do we do this?” Then he is playing to the strengths of his students. From their perspective, FOILing is a robust technique. It works just as well for $(2x - 5)(3x + 9)$ as it does for $(2x - 5)^2$. Why should they, students who are uncomfortable with formulas, learn a separate rule to deal with the latter when the FOILing technique, with which they are so familiar, will do the job for them? Fred admitted after the class that he was really surprised to see how much his

students had struggled with $(a - b)^2$ because his other section had been able to manage it. He also recognized that his original approach of doing the expansion and then asking the students to confirm his calculation with the question, “Right?” took up much more time than if he had simply had the students do the steps by FOILing.

The observant reader will have detected Fred’s tendency to end his sentences with “Right?”. Others choose to use “OK” as a universal appendage, or to begin every sentence with “So”. These verbal tics are a distraction. I can remember, as a boy, sitting in a class counting how many times a particular teacher said, “OK”. While keeping tally, I was certainly not giving my attention to the material being covered.

In general, the word “Right” is appropriate for acknowledging a correct response from one of your students. Moreover, injecting enthusiasm into the tone of your voice when making such a comment turns it into a compliment that encourages the student. But, if you find yourself using “Right?” as a question, it means that you have wasted a chance to involve your students in the lesson.

2.1.3. *Vary the difficulty of your questions.* In the last section, I discussed how Bill’s first solution to the problem of getting his students involved had been to ask lots of yes-no questions. Since it is sometimes difficult to get students to speak at all, such questions may have some value as ice-breakers but their answers convey very little useful information. Getting the students involved means getting them to process the material at some level other than a very superficial one. It is easy to become complacent when your students are responding regularly to your questions especially when all of the answers you are eliciting from them require some thought. One issue that I frequently raise with TAs concerns the range of abilities that exist among their students. If all of the class is aimed at an average student, it is easy for a strong student to lose interest. Such a student may switch off out of boredom and may even become disruptive. While it is a mistake to teach exclusively to the A-students, it is also wrong to completely ignore their needs. Throwing out a question every so often that may be beyond a C-student is fine. It challenges such students and engages the A-students. When you get a response to a harder question, after acknowledging the students who have answered, you can then draw the other students into the discussion by putting in stepping-stone questions designed to help them to build a bridge to the answer that has already been given.

Once you have managed to get students responding to your questions, you are then faced with the issue of how demanding you will be with your questions. Clearly this will vary with the topic and the time constraints imposed by the syllabus. Your aim is to constantly challenge your students while avoiding overwhelming them. Being aware of the different cognitive demands of various questions will help you to appropriately engage your students. In 1956, a committee chaired by Benjamin Bloom proposed a hierarchical way of categorizing the different level of questions one may ask and the kind of processing that is required to achieve an answer. In the 2001 revised version of what is now known as *Bloom’s Taxonomy* [2], the three lowest levels in the hierarchy are *remember*, *understand*, and *apply*; the other three levels are *analyze*, *evaluate*, and *create*. Definitions of these terms are given in 2.5(i). One of the most significant barriers to engaging students is failing to present them with appropriately challenging questions.

2.1.4. *How to deal with wrong answers.* “What is $(x + 3)^2$?” Bruce asked his college algebra class. Bruce, who was a new TA, was getting lots of responses from his students and he was really pleased. Mixed in with the responses such as “FOIL it” and “ $x^2 + 6x + 9$ ”, Bruce heard

" $x^2 + 9$ ". Bruce wanted to correct this common error straightaway, so he asked who had answered " $x^2 + 9$ " and identified Chuck as the student who had given that answer. Bruce then proceeded to explain what was wrong with this answer as Chuck tried to hide his embarrassment. A few minutes later, Chuck got up and left the class early.

Here's another way this situation could have developed. Hearing the answer "FOIL it", Bruce asked the class how to do this with $(x + 3)^2$ and they described the FOILING process that led to the answer " $x^2 + 6x + 9$ ". Bruce then said, "Now you might think that $(x + 3)^2$ " should be $x^2 + 3^2$ but we've just shown, by FOILING, that this is not true." Notice that Chuck's error is addressed, as it should be, but Bruce does not attribute this error to Chuck so the chance of him being humiliated is reduced. If you are training students for a Math Olympiad, the students are all highly confident in their abilities and you are trying to sharpen those abilities. But, in a college algebra class, many, perhaps most, of the students are embarrassed by their lack of mathematical proficiency. As you attempt to build their confidence, you do not want to reinforce the negative thoughts that many struggle with by humiliating them, even unintentionally, in front of their classmates.

Having learned the lesson above, Bruce was not sure what to do in a later class when he asked a question and there was just one answer, which was clearly wrong. Bruce wanted to avoid humiliating John, the responder, so he tried asking the question again in the hope that he would get more responses. In general, this tactic is a good one. Some students may not have heard either the original question or John's response so, for them, the question is new. Others may have heard the original question or answer, and might feel that the fact that the question is being asked again indicates that the original answer was wrong. Asking a stepping-stone question here is another possibility for Bruce. The basic principle here is to get more students involved so that John's response does not stand out. Sometimes John is so persistent in promoting his incorrect answer that there is no choice but to address it head on. All you can do then is to try to minimize John's discomfort by dissociating him from his answer.

2.1.5. *How to deal with dominating students.* Tamika, an experienced TA, had dealt with classes before where one or two students tended to dominate all of her interactions with her classes. She would deal with such circumstances in the following kind of way: "Brenda, Fred, you guys are doing well. Why don't you have a rest for a while and let everyone else have some fun?" Or, just after asking a question, she'd say, "Someone who has not answered yet today." These tactics had worked well for her so she was somewhat at a loss to deal with a situation when Harry did not appear to heed her words and just continued to answer all of her questions. Finally, she implemented a program where each student was allowed to respond once in each class after which that student could not respond again until everyone else in the class had spoken up that day. This approach worked because Tamika was very good at eliciting responses from her students. Additionally, the students in the class were well-motivated. Tamika knew her students, she knew her goal was to get lots of them involved in class, and she knew that her standard approach had failed. So she tried something new. Sometimes such a move will work, sometimes not. An approach that works well for one class may fail for another. Tamika realized that individual variations may demand new approaches. The confidence Tamika had developed in her teaching meant that she was prepared to try new ideas when the old ones had failed.

One of the experiences that had shaped Tamika's experience had involved a college algebra student named Brad. It had been a while since Brad had taken any math courses but he was really anxious to do well. He spent lots of time working on homework but tended to struggle in class,

demanding immediate attention when he failed to understand something. Tamika recognized that, although some of Brad's questions involved issues that affected a number of students, some reflected Brad's long period away from mathematics. In addition, Brad's persistent questions were frustrating the other students; Tamika could see them rolling their eyes after a flurry of his questions. Typically, she would repeat one of Brad's questions thereby opening it up to the whole class for a response. Once Tamika realized that Brad was going to pepper her with regular series of questions that were threatening to disrupt her class, she knew she needed a strategy for dealing with him. Initially, she responded to one of Brad's follow-up questions with some variant on, "Brad, I know this is still bothering you. Let's talk about this after class because I really need to move on so that everyone will be able to complete today's homework." Following up with Brad after class, Tamika was able to address his confusion. Also, because she'd taken Brad to her office to allow her to talk privately to him, she was able to chat to him about his history and then to suggest to him that his persistent questioning was actually causing a problem in class. Tamika urged Brad to initially make more use of her office hours but, more long-term, to strive to note down his questions in class and then to work on them by himself, since his ultimate aim was to become independent of her teaching.

2.2. "Socrates himself is particularly missed."

- "You were a terrific teacher! You made me feel like you cared if I learned."
- "Out of all my classes, his class was the one I looked forward to the most because how he pushes us to learn and the energetic environment he creates."
- "He was extremely enthusiastic and really knew how to communicate on our level. He was also really good about making sure that everyone in the class was understanding the material!!"
- "We also moved far faster than the other calculus sections and learned the material on a much deeper level. I can easily teach students in other sections how to do their "more complicated" problems."

Taken verbatim from the undergraduate-student evaluations of some LSU graduate assistants.

When interacting with students, I am a strong believer in the Socratic method of using well-chosen questions to guide the students to discover key ideas for themselves. When we discover something, there is a feeling of joy accompanied by a sense of ownership of the discovery. If our teacher merely shows us the solution, both the joy of discovery and that sense of ownership are lost. Once again, the demands of completing the syllabus are an issue here, but my prevailing recommendation is to try to construct your lessons so that your students can discover the punchlines for themselves. This requires artful preparation and a readiness to respond on the spot. As a default, my recommendation is to make your first instinct as a teacher to ask a question rather than to make a statement. *Ask. Don't tell.*

2.2.1. *Sending signals.*

- "I normally fear math classes but he was so encouraging and positive I felt confident in my ability."
- "Our whole class could tell that our instructor cared about us learning and not just getting the grade. I learned so much because of our instructor and his teaching style."
- "The class was very enjoyable as well as the instructor. She was the highlight of the class and made every effort to have the students enjoy the class itself."

- “I love the attitude the teacher gives to his work and the students, It provides a fun and safe space for math.”
- “Teacher told students they were not ‘mentally capable’ of doing calculus.”

Taken verbatim from the undergraduate-student evaluations of some LSU graduate assistants.

Ted was teaching his first class when I entered part-way through to observe him. He seemed to be doing fine so I was very taken aback when one of his students suddenly said, “Can you relax a little because you are really nervous and it is making me nervous too.” It was a sign of the rapport that Ted had already established with his class that one of his students felt able to say such a confronting thing to him. I was impressed with Ted’s composure and honesty. He admitted to being nervous and took a deep breath and continued. Ted’s student had meant well when she challenged him but her comment was potentially humiliating especially in front of someone evaluating his teaching. Ted managed to continue with the lesson but did not really relax until about the last ten minutes of class when he did an ice-breaking exercise with his students. That prompted a discussion with several of them and the tension was broken. I observed Ted later that week and he displayed no sign of nerves in front of his class. In fact, he generally projected a confident image and that made the encounter in question all the more surprising. When I discussed it with him after the class, he admitted to being surprised about the fact that he’s felt nervous in that first class. Such nerves are normal. Indeed, a lack of them from a new teacher could indicate insufficient concern about the class. Your nerves should fade as you gain familiarity with your students. It is extremely unlikely that a student will challenge you as Ted’s did. The larger lesson here is that your students will pick up on subtle, possibly non-verbal, signals you are sending during your presentation and they will respond to them.

Because I do not see very well, I tend to squint rather a lot, particularly when I am trying to read what has been written on a board. Many graduate assistants have told me that they have found my frown to be very disconcerting when I was observing them teach. It made them feel that I was unhappy with their presentation or that they had made some kind of mistake. What, for me, was a squint in order to see better was, for them, a sign of disapproval. Intentions and interpretations are easily confused with body language.

