Graduate Student Teacher Training Seminar Coursepack

Martha Byrne, Dusty Brooks, and Rob Niemeyer

Contents

CHAPTER 1

Preface

1. Purpose of the Course Pack

This version of the Course Pack is based on the Graduate Student Teacher Training Seminar (GSTTS) that was run during the fall semester of 2013. Its purpose is to facilitate running the GSTTS in the future by providing ideas, materials, and advice. By no means is it meant to be a finished product and current and future GSTTS coordinators should feel free to reorganize, rework, scrap and introduce sessions.

2. Format

- Abstract
  - Abstract for Seminar Leaders This is where we describe what we see as the purpose of the individual sessions and talk about what we think are the most important details to try to draw out of discussion with the participants.
  - Preview for Students This will be posted on the MCTP website so that participants and other TAs can see what's coming up. We welcomed all interested TAs to come to the seminar, so this preview gives them a chance to chose to come for topics that particularly interest them.
  - Pre-Assignment Sometimes it is important for participants to have prepared something for the upcoming session. These pre-assignments are listed here. This will be posted on the website at the same time as the Preview.
  - Homework It's homework. You know what it's for. This will be posted on the website after each seminar.
- Seminar Outline
  - Schedule Our schedule, includes amount of time to spend on each topic (ideally) and details about whether to address that topic in the large group or with students in small groups.
  - Post-Seminar Notes What we thought about how that particular seminar went. What went well, what didn't and **what advice we had for future coordinators**. Be sure to read these sections as you are preparing for your own seminars.
- Summary What really happened as we didn't always stick to the schedule. Sometimes that was a good thing. Other times, not so much.

CHAPTER 2

Inservice

1. Abstract

1.1. Abstract for Seminar Leaders. There are things every TA should know before the first day of class including who the important people are in the department and when/why they should go talk to each one. Invite these people - Deborah, Ana, Jurg, Monika, Alex, Dann, and Bobby - to the inservice so our new TAs will know who they are. Since some of the new TAs will be teaching for the first time this semester, we want to give them a chance to teach a "lesson" and get feedback on their presentation style and board work. There is a TA handbook that should be BRIEFLY introduced. This is also a time to talk about any concerns people have about the upcoming semester.

1.2. Preview for Students. You're a Teaching Assistant. Now what? Meet some of the people in the department you'll need to know as you fulfill your TA duties, and get ready for your first day of class.

1.3. Pre-Assignment. Prepare a 5 minute lesson on a topic of your choosing (we've had lessons on everything from the midpoint formula to how to make crepes). You will be presenting this lesson to your fellow participants and getting feedback. Make sure that your lesson will require board work.

1.4. Homework. Read the TA handbook. Get your keys and textbook. Figure out where your classroom is.

2. Seminar Outline

2.1. Schedule.

2.2. Post-Seminar Notes. Marthas and Dustys reflections on the in-service meeting:
What went well:

- Having the TAs present in two separate groups in different rooms. The smaller groups were friendlier, and helped the TAs feel more comfortable I think.
- Specifying that TAs needed to use the board in their presentations. Most of the useful comments that we had for each other came up as a result of common board work mistakes.
- In one group we let everyone talk, and the audience wrote down comments. Then afterwards we talked as a big group about things we saw that were good, things we saw that werent as good, and how to go about fixing these issues. This was better than discussing each person individually because it was more time effective, and it lessened the likelihood that anyone would feel attacked or overly criticized. In the other group, we discussed the presentations individually, but as they were all fairly strong presentations, that still went well
- Having the staff actually come in and explain who they are and what you should contact them for.
- The location for the meeting was very good. The circular tables I think facilitated talking more, and having the conference room available for presentations next door was convenient.

What did not:

- Some students were not prepared to give their mini-lectures
- As a personal preference I like to have one speaker at any given time. I thought were tended to trade back and forth too much while covering the material. We split the sections up by primary presenter, but ended up switching back and forth anyway.
- TAs didnt seem to know the most pertinent questions to ask. This could be because they had not yet met with their coordinators, and so had limited information to work with.

- We didnt end up using our ice breaker idea (quotes) because most people didnt show up with quotes.

Proposed changes for the future:

- Include in the schedule for in-service that TAs should come prepared with a 5-minute lesson on anything that includes board work. If it is in the schedule, TAs may be more likely to come prepared. Unfortunately, many of them do not read all of their emails.
- We split up the lectures fairly well to begin with, but during our presentations we realized that we had extra information or corrections to make individually. If in the future we plan out the presentations in more detail, discuss exactly what we are going to present, and stick to that plan (aside from stuff that comes up in questions), we will be less likely to present information that all of our team does not necessarily agree with or want to promote.
- Have our in-service meeting after the Big Meeting and after everyone has met with the course coordinators. This way TAs have more information about their specific classes and can ask us better questions with that knowledge.
- Prepare an ice breaker that doesnt require the TAs to prepare ahead of time. We should still have an ice breaker though, as it helps people get more comfortable talking to each other.
- Make sure someone has access to the conference room next door if we meet in the education classroom again. Martha already did so it wasnt a problem for us, but could be for the next team.
- Follow the example of the presentation group that saw all TA presentations and then had a discussion rather than discussing the presentations individually.

Robs additional comments: none

3. Summary

1:00-1:47 Intros and Ice Breakers

- Ana Parra Lombard
  - Consult Ana if you would like to be a grader and have a grader for your class. She also handles our contracts, and you should send any students with prerequisite issues to her.
- Deborah Moore
  - Deborah supervises staff. If you have a grader, she is the person who must approve your grader's timesheet after you have signed it. Also contact Deborah if there is a scheduling conflict with regards to when you teach.
- Claudia Gans
  - Claudia issues keys, copy codes, desk copies of your textbook, and assigns offices and mailboxes. She is the person to contact if there is an issue with the copiers. You should contact Claudia if you do not receive your IDEA course evaluations towards the end of the semester. On the day of the final exam, go to Claudia to pick up the exams for your class.
- Dann Brewer
  - Dann is the person who manages computer accounts, proximity crds, and IT issues. Our IT department is separate from UNM's IT support. For IT issues, email ticket@math.unm.edu
- Bobby Ortiz
  - Bobby is the building manager. You should only need to contact him in the event of vandalism or other issues with SMLC.

1:47-2:03

We broke into small groups and had the instructors discuss with each other what they want to get out of the seminar. The ideas were:

- Bridging the gap between what students are expected to know when they enter a class and what they actually know.
- Time management in class and on a weekly basis.
- How to be consistent, efficient, and fair when grading
- The responsibilities and freedoms of recitation instructors

- Group work and problem solving approaches to teaching, how to implement them, and how effective they are
- Cheating
- First time teaching, what to expect

Dusty, Martha, and Rob's ideas for the purpose of the seminar:

- Provide professional development for teaching assistants, get them involved in mentoring
- Help new teaching assistants develop some sense of comfort int he classroom
- Place an emphasis on teaching and good teaching practices within our department culture
- Create a supportive community for teaching assistants to help them become better teachers
- Improve student perception of math and math classes
- Be better teachers for our students so we can better serve them and they will learn more.

2:03-2:43

We told the teaching assistants that there is an MCTP website that will be updated and has two teaching handbooks for them. One will be a living document that we add to and edit as the seminar progresses. It is UNM Math Department specific and has policies, advice, and good practices for teaching assistants. The other handbook is a teaching assistant handbook from the Mathematical Association of America. It is geared towards general math instruction not specific to our department.