Guy was an international TA who had a rather challenging approach to his students. His manner was serious but I felt as if his basic message to his students was, “Come on, show me that you can do this.” It seemed like a sound approach and I found it engaging. It therefore surprised me when a review of Guy’s teaching evaluations showed them to be low. Then I remembered a habit of Guy’s that I had observed. He would pause, rest against the board, and let out a prolonged sigh. These sighs did not seem to be in direct response to anything and, when I asked Guy about them, he said he was just catching his breath. But a prolonged sigh is a universal expression of boredom or exasperation. Sending a signal to your students that you’d rather not be there or that you are frustrated for whatever reason will not improve your rapport with your students and may do irreparable harm to it. Imagine then how I felt when in a subsequent class of my own, after I had been asked a question, I let out a sigh of frustration as I found myself unable to come up with a quick and clear response to my student’s question. The downcast look on my student’s face told me that he interpreted my frustration as being directed at his inability to follow my initial explanation. Without saying anything, I had unintentionally told him not to bother me with his questions.

2.3. The power of examples.

- “The thing I liked most was the way the teacher taught the material. He made it very clear by explaining and offering ample examples.”
- “Do more examples in class. Do some examples and then let the students try some examples.”
- “The thing that really helped me was the examples he chose in class. He started easy then challenged us with more intense and thinking examples.”
- “i enjoyed the fact that the teacher did a lot of examples and explained everything very well.”

Taken verbatim from the undergraduate-student evaluations of some LSU graduate assistants.

“Don’t worry about understanding this now. It will become clear after I do an example.” As these words came out of Joseph’s mouth, they sounded hollow to him. He was so accustomed to the Definition-Theorem-Proof-Example routine from his graduate classes, that he tended to follow this routine in his calculus class. He was teaching the Intermediate-Value Theorem and he followed the book by presenting the formal statement of the theorem first, then giving an intuitive explanation, and then giving an example. But his students were still not very familiar with the formalism that accompanies theorem statements, so Joseph wondered what they really gained from presenting the material in that order. This discomfort was reinforced by his recognition that, in his graduate classes, he only absorbed an idea once he looked at examples or someone explained to him the intuition behind a result.

These kinds of thoughts prompted Joseph to change his approach the second time he taught calculus. Reasoning that examples play such a fundamental role to understanding, he decided to give them a more prominent role in his treatment. Challenging his students to draw the graph of a continuous function that passed through the points $(3, -2)$ and $(7, 5)$ but did not cross the line $y = 4$, Joseph was able to use an example to convey the intuition for the Intermediate-Value Theorem, helping his students to recognize that the continuity of the function made this task impossible. Once his students had grasped the key ideas in a concrete application of the theorem, Joseph found that they were able to assist him in writing down the precise statement of the theorem. This process enabled them to learn about formulating the technical language of a theorem statement. Joseph had covered everything that he did when he began with the theorem statement but he could sense that his students not only had a better grasp of the intuition behind the theorem but that they had also learned more about mathematical formalism.

Encouraged by this success, Joseph expanded on his use of examples in all of his classes generally beginning his treatment of a topic with an example. He then used this example to help the students extrapolate from his specific, yet generic, example to the broader underlying general principle. He even found that well-chosen examples meant that the students were able to predict the theorem statements giving them a sense of ownership of the theorems based on their “discovery” of them.

For Joseph, it seemed natural to give examples a very prominent role. Why did key concepts ever get defined? Because they had proved to be fundamental in many examples. What led to the formulation of general theorems? The observation from examples that, for instance, whenever property A holds so does property B. How does one prove such a result? By trying to extrapolate from generic examples. The Definition-Theorem-Proof-Example approach lost its appeal to Joseph despite the fact that he continued to see so much of it in his graduate classes.

Examples had always been Joseph's pathway to understanding, so he was going to use them to guide his students to comprehension, with no loss of rigor.

Another TA, Lizzie, liked to introduce the idea of a tangent line by telling a story of when she was riding on a roller coaster and texting a friend about how cool it was. It was a hot day and her palm was sweating and, on a very undulating (up-and-down) section of the ride, her cellphone flew out of her hand. "What path did it follow just as it was leaving my hand?" she asked her students. Lizzie told me that the intuition provided by this real-world example appealed to her students far more than the explanation that she had used earlier about the tangent line being the line that just touches the curve.

Later that week, as Lizzie tried to get the idea of instantaneous velocity across, she recalled getting her first speeding ticket the previous summer. She asked how many of her students had had speeding tickets and found more than half the class had. Lizzie was still annoyed about getting the ticket for she came from a small town where the local police force were known not to have any speed guns. Just before Lizzie returned home for that summer, her town had bought one laser speed gun as an experiment and Lizzie, lucky her, was just the third person to get a ticket. She had learned about the older form of speed gun in high school physics class since it used radio waves and the Doppler effect to measure velocity. Reading up about these newer laser speed guns, Lizzie found that they basically calculated average velocity over a very, very, very short time interval. Although the cost of the ticket still infuriated her, she realized that she now had a good way to convey the intuition for instantaneous velocity through an all-too-familiar experience and a very, very, very, very, very short time interval.

Juanita had found in her college algebra class that, when she answered questions by stating general principles, many of her students tended to get lost. Of course, they needed to know the laws of exponents. But they never seemed to be able to remember that $x^a x^b = x^{a+b}$ and that $(x^a)^b = x^{ab}$ and they often got these formulas confused. Juanita developed the following mnemonic (memory prompt) that seemed to help her students.

Consider $x^2 x^3$. "What is x^2 ?" Her students were able to tell her that it was xx . Likewise, they could tell her that x^3 is xxx . Thus $x^2 x^3 = (xx)(xxx) = x^5$. "Where does 5 come from here?" Of course, her students were able to answer that it is $2 + 3$. So she was able to write

$$x^2 x^3 = x^5 = x^{2+3}.$$

Then Juanita asked her students what they thought $x^a x^b$ should be and they were able to identify it as x^{a+b} . So one of the laws of exponents had been presented in a way that her students could easily remember. Similarly, Juanita was able to present another law of exponents as

$$(x^2)^3 = x^2 x^2 x^2 = (xx)(xx)(xx) = x^6 = x^{2 \cdot 3}.$$

Again her students were able to formulate the general law $(x^a)^b = x^{ab}$ from this example. Juanita was a bit nervous about her students using one example to formulate a general principle. But she found that her students were able to much more reliably remember these two laws of exponents. As a memory aid, it proved very successful especially as it was free of accidental coincidences.

2.3.1. *Is abstraction the enemy of understanding?*

- "She makes (almost all) the math mumbo-jumbo turn into english."
- "It seemed as though [he] just wanted to show off his math knowledge."
- "Was the only teacher to put math in terms I could understand. Would be interested in taking one of her classes again."

- “A lot of people in the class are engineering majors and don’t care about the concepts as much as knowing how to do the math; so the focus on the concepts behind the felt unnecessary and useless to some.”

Taken verbatim from the undergraduate-student evaluations of some LSU graduate assistants.

Dino was teaching his calculus students the method of integration by partial fractions, so he considered the partial fraction decomposition of an expression of the form

$$\frac{p(x)}{(a_1x+b_1)^{k_1}\dots(a_nx+b_n)^{k_n}(c_1x^2+d_1x+e_1)^{h_1}\dots(c_mx^2+d_mx+e_m)^{h_m}}$$

with all the conditions governing such an expression. He found that, rather than being helped by the abstraction, his students were overwhelmed by it. He resolved that in his next class, he would begin by showing his students the form of the partial fraction decomposition of the concrete expression

$$\frac{x^3 - 3x^2 + 4}{(x - 2)^3(x^2 + 1)^2}$$

Would his students fail to grasp that this example illustrates a general principle? Of course not.

For many reading this, for whom abstraction is the embodiment of understanding, the title question of this subsection seems absurd. Indeed, all of the mathematical formalism on which we base our knowledge is rooted in abstraction. We teachers of mathematics inhabit a world of abstraction and are totally comfortable living there. But how did we develop that comfort? A very tiny fraction of us may always have had it but, for most of us, comfort with the abstract formulation of a principle grew from developing a thorough understanding of specific examples or classes of examples.

Textbooks tend to favor abstract formulations and such formulations are totally appropriate for such a context. But these abstract formulations have their roots in concrete examples and building from such concrete examples helps all of us to appreciate the general principles these examples illustrate.

2.4. Responding to questions.

- “I really enjoyed this class, because I could ask questions and he was a great listener.”
- “I didn’t sign up to get shamed for not understanding and then to figure it out on my own.”
- “He is very helpful & would always welcome questions. I could tell he enjoyed teaching & was very enthusiastic about the subject.”
- “[He] was a teacher who could recite the notes and convey the information, but did not have a complete enough grasp on the material to field students’ questions in an effective manner.”
- “The instructor was very enthusiastic and kept the class interesting. He motivated us to ask questions and participate.
- “It felt like if you ever asked him for help he would either make it more confusing or make you feel bad for not getting it right away.”

Taken verbatim from the undergraduate-student evaluations of some LSU graduate assistants.

One of the most challenging tasks for a teacher is responding appropriately to students’ questions. Asking a question can take some courage for it makes the questioner vulnerable

as it means admitting to a lack of understanding. It is important, then, to respond in a way that acknowledges that you are taking the question seriously. Many teachers will try to set the questioner at ease by immediately responding to a question with “Good question” before setting about answering it. Some questions point out a mistake that you have made. Acknowledge it; correct it on the board in a different color so that note-takers can clearly see the change; and thank the student. Do not try to pretend it was a teaching trick; your students will lose their trust in you. Other questions ask about a variation of the problem you have just done. In such circumstances, it is very easy to use the board to quickly alter the original problem to the proposed variant, but this can create massive confusion for note-takers. Instead, write the new problem out separately and then engage the students in its solution highlighting the differences between the old and new problems. Sometimes a question is little more than a poorly formed expression of confusion. “I am lost. HELP!” For such a question, you often have to guess what is intended. While it is reasonable to seek to clarify the meaning of a question, challenging an already confused student about the wording of the question can often just increase the student’s anxiety. When you perceive that the question is a cry for help or you are unable to determine precisely what question is being asked, it is often best to offer to do another example of the relevant type.

When you have attempted to answer a question, find out from the questioner whether the answer is acceptable remembering that the student may be reluctant to acknowledge a continuing lack of understanding. With persistent confusion, you need to determine whether the confusion is confined to one student or whether it is widespread. In the former case, an appropriate response to the questioner, whose name one hopes you know, is, “Jack, I can see this is still bothering you. Let’s talk about it after class.” In that case, it is really important that you follow up with Jack after class if not in person, then by email. When the confusion is widespread, it means that you will need to address it with the class as a whole. You may need to do several more examples to clarify the situation. If you fail to address an outbreak of widespread confusion, it has the potential to cause serious problems for the class as frustrated students can be unpredictable. If you suspect that a questioner did not really understand your explanation, follow up with that student after class. In private visits to your office hours, students tend to be more willing to acknowledge a lack of understanding than they are in front of their peers.

The more experience you have, the more you will know the kinds of problems that students have and the better able you will be to address their questions. But, when you lack experience, it is still important to get across to the questioner how anxious you are to help. One approach that can be counterproductive is to overwhelm the questioner with question after question seeking to clarify the original question. This can produce a deer-in-the-headlights response from the student resulting in more anxiety. With a nagging problem that you are unable to settle in class, convince the student to come to your office hours. Out of the glare of public scrutiny, it will be easier for both of you to address the issue.

2.5. Notes.

- (i) In 2001, Anderson et al. [2] introduced a revision of Bloom’s Taxonomy [8], a hierarchical model for classifying educational learning outcomes. This model is often presented as a pyramid. When crafting questions, it is helpful to consider the cognitive demands imposed on the students by these different types of questions. In the Revised Bloom’s Taxonomy, six levels of increasingly complex questions are identified. These are listed below with a brief definition of each (Krathwohl [40]).

- (a) Remember. Recalling basic factual, conceptual, or procedural knowledge.
 - (b) Understand. Determining meaning by interpreting, exemplifying, classifying, summarizing, comparing, and explaining.
 - (c) Apply. Carrying out or using a procedure in a given situation.
 - (d) Analyze. Breaking material into its constituent parts and detecting how the parts relate to one another and to an overall structure or purpose; differentiating, organizing, and attributing.
 - (e) Evaluate. Making judgments based on criteria and standards; checking and critiquing.
 - (f) Create. Putting elements together to form a novel, coherent whole or make an original product; generating, planning, and producing.
- (ii) Stork and Hartley [65] have the following warning based on a study of classroom behaviors they performed: “Calling on students when they are unprepared may have greater costs than pay-offs. Students feel anything but challenged when they are feeling impaired in the classroom, for whatever reason the impairment. Professors should be aware of what they are trying to accomplish when they embarrass or single out a student intentionally, and when they do so inadvertently.”
 - (iii) “Socrates himself in particularly missed” is taken from the penultimate line of Monty Python’s *Bruces’ philosophers song* [59].
 - (iv) Pedrosa-de-Jesus and Watts [58] note that “Teachers feel vulnerable when there are a large number of questions coming from the audience – it is often much easier to teach, to lecture, without the distraction and delay of having to deal with a plethora of interruptive questions.”
 - (v) In the paper *Teacher questioning and invitations to participate in advanced mathematics lectures*, Paoletti et al. [57] examined the practices of eleven lecturers who taught advanced mathematics courses at the university level. They report: “Although we examined a new population, advanced mathematics lecturers, the results of our open coding are largely consistent with the K-14 literature. For instance, we found that lecturers predominately (66% of all questions) asked students to provide factual information or a next step (e.g., Boaler & Brodie, 2004 [9]; Franke et al., 2009 [25]; Viirman, 2015 [73]); in our population, lecturers infrequently asked questions seeking other types of mathematical contributions (e.g., warrants, evaluation). Such findings may indicate that, regardless of grade level or content, questions soliciting a fact or next step tend to be the easiest questions for teachers to ask or the questions teachers believe students are most capable of answering.”
 - (vi) To help motivate students, it is helpful to recognize the importance of immediacy, that is, “Communicative behaviors that enhance closeness to and non-verbal interaction with another” (Mehrabian [49]). Liu [43] notes that these include non-verbal behaviors such as “employing physical gestures, making eye contact, having a relaxed body position, directing body position toward students, and smiling (Chesebro and McCroskey, 2001 [14]; Hsu, 2010 [34]).” Liu identifies various verbal behaviors designed to engage students including “calling students by name”, “asking for students’ feedback about the lessons”, “referring to the class as we and our”, and “engaging in conversations with students before and after class”. In summary, Liu writes “Employing verbal and non-verbal actions, teachers can increase the psychological intimacy between themselves and

their students, which contributes to increased student motivation (Averbeck et al., 2006 [5]; Richmond et al., 2008 [60]). A higher degree of students' motivation can increase their learning outcomes”.

3. CLASSROOM OBSERVATIONS

Each time I visit a class, I complete an observation form, which appears on the next page. I give one rating for each of the five broad categories. The bullet-point items are to draw attention to what I view as the important aspects of that characteristic. Any such form has weaknesses but I hope this one provides some guidance for TAs and their mentors.

While I keep these completed forms for my records, I usually do not share them with the TAs. I have been repeatedly told by TAs how my presence in the classroom makes them nervous. Worse still, as TA Ruth told me recently, her students were participating actively until I entered the room some thirty minutes into the lesson. Once I was there, the students were very reluctant to speak. I advised Ruth to directly address the distraction created by my presence by saying something like, “That’s Professor Oxley. He has come to observe me, not you. He wants to see you participating as you have been, so don’t let me down.”

If you are mentoring TAs, remember that they are trying to learn the complex process of teaching. They lack not only experience but also confidence. I always follow a classroom observation with a conference with the TA. Such conferences may be squeezed into the ten minutes before the TA’s next class, but usually they are more substantial. I find a good way to begin these meetings is to ask for the TA’s feelings about how the class went. I have had to work hard to avoid my natural tendency to highlight what needs correcting at the expense of what went well, for that tendency biases the TA’s view of my opinion of the class. Indeed, an excellent class may feature three or four minor things that I think should be changed. Before discussing these minor changes, I try to point out my overall satisfaction with the class and to acknowledge the positive features of the TA’s performance. In addition, I try to emphasize the relative unimportance of my recommended changes to avoid giving a distorted view of the lesson. Although I have been fortunate enough to mentor many gifted TAs, I always look for something I can comment on to help them improve. I am also surprised when postdocs tell me that they never received detailed feedback on their teaching when they were TAs. The most feedback they often got was a generic comment like “You’re doing fine.”

It can be intimidating when someone watches you teach. In Section 1.3, I recounted how, many years ago, when my teaching was being observed as part of my tenure review, I gave the worst class I have ever given. I got stuck on a homework problem that one of the students had asked me to do. Although I had assigned the problem, I had not done it in advance of class, assuming that I would be able to do it if I were asked. On this occasion, my lack of preparation was brutally exposed. Getting lost in front of a class is truly terrifying.

After including the observation report, I will devote the rest of this section to the last three subsections of the report. The teaching characteristics noted in the first two subsections were discussed extensively in the first two sections of this guide.

CLASSROOM OBSERVATION REPORT**Instructor:****Course/Section:****Time/Date:****Attendance:**

Teaching Characteristic	Out.	VGd	Acc.	NI	Uns.
Preparation and command of the subject <ul style="list-style-type: none"> ● had prepared notes ● answered questions correctly ● dealt appropriately with errors ● showed that the lesson had been carefully planned Comments:					
Teacher-class interactions and student involvement <ul style="list-style-type: none"> ● asked enough questions ● listened to responses ● encouraged the students ● ensured many students got involved ● used students' names Comments:					
Teacher's manner <ul style="list-style-type: none"> ● confidence ● energy level ● enthusiasm ● gestures and body language Comments:					
Teacher's method <ul style="list-style-type: none"> ● appropriate balance between examples and theory ● linked lesson to old or new material or to experience ● highlighted main ideas and common errors ● motivated material Comments:					
Mechanics <ul style="list-style-type: none"> ● use of the board or document camera ● volume, clarity, and speed of speech ● used time in the class well ● limited controllable distractions Comments:					

Out. = Outstanding; **VGd** = Very Good; **Acc.** = Acceptable; **NI** = Needs Improvement; **Uns.** = Unsatisfactory.

3.1. Manner.

- “The students are always her #1 priority and it was a pleasure going into her class every day.”
- “Unbelievable teacher. Thoroughly cared about his students and if they learned.”
- “Keep up the enthusiasm and excitement for what you are teaching. It helps students to really stay engaged.”
- “Extremely caring & considerate instructor. She goes beyond what is expected to insure the subject is learned.”
- “By far the best teacher I’ve had in the mathematics or engineering departments. Genuinely interested in her students well being as well as enthusiastic about the subject matter. Reinvigorated my interest in learning, that had been lost slightly, due to indifferent professors.”
- “My favorite part was how much she cared. She wants us to learn and understand the math, which is monumental in giving motivation to the students.”
- “what I liked most about this class was the environment the professor was able to maintain. My previous math courses were very stern and serious, but this class had a warm and welcoming aura to it, and it made me excited to go to class.”
- “I was very intimidated coming into this course but the instructor is incredibly helpful and welcoming to questions.”

Taken verbatim from the undergraduate-student evaluations of some LSU graduate assistants.

Two consistent themes emerge from the quotes above. Students appreciate an enthusiastic teacher and one who cares about their learning. One of our multiple award-winning TAs, Julius Esunge, spoke once at a university-wide orientation for new TAs. He talked about how to stay fresh when teaching a section of some course for the umpteenth time. He asked the new TAs to imagine they were attending a long-running Broadway show, one that had given hundreds of performances. Most of the audience on any given night had never seen the show before. Perhaps they had traveled to New York especially to see it. They had paid hundreds of dollars for their tickets. They expected the very best performance the cast could give. “Well,” said Julius, “That’s what your students deserve from you. The very best you can give.”

Julius’s analogy linking a stage performance to a class may seem false to some. But, if you are going to communicate with a class, you must first get and hold their attention. You may be low-key outside of the classroom, but, as a teacher in the classroom, you are the leader, the orchestra conductor. Without your control and direction, the class does not work. One of our TAs, Kevin, always had a very subdued manner when teaching. As a result, he had trouble holding the attention of his students. I asked him whether he had ever had a leadership position in his life and he had not. Many people shy away from such positions. But, when you are teaching, you cannot avoid the leadership position that this bestows on you. You are not hanging out with a group of friends shooting the breeze. You are in charge and what does or does not get done in the class depends on you.

I watched Sophie stop and look at her class as their uncontrolled discussions swelled but the clamor did not die down and Sophie did not really know how to quell the mutiny. When I discussed this situation with her, I advised her to use the skills she had learned in leadership positions when she was younger to firmly but gently assert control. Adult learners tend not to respond well to authoritarian behavior and such behavior may even produce a backlash.

However, the students need to know that the teacher is in charge. This message of control is usually conveyed in a variety of subtle ways using body posture, tone of voice, and facial expressions. The worst situation I ever saw in this regard arose when a TA, Sean, tried to prevent his students leaving a class early by using his body to obstruct the doorway. Fortunately, he relented but this unpleasant confrontation arose because of Sean's earlier failure to assert control. As the teacher of a class, you have control of the class. You need to believe in that fact and so do your students for if they perceive that you are willing to give up some control, they are willing to take it from you. You need a friendly but firm manner that immediately addresses discussions not related to what is being covered in class. When such talking begins, you should immediately stop, stare at the offending student, and wait. Perhaps you may ask, "Is there a question?" Some judgement is needed in these situations. A student may be seeking some quick help from a classmate. As long as that is done relatively quietly and is not too prolonged, it should be allowed. But boisterous, disruptive behavior has no place in a class. As a freshman, I still remember my calculus professor asking an unruly student to leave the very large class. The student left but the incident delayed the class by perhaps five minutes. When I was a sophomore, some students in my calculus II course launched a giant paper plane from the back of the lecture theater. This was a relatively good-natured prank but it indicated that a certain group of students in the class were frustrated with our teacher's style.

I view ejecting students from a class as a last resort. I did it once, not as the teacher, but as the observer. A male student near me, who had clearly taken the course before, was loudly telling the female students around him about the course at the same time as the new TA was trying to deliver the same information. I identified myself as a mathematics professor and I politely asked him to stop being disruptive. In response, he was rude to me so I asked him to accompany me as I left the room. When we spoke outside, he complained to me that I had made him look bad in front of the group of women he had been trying to impress. Do not underestimate how important it is for students to save face in front of their peers.

Assume Toby is misbehaving. If stopping and looking at him several times does not solve the problem, ask Toby by name if there is a problem. Once again, we see the importance of names. The next step is to talk privately to Toby after class. Use some pretext to arrange a meeting like "I forgot to record the grade on your last quiz" or "I need to talk to you about one of the homework problems." When Toby is no longer in front of his peers, the issue of loss of face vanishes and you can expect Toby to be reasonable. Talk to him as an adult, not as a child, and try to find out more about him as an individual. Ask him for his help to ensure that the class flows smoothly. Explain that his behavior has been disrupting your concentration and hurting your ability to do the best job you can of teaching the class. It is very hard to say "no" to someone who approaches you in a friendly manner and asks you for help. If Toby is bored because he knows the material well, perhaps he will be willing to run a study group for some of his classmates to prepare for tests. If Toby is struggling and, as a result, is frustrated, try to get him to attend more of your office hours or to attend the available on-campus tutoring. By making it clear to Toby that you want him and his classmates to succeed in the course, you are showing him that you are allies. This will likely significantly diminish his tendency to be disruptive.

As an indication that most students in a class want to learn and find such distractions annoying, let me quote a student comment from a teaching evaluation.

- “I really wish he would make the back half of the class treat him w/ more respect, as it was hard to hear him sometimes because they were so rude. Otherwise, great teacher.”

Finally on this issue of firmness, I have been told by more than one young teacher that they have learned the hard way about the importance of maintaining professional distance. The teacher’s friendly manner had been misinterpreted by a student in the class who then sought a personal relationship with the teacher.

“The class that you watched was so different from the one I taught earlier today when the students were so much more engaged,” complained Isaac. This is a common complaint. Each class has its own personality and some will participate much more readily than others. Very early or very late classes or those around lunchtime can be very flat. As a teacher, you need to respond to a lack of energy from the students. “Come on you guys, I know it’s early but you can do this.” Injecting some humor into the situation can also help. Begging them to respond does not work and can make you look foolish. Just continue to press your usual questions and make it clear, by waiting for them to respond, perhaps by repeating an unanswered question but not by saying so explicitly, that you will not proceed until you get some responses. When these do begin to flow, give praise that is a little more enthusiastic than what you usually give. The basic message here is that, for some classes, you will need to work harder to get them engaged but, without that engagement, the students will not learn as much as they might. Of course, any extra enthusiasm you convey to the students needs to be controlled. Over-the-top behavior will not be well received.

Evan was an excellent teacher and I had praised him many times for his work in the classroom. Then I began to notice a disturbing trend in his teaching. He had fallen in love with the sound of his own voice. His jokes were making the students laugh and he seemed intoxicated by the power that came with having the entire class under his control. The downside of this was that the mathematics that he was teaching began to take second place to his comedy act. I spoke to him on a number of occasions about this and he gradually learned to control this tendency of his to get carried away by the power of controlling a group. Getting and holding the attention of the students is important to assist them in learning mathematics. But one must never lose sight of the ultimate goal here, that the students learn mathematics.

3.1.1. *Respect.*

- “one thing I didn’t appreciate was when he laughed at us when we were confused or didn’t know something.”
- “He gets really frustrated with my class for not understanding any of his concepts and then stops teaching us, tells us to figure it out on our own”

Taken verbatim from the undergraduate-student evaluations of an LSU graduate assistant.

The student comments above represent a mentoring failure on my part. I was never able to convince the TA in question to prepare properly for each class and to modify the way that he interacted with his students. In hindsight, I should have been firmer with him and drawn his attention to the fact that the continuation of his teaching assistantship depended on the satisfactory performance of his teaching duties.

If your students perceive that you do not respect them or if you ever belittle them, you will have created a rift between you and them from which it will be very difficult to recover. Reporting

on their research, Kelsey et al. [38] write that “this study suggests that students are not very forgiving of their instructors when those teachers misbehave.”

3.2. Method.

- “I enjoyed that there was step by step process for visual learners and he gave opportunities to try problems ourselves which aided with the learning!”
- “This class was a very unorganized class. This teacher was rarely prepared for class, was always late, disrespectful, unkind and not an effective teacher.”
- “The part I like most about the class was that it was very well structured. She had a plan and she stuck to it. This was very helpful and because she was so well organized I believe I learned the material much easier.”
- “She was dedicated to helping each individual person learn the material. She was an easy teacher to understand and learn from, which made
- “I liked that the class was organized and that the instructor explained the material in a step-by-step way.”
- “Honestly, this class was *BYFAR* my favorite class of my college career. Unlike other classes, this class forced me to learn instead of memorize.”

Taken verbatim from the undergraduate-student evaluations of some LSU graduate assistants.

What emerges from these comments is how students both crave and appreciate organization in the way that the material is presented. In the last section, we saw how students welcomed an enthusiastic and caring manner in a teacher. But as the following quote from a student indicates, such a manner is not enough.

- “I really appreciated his attitude towards the class. He wanted people to understand and do well, however he tended to ramble and work in a very unorganized manner. I liked him as a person and a teacher but he needs to work on how he presents, explains, and organized the material.”

When I began teaching, my preparation consisted of writing out in full most of what I planned to say. The virtue of this approach is that it meant that I had carefully thought through how to motivate and present the concepts so I was not having to formulate my explanations on the spot. The disadvantage of this approach is that I tended to write too much on the board at the expense of engaging the students. There is a constant tension for teachers between involving the students in the lesson and ensuring that the students have a good set of lecture notes. Some teachers will make lecture notes available in some form, sometimes with gaps to be filled in during class. When using printed lecture notes, it is worth noting that there is documented evidence that students benefit from writing out material themselves as this is an active process that forces them to engage with the material. As you can see, I am not trying to resolve this conflict but rather to make you aware of some of its deeper aspects.

Imran was a star international student who had managed to get to graduate school in the US because he had worked very hard throughout all of his mathematics courses. He had been required to take and succeed in very competitive exams. He believed that his success in these exams relied on the fact that he had learned every variant of every problem that could possibly appear on an exam. As a teacher, he wanted his American students to succeed so he followed what he viewed as the one true path to success. In order to show his students every variation that

might arise, he spoke very fast and rushed through the material rarely providing the students the opportunity to speak.

When I spoke to Imran, I likened his class to drinking from a firehose. The information was there but it was coming at the students too fast for them to be able to absorb it. Imran had fallen into the very common trap of teaching to himself. This is the way I learned it so this is the way that I will teach it. But consider the audience! Imran's class was not filled with a bunch of students like him. He was a Ph.D. student in mathematics whereas only a small fraction of his class were math majors, most being engineering majors. Although few of his students were like him at the same stage, Imran taught the class as if they were all his clones and so he failed to connect with his students. His conscientious efforts to help his students as he had been helped could not bridge the gap he had created between himself and his audience. His teaching was ineffective because he was teaching to the wrong audience.

In the last section, I highlighted the importance of using examples early and often when teaching. Their use provides a way to draw students into the lesson. Motivating the material you are teaching is crucial to getting and keeping the students attention. How can you appeal to their curiosity? Are you linking what you are teaching to something they may have seen in a previous mathematics course or to something they are covering in their physics or economics classes? I conclude this section with three more quotes from student evaluations of TAs that highlight well-received teaching methods.

- “He is very kind, patient, and helpful. When someone does not understand one way that he has shown how to do a problem, he always has another way to explain to make sure everyone understands. His different methods and different explanations really helped me to learn.”
- “The instructor's most effective teaching tactic was giving the ‘intuition’ behind the formulas and math and explaining how the math fit in words.”
- “She always encouraged questions and always motivated us to participate in class.”

3.3. **Mechanics.** “Is that a ‘9’ or a ‘g’?” asked a student because the TA had written a symbol that could have been interpreted as either. Then another student noted that the equation that had been written down had two variables ‘ x ’ and ‘ g ’. But this was not what the TA had intended. For him, it was natural to write a ‘9’ so that it looked like a ‘g’. The problem for him was that this was an unnecessary distraction for his students. Habits like this are hard to break but distractions to what is going on in the classroom are an impediment to learning.

3.3.1. *Use of the board or document camera.* Should you use the board or a projected image from a document camera or an iPad? My preference is usually for the board. It has the advantage that one can simultaneously display about four times as much material as can be displayed in a projected image. This enables you to reinforce ideas by referring back to material covered earlier. Using the board introduces some energy to your presentation as it means that you have to move across the front of the room. Usually this will bring you closer to the students. The use of projected images needs to be carefully managed. I will discuss such usage in detail below.

Here are some basic things to consider when using the board.

- (i) Is your writing clear enough and large enough for the students at the back of the room to easily read it? Are those students at the back talking about where they will go partying tonight or is one checking with the other about something you have written on the board?
- (ii) Is your presentation on the board clear and well-organized, or do you jump around on the board in a manner that appears designed to torment note-takers?

- (iii) Are you making use of all of the board, reaching up as high as you can so that you are using the part of the board that all can see? Are you avoiding the bottom of the board, the view of which is blocked for students at the back?
- (iv) Do you erase what you have just written or do you omit writing down some key facts that you want the students to know?
- (v) As you write on the board, do you say aloud what you are writing to help note-takers and those who take in information better through their ears than through their eyes?
- (vi) Are you sharing your attention across the class or are you focusing on that part of the class that you can most easily see when you turn slightly after writing on the board?

Some teachers produce beautiful boards with the material well organized, the main ideas highlighted with careful use of colors, and with everything laid out neatly and clearly. I am not such a teacher so what do I do to compensate? I think of the board as being divided into, say, four columns and I proceed down these columns from left to right and then return to the first column when the fourth is complete, waiting until then to erase the first column. Perhaps I am asked a question, and I want to write part of my response on the board. Where do I do it so as not to disrupt my careful organization? Perhaps there is a side board in the room that I can use. That will work provided it is clearly visible to all in the class. In the absence of a clearly visible sideboard, if I am writing in column 3 of 4, I can probably safely erase the top of column 1 and use that to help answer the question. If the questioner has pointed out an error in what I have done on the board and it can be easily corrected, I must resist just quickly correcting my slip and moving on. I recommend using a bright contrast color to make the correction as well as drawing the attention of the whole class to the slip.

Earlier, we considered how to respond when you are asked about a variant on a problem for which you have just presented the solution. While you can very quickly change what was originally written to replace it with the new problem, note-takers cannot do that. They want their notes to contain both the original problem and its variant in order to differentiate between the methods used and to integrate these differences into their understanding. This means that, just as a note-taker must, you as the teacher need to write out the new problem and its solution with only obvious abbreviations.

Taking notes is very important for students. If you erase what you have just written, then a student may miss the chance to copy it down. She was thinking about something that confused her and just did not have a chance to get it down. A good note-taker will write down important things that are said even if they are not written on the board. Many students are not good note-takers. Being aware of this helps you to recognize the need to write down the important things on the board.

If your goal is to engage the students in the class, you need to think about how much you write. If your students are frantically trying to write down what you said two minutes ago, how much attention do they have to give to your current explanation? Finding the balance between giving the students a good set of notes and helping them to grasp concepts contemporaneously can be challenging. For courses such as calculus where one tends to closely follow a textbook, remember that the students have the book so copying out large sections from it is of little value. Ask yourself how your class differs from just having the students copy out sections of the book.

I mentioned earlier how I was confused by a criticism of my teaching that I always did exactly the same examples in the book. Certain examples are fundamental. For instance, in a calculus class, one wants to investigate how $\sin\left(\frac{\pi}{x}\right)$ behaves as x approaches zero. I suggest covering that

in class although it is in the book. But most examples that one does in class illustrate the basic techniques being taught and so can easily be altered from those in the book. If this is done, the students have doubled the size of the library of worked examples they have. If you work exactly the same examples as in the book, how do you know whether your students are processing the material (as opposed to just reading from the book) when you ask a question about how to do a problem?

The use of projected images from a document camera or an iPad is challenging. One must ensure that what is being projected is large enough to be clearly seen by all; and one is faced with the fact that so little can be projected at a time. Working a long problem inevitably involves losing the ability to display the whole solution at once and provides potential frustration for note-takers. Providing printed notes for the students with gaps into which material can be inserted probably optimizes how projected images can be used in a dynamic way. One static use of such projected images is to display a table of integrals, say, when one is reviewing integration.

3.3.2. *Say what?* Tom Brylawski was a mathematics professor at the University of North Carolina who was my postdoctoral advisor. He was an extremely enthusiastic teacher and, as his colleagues would remind him, his voice was so loud it could be heard all down the main corridor in the mathematics building. This was partly because he always left his classroom door open. His students never had any problem hearing him. The same is not true for many of the TAs I have observed who, when they begin, are just too quiet. Apart from creating problems for the students who are unable to hear a teacher's quiet voice, such a quiet voice can send a signal of weakness that invites some students to be disruptive. When I find a TA who is too quiet, I encourage him to go into an empty classroom with a friend and then to have a conversation with that friend when the two of them are standing a maximum distance apart in the room. This can help to raise awareness of the need to project one's voice in a large room.

As a teacher, your voice is perhaps your most powerful tool. The way you vary the volume and stress, the pauses you use, the changes in tone or emphasis, all of these are tools for manipulating the students' attention. There are some truly great speeches one can listen to online. These highlight the power of the human voice. As a teacher, you need to recognize and harness that power.

My Australian accent often gives American students problems particularly when I speak quickly. Once, after returning from a holiday in Australia, I found that one of my long-time colleagues was unable to understand me. I had forgotten my audience. When I am teaching, I try to speak more clearly and more slowly. I try to face the students when I am speaking to them and to keep my hands away from my mouth when speaking so that I do not block the sound. My students would understand me better if I had an American rather than an Australian accent. Because of this, I need to compensate as best I can. We have had students here at LSU who have complained about not understanding professors from the north-east of the US who speak very rapidly, so it is not only foreign accents that can cause problems for your students. If, like me, you have an accent that is unfamiliar to your students, try to be aware of how that may interfere with your students' understanding and do what you can to help them adjust. Generally, your students will adapt to your accent, but showing that you recognize that it may be a problem sends a strong signal to them of your willingness to communicate successfully with them.

Some unexpected things can arise without you even being aware of them. I have heard a number of Indian students say " a by b ". For such students, " a by b " is an abbreviation for " a divided by b " and they assume their students will interpret it in the same way. Unfortunately, to

an American student, “ a by b ” means “ a multiplied by b ”. Similarly, “ a into b ” means ab in Indian English but means $\frac{b}{a}$ in American English. These kinds of regional variations in the use of language come up occasionally. To avoid confusion when you are teaching, it is important that you try to conform to the local norms.

3.3.3. *Limiting controllable distractions. Brain drain: The mere presence of one's own smartphone reduces available cognitive capacity* is the title of a 2017 paper by Adrian F. Ward, Kristen Duke, Ayelet Gneezy, and Maarten W. Bos [76]. This paper has the disturbing finding that “results from two experiments indicate that even when people are successful at maintaining sustained attention—as when avoiding the temptation to check their phones—the mere presence of these devices reduces available cognitive capacity.” What are the implications of this finding for you as a teacher? I suggest that you have a written policy in your syllabus concerning the use of laptop computers, tablets, and cellphones in class. Because of the incredible ability of such devices to distract not only the device owner, but also those sitting near them, some teachers severely limit their use or even ban them altogether.

Enforcing such limits can meet with some resistance. If you choose to impose limits, I suggest addressing this issue on the first day by explaining that, because you wish to ensure that your students have the best chance to succeed in your class, you are restricting the use of such devices to legitimate purposes directly related to your class. When violations of your rules occur, deal with them privately preferably through a conversation with the offending student. Your goal is to avoid a public confrontation with the student that runs the risk of embarrassing the student and alienating the rest of the class.

Because cellphones are so addictively distracting, I encourage teachers to use ordinary watches to keep track of time in class rather than using their cellphones. Anything that draws attention to the cellphone is a distraction.

In the Math building at LSU, there are four classrooms that have doors very close to each other. I am always surprised to see how many of these doors are open when there are classes going on. On many occasions, I have sat in one of these classrooms by an open door and been able to clearly hear the teacher from a nearby classroom. Closing your classroom door dramatically reduces the potential for your students to be distracted by what is going on in neighboring classrooms.

Do you have any pet words or expressions that you dramatically overuse? Have you ever sat in a lecture where the teacher jangled keys or coins in his pocket, or where her large bracelets clanged noisily together, or to where his cowboy boots clip-clopped loudly across the floor? These are examples of controllable and unnecessary distractions. When you are teaching, your goal is to focus the attention of your students on the material being learned. By being aware of and eliminating these kinds of distractions, you can help to maintain the students' attention on the lesson.

In many of our classrooms, the chairs are movable and, as some classes use the space differently, the chairs can wind up in a position from which the board cannot be properly seen. As the teacher, you need to be aware of this. I have seen students who clearly cannot see the board telling a concerned teacher that they can actually see. If you get into your classroom early before each class, you can, if necessary, move the chairs around to prevent this problem from arising.

Occasionally, you will want to give the students a mental break by telling a joke or talking about sports or some recent news story. You may even inject an anecdote about a famous mathematician or give the students a puzzle that does not relate directly to the lesson. These are

distractions from the lesson that you control and that you are using for a pedagogical purpose. What you are trying to eliminate is the advertising poster that is affixed to the board, or the marker pen that cannot be easily read, or the chalk that squeaks.

I encourage all TAs to clean the board at the end of each of their classes so that the room is ready for the next teacher.

3.3.4. *The end.*

- “He came to class 5 minutes late every day”
- “He was often late for class, and when doing practice problems, did not know what the solution or concept was. People stopped showing up to class because they knew he was not going to help in the slightest.”

Taken verbatim from the undergraduate-student evaluations of an LSU graduate assistant.

As you can see from the comments above, students react negatively towards teachers who are late and this can harm their ability to learn from the teacher. Our classes at LSU are usually fifty minutes long. You should try to use all of that time. This means that you should arrive, say, five minutes early for class. If you have graded work to return, then arrive even earlier. Then you can distribute most of the papers before the class is actually scheduled to begin. There are invariably matters to take care of before class. Perhaps the board needs to be cleaned or you have to set up the computer in order to display something later. Maybe you will need to move some chairs around so that the board can be clearly seen from every chair in the room; or perhaps there is a test or review session coming up whose timing you want to write prominently on the board, drawing particular attention to it when class formally begins. If all these logistical issues are taken care of, a few informal minutes to chat with your students provides you with a chance to get to know them. I have seen many graduate students stand silently and awkwardly at the front of a classroom waiting for the official start time. You don’t need to talk to all of the students at once. Concentrate on a small group of them, varying that group each day. You can learn their names as you chat with them, see if there is anything from an earlier class that is confusing them, find out their majors, or see whether they are interested in getting a minor in math. One of my grad students switched her undergraduate major to math because one of her math teachers recognized and encouraged her mathematical talent.

Sometimes in a class, students will start to make packing-up noises with five minutes or so to go. A brief comment, in a positive tone, like “We still have five minutes” or “You guys have paid for fifty minutes” will usually quiet this noise. It is important though to take control of this moment. Class time is valuable and you need to use it all. Note that this means use it all but no more. It is okay to very occasionally go, say, a minute over but going longer just annoys the students who have other classes to get to in different buildings. You will also find that students stop listening when you go over time, so you have annoyed them for no gain. Many times I have seen a teacher give the signal that a class is over only to then want to say a number of other important things. The end-of-class signal should not be given prematurely and you cannot expect the students to reliably hear anything you say after giving that signal.

3.4. **Notes.**

- (i) Kearney et al. [37] identify three general categories of what they call instructor misbehavior. These are incompetence, indolence or laziness, and offensiveness. Vallade and Myers [72] note that “In the instructor-student relationship, relational transgressions

may primarily consist of instructor violations of student expectations. For instance, in the college classroom, students expect their instructors to be knowledgeable, to utilize a variety of teaching methods, to provide them with the information necessary to guarantee academic success, to establish a supportive classroom climate, and to develop interpersonal relationships with them (Chen, 2000 [13]; Moore, Moore, & McDonald, 2008 [53]; Shelton, Lane, & Waldhart, 1999 [61]).” Summing up their study, Vallade and Myers write “when engaging in any type of misbehavior, it might prove fruitful for instructors to engage in communication (e.g., explanations) that mitigates the perceived transgression severity and transgressor blameworthiness. By doing so, instructors can prevent relational transgressions from escalating and damaging the instructor-student relationship.”

- (ii) Concerning their research, Kelsey et al. [38] write that “the results of the current study suggest that students care less about teacher demeanor than they do about how professionally and consistently teachers conduct their classes.” They also write that “Examination of students’ qualitative responses suggests that student motivation and judgments of their teachers’ effectiveness are both adversely affected by teacher misbehavior that is attributed to internal causality”, that is, to some internal issue that is specific to the teacher.
- (iii) A study of Vallade [71] investigates how instructors “should communicate *after* a misbehavior in order to mitigate its negative impact.” She notes that “Following competence-based misbehaviors, providing compensation or attempting to rectify the situation emerged as particularly important to students.” Another class of misbehaviors involves violations of integrity-based trust, that is, of behaviors that “involve characteristics such as honesty, sincerity, conscientiousness, and fairness (Schlenker et al., 2001 [62]; Tomlinson, 2012 [69]).” After such integrity-based violations, instructors may find it “fruitful to put efforts toward image repair and demonstration of caring for students.”
- (iv) Another study of Vallade [70] considered the impact on student learning of instructor misbehavior. Summarizing that study, the author wrote “In order to avoid the mutual perception of misbehaviors between instructors and students with regard to academic rigor, teachers can frame their high expectations as beneficial challenges. Additionally, they can supplement course workload and demand with ample support mechanisms, such as making oneself available to students outside of class for extra guidance and support (Goldman, Goodboy, & Bolkan, 2016 [27]) and providing meaningful and constructive feedback (e.g., Kluger & DeNisi, 1996 [39]).”
- (v) McCoy [48, 47] surveyed college students in 2012 and 2015 regarding their use of digital devices for non-class related purposes. The second survey included 675 respondents in 26 states. McCoy reports that “Respondents spent an average of 20.9% of class time using a digital device for non-class purposes. The average respondent used a digital device 11.43 times for non-class purposes during a typical school day in 2015 compared to 10.93 times in 2013.” He adds “such digital distractions are often habitual and frequently happen despite an admission by a large majority (89%) of respondents that this behavior hampers their ability to pay attention in the classroom.”

- (vi) Flanigan et al. [20] propose measures for managing student digital distraction because “these digital distractions can negatively impact learning and performance”. The proposed measures require instructors to “proactively regulate student use of digital devices to protect the integrity of the learning environment.”
- (vii) Acknowledging the dilemma that face instructors when trying to manage the distraction created by digital devices, Flanigan et al. write that “punitive, confrontational reactions to student digital distraction should not be an instructor’s first response when students are caught misusing devices during class. Less confrontational reactions like privately talking with or emailing the offending students after class can prevent future digital distraction while simultaneously protecting student perceptions of rapport with their instructors.” They also note that undergraduates “identify instructor reactions like embarrassing students, ridiculing them, or imposing unreasonable punitive penalties as offensive instructor misbehaviors they can be slow or unwilling to forgive (Vallade, 2021 [71]; Vallade & Myers, 2014 [72]).”

4. TESTING

With respect to testing, it is very important that you treat all students equally.

As a teaching assistant, you will get involved in the testing process at some level. If you have had input in writing the test or have seen a copy of the test, you must be very careful that the only time you discuss the test with your students is when you are in class, otherwise you risk providing different treatment to different students.

This section gives some guidelines for dealing with the testing process; it breaks the process up into four steps:

- (i) writing the test;
- (ii) administering the test;
- (iii) grading the test;
- (iv) assigning grades for the test.

While you may not be initially involved in all of the steps above, during the course of your graduate studies, you are likely to need guidance on all of them.

4.1. Writing the test.

- “Her quizzes and tests reflected what we had been taught, never did she put something were we hadn’t had the chance to be exposed to it prior to being tested on it.”
- “The only change that would make this class better would be to make the exam reviews more similar to the actual exam. On two of the exams, I felt fairly confident when I completed the exam review, but when the actual exam came around, the questions were more complicated or simply weren’t related to what we reviewed.”

Taken verbatim from the undergraduate-student evaluations of some LSU graduate assistants.

Whenever you write a test, your goal is to ensure that your students have mastered the basics of the course. You are not trying to trick the students. If you are an international student, you may have come through a system where your exams were highly competitive and only the very best students succeeded. This is not the testing environment that you should think of when preparing your tests. The goal in writing a test should be to prepare something that can be done by students who have been able to successfully do the homework in the course. If your classes are fifty minutes long, then that is the usual length of the test. You should always avoid very hard problems of a type the students have not seen before. There are certain standard types of problems that students need to be able to do to demonstrate mastery of the material. Such problems occur in abundance in their homework. Writing a test made up of such problems should be your goal. You may choose to put in a problem or possibly two to separate out the A-students from the rest but most of the exam should consist of variants on homework problems. Some teachers will give their students practice tests. These can be helpful to the students in preparing for the test, but, if the actual test varies very little from the practice test, then you will be requiring your students to be good mimics rather than to have a thorough mastery of the material.

Here is a list of things to consider when writing a test.

- (a) **Start with a couple of routine problems.** If you begin the test with hard problems, you can shatter the students’ confidence. Giving a problem or two at the beginning to help

ease the students into the test can reassure them so that they can show you what they know.

- (b) **Test the key concepts.** Your focus should be on ensuring that the students understand the main ideas of the course, not on looking for obscure problems to trip up your students.
- (c) **Balance your coverage of different sections.** One way to do this is to consider the sections of the book from which different problems come. Overtesting some concepts while minimizing your testing of other equally important concepts can be unfair on the students.
- (d) **Be careful with problems with interdependent parts.** A problem with many parts each depending on an earlier one can be hard to grade since a student may make a mistake on an earlier part yet use a correct method on later parts.
- (e) **The test has to be graded.** Do not write a test that is too long or too difficult for the average student. It is just too time-consuming to grade and you will not find out what the students can do by overwhelming them. Remember your students are not competitors in a Math Olympiad.
- (f) **Give clear instructions at the beginning and throughout the test; clearly indicate the point-value of each problem.** A good statement to make at the beginning of a test is something like “You must show the work that justifies your answers.” If you require an answer in a certain form, you should indicate that.
- (g) **Consider the layout of the test paper and proof-read the test carefully.** It is preferable for the test to be typed. Mistakes are inevitable, so proof-read the test carefully before printing it. If the students are to write their solutions on the test paper, ensure there is enough room. Providing an answer box for each problem when this is appropriate can make the grading task easier as students are often somewhat haphazard in the way they write their answers. A problem whose solution needs to be written on a different page or even on the back of the current page can waste the time of the students as they are doing the test.
- (h) **Do the test yourself.** Before giving the test to your students, do the whole thing yourself. This will ensure the problems have no unexpected difficulties that would take more time than you had anticipated. Be aware that your students may need perhaps three times as long to do the test as you do.
- (i) **Check your test with the course coordinator.** This is particularly important if you have not taught the course before. Fellow graduate students who have previously taught the course can also be valuable sources of advice.
- (j) **Ensure the test is ready early and is kept in a secure place before it is given.** If the copying machine breaks down as you are copying the test and you need to give the test in ten minutes, then you have a problem. On the other hand, once you have copied the test, you need to be confident that it is not compromised. Students have stolen tests from teacher’s desks or offices in the past and this is problematic.

4.2. **Administering the test.** On the day that you are giving a test, you should get to class at least five minutes early. Regrettably, when you are administering a test, you need to try to minimize the opportunities for students to cheat. As the first step in this process, you should try to spread out the chairs in the room as much as possible. Since you are not using the board on test day, you can put chairs in the space at the front of the room that you would usually be occupying when teaching. If your room is particularly cramped, you can prepare slightly

different versions of the test and distribute these so that students near to each other get different versions of the test.

Students should not be allowed access to their notes, their mobile phones, or even their smart watches during the test. Students wearing caps should be asked to turn them around or to remove them. You should walk around the room where possible without disturbing the students. These observations may lead you to suspect that cheating is occurring. All universities will have very clearly stated policies concerning academic dishonesty. Before you give a test you should ensure that you are familiar with these policies. Here at LSU, if you believe students to be cheating, you should do nothing to indicate your suspicion to the students involved. You should make a private note of the names of the students so that you can compare their papers when grading. Moreover, you should immediately discuss the situation with the course coordinator, if there is one, or the professor in your department who is responsible for administering teaching. Knowing the local rules and how to respond appropriately in accordance with them will help you be prepared for handling what can be a very tricky situation.

Even though you have arrived early for class on the test day, you should not begin the test until the actual start of class time. Moreover, you should end the test on time. Some teachers will allow the students to use five minutes of the time between classes as part of the time for working the test. But if some students have a test in another class that begins right after yours while others do not, the former students are disadvantaged. You also need to be aware that the next class in your room may have a test. You do not want to get involved in a turf war with the teacher of the next class. You should warn the students when time is running out, say with fifteen minutes, ten minutes, and five minutes to go. When you tell the students to stop work, some will keep writing, particularly if your exam is too long. You cannot rip the paper out of a student's hand but if John stops when you indicate that time is up but Bill does not, then Bill has a slight advantage. This can be handled in a good spirit without you being overbearing.

4.3. Grading the test.

- “she always made test and quiz grades available in a timely manner.”

From the undergraduate-student evaluations of an LSU graduate assistant.

The most important thing about grading is that you do it consistently from student to student.

In preparation for grading the test, make up an answer key deciding on a point allocation for each part of each problem. To help with this, grade the test a page, or even a problem, at a time. During this grading, you will come across common mistakes that are made. You should take a note of these so that you can ensure that you treat all students the same. This may also require you to go back through the graded papers to ensure that all students who make a particular error receive the same grade. It can be exasperating to see the same mistake made repeatedly and your patience may wear thin, but your exasperation should not be reflected in your grading.

Even with a well-designed answer key, you will come across solutions that do not fall into a pattern you have seen before. Such solutions will take extra time to read but you need to make sure that you do that. Your goal with grading is to reward students who essentially know what is going on. Harshly penalizing minor errors should be avoided.

The students will learn from the mistakes they make on their tests. Once the papers are graded, you will return them to the students, so you should write corrections and comments on

their papers to show them where they have gone wrong and how to correct their errors. This takes extra time but is an essential part of the process. Sometimes teachers will indicate the score on a problem by assigning points to the correct parts. Other teachers will indicate deductions associated with specific errors. Both methods are acceptable as long as it is clear which is being used. A single number assigned to a problem or to a page without any comments or corrections is inadequate and just frustrates the students.

When I taught calculus, I gave each test on a Friday and I returned the graded tests on the following Monday. Your students need the feedback that a test gives them to assess their understanding of the material. Delaying returning tests weakens the pedagogical power that testing can generate.

4.4. Assigning the grades. The convention is to grade each test so that the maximum grade is 100. When you grade the test, your hope is that the median score is in the mid-70s. A median in the 40s means the test was too hard; one in the 90s means it was too easy. It is better to give a test that is a little too hard than one that is too easy. For the final grades for a course, students may get to drop one of their test grades. This means that you will want the different tests to count equally. To do this, you should curve each test noting that if a student scores 85 on a test, you cannot curve that down to, say, 82. This reinforces your need to make the test a little too hard rather than too easy.

The convention is to assign grades as follows:

$$A = [90,100]; B = [80,89); C = [70,79); D = [60,69); F = [0,59).$$

Note that, although plus-minus grading may be used for final grades, it is unnecessary to use this for tests. Once you have graded the tests, you have a raw score from $[0,100]$ for each student. If you are responsible for assigning the grades for this test, your next step is to put all of the scores on a number line marked from 0 to 100. With a class of at least thirty, you then look for natural breaks in the scores. For example, the raw scores may be 23, 42, 48, 55, 56, 62, 63, 66, 67, 68, 68, 69, 69, 69, 70, 70, 71, 72, 73, 74, 75, 76, 76, 78, 79, 80, 82, 84, 85, 87, 88, 89, 90, 91, 92, 94, 96.

The median score here is 73. You next need to decide where the natural breaks are to decide the lowest grade for an A, a B, and so on. In this example, there is a block of consecutive scores from 87 to 92, but no score of 86. In this circumstance, it is reasonable to decide that a raw score of 87 becomes a curved score of 90. Then you can adjust all of the scores above 87. This can be done linearly so that, for example, 92 becomes $90 + \frac{92-87}{100-87}10 = 90 + \frac{5}{13}10 = 93.85$, which should be rounded to 94.

There are natural breaks at 78, at 66, and at 55, so we will let these raw scores translate to curved scores of 80, 70, and 60, respectively. Then, for example, the raw score of 82 is curved to be $80 + \frac{4}{9}10 = 84.44$, which should be rounded to 84. Our median raw score is curved to $70 + \frac{7}{12}10 = 75.83$, which is rounded to 76. One thing that it is worth doing after you have made a tentative assignment of these cut-off scores is to look at the papers that are near the cut-offs to see whether you have been fair.

If, for example, your class is small, then the process of looking for natural breaks in the scores suffers because there are so few scores. You will then need to make an initial choice of the breaks between the grades. The usual 90-80-70-60-model is a reasonable starting point. Having done that, you should then look at the test papers with scores above and below the cut-offs to

see whether they match with your judgement of the required level of mastery for the grade. If not, you can always adjust the cut-offs.

You do not want to get involved in arguments over grades. The process of looking for natural breaks in the scores near to the 90, 80, 70, 60 cut-offs can help to avoid this. If there are initially no natural breaks, sometimes you can find breaks by looking at the papers for which the scores are near natural cut-offs to see whether such scores should be adjusted down. If you try to change the cut-off for an A to, say, 93, you will find that your students are very unhappy.

4.5. **Cheating.** All teachers should be aware of the rules concerning academic integrity that apply at their college. For example, the Code of Student Conduct [44] at Louisiana State University makes the following statement.

In accordance with the LSU Faculty Handbook, an Instructor may not assign a disciplinary grade, such as an “F” or zero (0) on an assignment, test examination, or course as a sanction for admitted or suspected Academic Misconduct in lieu of referring the Student to SAA [Student Advocacy and Accountability] under the provisions of this Code. Any grade assigned because of Academic Misconduct must be in accordance with this Code.

As a teacher, it is important that you do not publicly accuse a student of academic misconduct. If you suspect that this has occurred, you should document the issue as thoroughly as you can and then discuss your options with your departmental chair or the person charged with overseeing instructional issues in your department. Because charges of academic misconduct can lead to drawn-out legal proceedings, the easiest thing to do is to put in place the series of measures outlined above under “Administering the test” to try to minimize the possibility that cheating occurs.

These measures are not fool-proof. In my career, I am familiar with more than one incident of students stealing tests from teachers' offices including one where the perpetrators entered the teacher's office through the ceiling. Taking extra precautions about the security of your tests should help to minimize the problems you encounter. If such problems do arise, ensure that you consult the appropriate departmental administrator as soon as possible.

5. CLASSROOM MANAGEMENT

5.1. Control.

- “He was very personable and respectful towards his students. He knew all of first names by the first week.”
- “If he had maybe showed up prepared, it could’ve been better.”

Taken verbatim from the undergraduate-student evaluations of some LSU graduate assistants.

When the conductor enters the concert stage to enthusiastic applause, she acknowledges the audience and then, tapping her baton on her music stand, she calls the orchestra to order and the concert begins, ideally always under her control.

While the students in a class will probably lack the focus of a concert orchestra, as their teacher, you are like the orchestra conductor in many ways. You will not have the rigid control that a conductor has over the orchestra. But it is important that the students recognize that you are in control. Experienced teachers take it for granted that they can control their classes but, early in your career, you may lack the confidence that years of experience provide. Regrettably, your students are very adept at recognizing your nervousness. You have probably had some leadership position on a sports team, a committee of some kind, or even as the oldest child in a family. Recognizing that you are not as devoid of experience in controlling a group as you might have initially imagined can help to calm your fears, but the only real cure for lack of experience is gaining experience. Remember that, while you may be nervous about teaching your class, for all of the students in the class, success or failure in the course can affect all of their futures, so the stakes for them are even higher than for you. You need to give them a reason to trust you. Projecting a confident demeanor, even when it feels like an act, can help.

While you lack experience, you can take advantage of the techniques discussed in earlier sections to form a rapport with your students. Being very well prepared immediately removes one potential source of anxiety. Learning and using your students’ names instantly lifts the veil of anonymity from your interactions. Engaging your students in the lesson makes the class a collaborative endeavor in which you are all working together to improve understanding. Looking your students in the eyes, smiling at them, and maintaining a positive spirit throughout the class should assist in building your students’ trust in you. All of these techniques aim to convey to your students that you care about their success in the class and that you are a friend not a foe.

As with the orchestra conductor, it is important that you get control of your class at the very beginning of the semester and maintain it throughout. Your body language and the strength and volume of your voice are powerful tools in your armory. While it may frighten you to think of a classroom as like a battlefield, one valuable lesson that one can learn from military tactics is that control is determined by one’s command of territory. If you hide behind a lectern in a corner of the room, you have ceded all of the room to the students. But walking across the front of the classroom, even down the aisles, helps in a subtle, non-aggressive way to assert your command of the room. Walking across the front of the room and down the aisles can also help you to engage some of the students who may have been reluctant to speak up. It is always harder to ignore someone who is standing quite close to you.

5.2. Eliminating distractions. In an earlier section, I discussed how a variety of easily controlled potential distractions related to the classroom itself can be tamed.

- (i) Ensure that the classroom doors are closed to limit the noise from the corridor and nearby classrooms.
- (ii) Can all of your students clearly see the board? If not, what are you going to do about it?
- (iii) Are the technological aids in the classroom functioning as designed? If not, how do you try to fix them immediately? How will you ensure that they work for the next class?
- (iv) Is the board clean following earlier classes? If not, have you brought the tools to make it usable?
- (v) Do you have an adequate supply of chalk or of marker pens? Do the latter have sufficient ink in them?
- (vi) Is your writing clear enough and large enough?
- (vii) Are you writing the right amount on the board? If you write too much, then the students will be spending all of their time writing and no time thinking. If some key points are only spoken rather than written, many students, who only record what appears on the board, may miss some important ideas.

5.3. Asking for help. I mentioned earlier how I had observed one of our international students ask his class to help him to improve his English while he was helping them to improve their math. Because of the power of asking for help, this straightforward approach worked very well.

A powerful technique for dealing with troublesome students is illustrated by the following anecdote. I was observing a class and noticed that it was being disrupted by an outspoken young man named David. It was clear that David knew what was going on and David's teacher was struggling to control him. This was leading to disruption of the class and was frustrating some other students, although David's cadre of friends in the class were enjoying the points he was scoring in his little battle with his teacher.

Discipline issues are among the hardest to deal with in a college class especially for novice teachers so David's situation needed delicate handling. To address this issue, I decided to speak privately to David after class. Identifying myself as a math professor, I began by praising David for his understanding of the subject and by asking him when he had mastered this material. Then I asked David for help. Acknowledging that David's teacher was struggling a bit to maintain control of the class, I asked for David's help to assist his teacher to succeed. Because it is so hard to refuse a request for help, I knew that this request would disarm David. I suggested that, rather than directing his efforts to making his teacher look bad, which was ultimately preventing many students from learning, he could be a student leader by helping his teacher to look good. I acknowledged that David's influence over a number of other students in the class could help to change the tone of the teacher's interaction with the class. David responded very well to this request to help. Indeed, David became a class leader who used his efforts for rather than against his teacher. Asking for help can work like magic.

5.4. Teaching evaluations.

- "I like being taught these types of subjects by grad students because they know how to teach in a way that's more approachable to students."
- "Lecture skills were pretty poor, trying to remaine [sic] engaged in the topics in class is extremely difficult."
- "She is respectful, considerate and understanding about her students lives both inside and outside of the classroom. She is always available for extra help and guidance outside of class hours."

- “This class was a very unorganized class. This teacher was rarely prepared for class, was always late, disrespectful, unkind and not an effective teacher.”

Taken verbatim from the undergraduate-student evaluations of some LSU graduate assistants.

Most universities have a system whereby students evaluate their teachers. There is considerable research indicating that such student evaluations are innately gender biased. Nevertheless, they continue to be used within universities across the world, so it is a good idea to be aware of what the students are being asked about your teaching. At LSU, the students respond to each of the following ten questions with one of “Strongly Agree”, “Agree”, “Disagree”, or “Strongly Disagree”.

1. The instructor provided a syllabus at the beginning of the semester that explained the course content, assignments, grading and other important policies.
2. The instructor presented information in a clear, understandable way.
3. The instructor welcomed questions and other class participation.
4. The instructor was knowledgeable about the course content.
5. The instructor was well prepared and organized.
6. The instructor focused tests, quizzes, etc. on the content outlined in the syllabus and/or the content discussed in class.
7. The instructor (or a designated assistant) was available for consultation during office hours.
8. The instructor’s attitude towards students was respectful.
9. The instructor made graded tests, quizzes, etc., available for review in a timely manner.
10. Overall the instructor is an effective teacher.

It is very difficult to please all of your students, so, when you read your evaluations, you should look for themes that are repeated. For example, if several students say that you go too fast, you may want to dismiss this by arguing that your rapid pace was necessary in order to complete the syllabus. But there will generally be others teaching the same course who manage to finish the syllabus without getting student complaints about their pace. While student evaluations can feel punishing, they do provide you with honest feedback from which you can learn. It may be tempting to ignore criticism and even to blame your students for being too inadequate to accurately rate your teaching, but you will find that carefully reading your evaluations can help to remedy some deficits that you may not have even been aware of. After you have identified these weaknesses, your teaching mentor or a trusted more senior TA can help to remediate them.

5.5. Notes.

- (i) Findley and Varble [19], reviewing effective university classroom management practices, write “Effective classroom management starts at the first class meeting. Everything a teacher does on Day One will set the stage for the procedures, routines, and expectations throughout the course. Having a detailed syllabus, outlining requirements for the course, defining expectations for attendance and participation, and explaining the “rules of the road” are just the beginning of how a teacher models expected behavior of the students.”
- (ii) The teaching and learning centers of many universities have easily found online guides to classroom management. One excellent such guide is available from the University of Connecticut Center for Excellence in Teaching and Learning [12].

- (iii) After making a study of classroom behaviors, Stork and Hartley [65] wrote that “One of a teacher’s roles, outside of conveying information and helping to build a knowledge base in others, is social – to help students learn to manage stress and redirect frustration and boredom. Doing this, and with empathy, enhances cognitive performance, keeps minds from wandering, and improves motivation and focus which enables students to learn to develop solutions to problems (Goleman, 2006 [28]).”
- (iv) Murphy [54] proposes strategies for dealing with disruptive behaviors. She identifies three phases within a teaching episode: preimpact, impact, and postimpact. Her strategies for the first phase include establishing clear behavioral expectations in the syllabus and varying instructional strategies to avoid the students getting bored. To deal with the impact phase, she recommends that instructors be judicious about which behaviors they respond to, that they use humor to help defuse the situation, and that they consider their tone of voice, their body language, and their posture during the incident. For the postimpact phase, her recommendations include one-on-one conversations with the student accompanied by an inquiry about how the teacher can be of help to the student.
- (v) Chen [13] wrote concerning a study she ran that “Through unstructured intensive interviews, the data obtained ranged from college students’ feelings about learning environments to their concerns about college education. All the students show their desire to get along with a caring professor who makes the course interesting and the classroom interactive.”
- (vi) Gainen [26] wrote in 1995 that “Each year, about one-third of college freshmen who select majors in science, mathematics, and engineering switch to other fields. Faculty may be able to reduce student attrition from quantitative majors by addressing four barriers to success: (1) pre-college preparation; (2) peer culture; (3) classroom climate; and (4) sink-or-swim instructional style.”
- (vii) There have been numerous studies (see, for example, [3, 11, 50, 51]) that have found a bias against female instructors on teaching evaluations. For example, Mengel et al. [50] write: “we find that women receive systematically lower teaching evaluations than their male colleagues. This bias is driven by male students’ evaluations, is larger for mathematical courses, and particularly pronounced for junior women.”
- (viii) Boring [11] writes that “Men are perceived by both male and female students as being more knowledgeable and having stronger class leadership skills (which are stereotypically associated with males), despite the fact that students appear to learn as much from women as from men.”
- (ix) In a study of Aragón et al. [3], the authors write “we found strong support for the idea of department gender composition as a driver of bias. Students generally evaluated their educators consistent with department gender majority and minority roles. In departments with gender disparities interactions between educator gender and course level were statistically significant. Yet, we found no such effects in departments nearer to gender parity.”
- (x) Two studies in Denmark of Binderkrantz et al. [7] found “no gender bias in favor of men in the evaluations made by students.” The authors of those studies wrote, concerning their work, that “The contrast between our findings and previous studies points to the role of context in explaining gender bias in teaching evaluations. While most existing experimental studies were administered in the US, we conducted our experiments in

a Danish setting.” As a partial explanation of these results the authors suggest that “gender-stereotypical expectations about faculty may be less pronounced in the Danish setting.” In particular, “Denmark scores high with respect to gender equality in education and female labor force participation (Boehnke 2011 [10]; World Economic Forum 2021 [79]).”

6. OFFICE HOURS

- “Office hours were the factor that most contributed to my learning.”
- “I thoroughly enjoyed this course and was very appreciative of his constant offering of help in office hours.”
- “She would add office hours or do zoom meetings, she would allow us to tell her what we needed, and she gave us what we asked for.”
- “He is always willing to answer any of my questions and has many office hours open to answer any further questions outside of class.”
- “Always has office hours and if her hours don't fit your schedule, she's willing to find a time that does.”
- “He was helpful in answering questions during office hours and showing he cared about the overall success of the students.”
- “I liked that this instructor encouraged the students to attend office hours and encouraged us to ask questions.”

Taken verbatim from the undergraduate-student evaluations of some LSU graduate assistants.

6.1. Why bother? High school students are not familiar with office hours and the role that they play in college. Because of this, when discussing a course syllabus, it is helpful to explain what office hours are and how they can help boost academic performance. Some teachers will have, as the first assignment in a course, for the students to attend an office-hours meeting and introduce themselves to their teacher. Many students are reluctant to “bother” their teachers or are frightened of looking foolish in front of their teachers; such students tend to avoid office hours. Having an approachable rather than an aloof or abrasive manner in class is more likely to encourage attendance. Convenience is a major factor in determining whether students attend office hours, so providing a variety of times can facilitate attendance. When you announce your office hours, check that at least one of the available times will work for all students. To accommodate students with very busy schedules, it is common to add “and by appointment” to a list of available office hours. If your office is hard to find or it is a long way away from your classroom, perhaps you can schedule some office hours in a central location like a library. Some teachers hold office hours before or after class in the same room as the class provided that room is free. Frequently mentioning the times of your office hours and explaining to the students that office hours are like a free tutoring session can be helpful. However, studies have shown that students tend not to make much use of office hours and that changing that behavior is difficult.

In their paper *The effect of student-faculty interaction on students' educational outcomes*, Endo and Harpel [17] have written “Students should be more persistent in seeking opportunities to be involved with faculty members outside the classroom. They should take advantage of structured events such as registration advising or faculty office hours to develop informal relationships with faculty. They should also avoid generalizing one bad faculty interaction experience to all future experiences. Finally, students must not limit their efforts in getting to know faculty members to their own disciplines (major fields) but should be open to interaction with responsive faculty whenever they may be found.”

6.2. Getting the most out of office hours. Just after I had begun teaching in the US, I shared an office with an experienced professor who, like me, was a visitor to the Mathematics Department at the University of North Carolina. I was always surprised when he would open our office

door during his office hours to eliminate one of the barriers that students face in consulting their teachers.

For the safety of both students and teachers, the teacher's office door should be left open during office hours. Allowing a student to sit closer to the door than the teacher can potentially alleviate some of the student's anxiety. When a student comes to your office hours, it is tempting to want to focus immediately on the particular source of your student's confusion. But your student may be nervous about attending office hours at all and then about looking foolish while there. A short ice-breaking exercise can help your student to relax. First checking that you know your student's name and are pronouncing it correctly, you can ask them about their career goals, their majors, and how they are finding the course as a whole.

When you move on to addressing the particular problems that are bothering your student, you may find that your student is so confused that they are unable to articulate a specific question. In that case, determining the sections of the book that are generating confusion gives a place to begin. Then you can begin to go through the problems at the end of the section. "How do you feel about this problem?" "Do you feel comfortable getting started?" Your goal is to engage your student, so you should be constantly asking questions. If those questions do not yield responses, put in stepping-stone questions. If you become exasperated or impatient with your student, you will just increase their anxiety and defeat the purpose of holding office hours. Try to remain constantly encouraging. It can help to point out that, in your research, you struggle with most of the problems you work on and often fail to solve them. The goal is to get students to embrace the struggle of learning rather than to view it as a potential source of shame or humiliation. Gradually building your students' confidence while helping them to become more confident is a time-consuming process but it is essential to ensuring that your students succeed.

It may be that a student is having some serious personal crisis and your willingness to talk to them may provide an opportunity for them to open up about it during an office-hours meeting. Such interactions can be particularly helpful to the student but they can also pose serious challenges. Many experienced teachers like me have been confronted with students who are so overwhelmed that they are contemplating suicide. Such situations require an immediate and urgent response. Your campus will have designated procedures for dealing with such crises. As with everything in the pedagogical domain, it pays to be prepared in advance in case such an emergency arises.

One useful topic to discuss during an office-hours meeting with a student is what their study habits are. Do they have a quiet place to study where they are not being distracted? Do they always work alone or do they engage in study sessions with classmates? Most large state universities will have something like the LSU Center for Academic Success. The goal of this Center is to help students to make the transition from high school to college. In particular, students are taught about how to study. If you are teaching a class for first-year students, drawing the attention of those students to the value of services provided by such Centers can make a big difference in how they cope with the intellectual challenges of college.

6.3. Tutoring during office hours. Most graduate students have had some experience of formal or informal tutoring when they were in high school. The general lesson that I have tried to convey in the earlier sections is that a class should be like a tutoring session except that the class has one teacher and forty students while a tutoring session has one teacher and a small group of students. The main goal of a tutoring session is to engage the students. A quick way to finish such a session is to just show the students how to do the problems. We can't swim just because

we have watched someone swimming. Likewise, watching someone else doing a problem is of limited value to students. Pat was an outstanding teacher who was very concerned about helping her students to succeed. She had an anxious student, John, who attended office hours almost every day and Pat was worried about John's reliance on her guidance. I told Pat how, when my daughter, Margie, was learning to walk, her grandmother would follow Margie around and catch her when she fell. This meant that Margie didn't initially learn how to deal with a fall. Pat was trying to prevent John from falling by doing too much for him. I encouraged Pat to try a different approach. Specifically, when John asked her a question, her initial response should be to reassure John that she was confident that he could answer the question himself. With some small nudges and words of support from Pat, John was indeed able to answer many of his own questions and this helped him to develop more of the independence from us that we teachers want for our students. One feature of the relationship between Pat and John that should be noted here is that Pat had patiently responded to John's questions from the beginning of the semester thereby establishing a bond of trust with him. This meant that, when Pat began to withdraw her support and let John act more independently, John trusted Pat enough to respond well to Pat's encouragement that he could indeed manage to do more on his own.

Early in my career, I was teaching calculus I, and I had a student who came to all of my office hours. I fear that my inexperience led me to do most of the problems for him thereby preventing him from developing independence. I believe that the student eventually dropped the course. One of the hardest things for a teacher is to see a student working incredibly hard but still struggling with the material.

6.4. Notes.

- (i) Guerrero and Rod [32] in their study of student-faculty interaction and academic performance find that "office-hour visits are positively correlated with academic performance."
- (ii) A study of Abdul-Wahab et al. [1] at Sultan Qaboos University in Oman concludes that "the main reasons behind the students' lack of interest in office hours were busy student timetables, conflicts between faculty office hours and students' timetables, and easier and faster ways of getting information than visiting faculty members. Additional reasons were related to faculty members' personalities and their discouraging attitudes toward attending office hours."
- (iii) Abdul-Wahab et al. also found that "engineering students are afraid to show weakness in front of a faculty member". They also note that "Students' lack of satisfaction with faculty members and perceptions of faculty members not providing adequate assistance to students were off-putting. In addition, faculty members perceived as having abrasive personalities caused students to avoid office hours."
- (iv) The results of a study of Griffin et al. [31] note that finding ways to induce students to attend office hours can be tricky: "Students who perceive the time and location of office hours as convenient are more likely to attend. However, the mechanisms instructors use to mitigate convenience issues (such as availability through real-time online discussion, or additional office hours by appointment) have no significant relationship ($p > 0.05$) with students' use of office hours."
- (v) A study of Li and Pitts [42] "explored the utility of using IM [Instant Messaging] for virtual office hours as a supplement to traditional office hours and found that even with the availability of convenient and easy-to-use communication technology, students were not inclined to initiate interaction with their professors."

- (vi) In a study of Graesser and Person [30] concerning the effect of tutors' questions in a tutoring session, they report that "35% of the tutors' questions were open-ended questions that gauged whether the student was understanding a topic being discussed (e.g., "Do you understand?" "Are you following?" "Okay?"). Students frequently answer "Yes" when they fail to understand the material because they want to be polite, because they want to avoid appearing ignorant, or because they are unable to detect their lack of understanding. Tutors often accept this feedback, assume the student has mastered the topic, and move on to another topic."

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DEPARTMENT OF MATHEMATICS, LOUISIANA STATE UNIVERSITY, BATON ROUGE, LOUISIANA , USA
Email address: oxley@math.lsu.edu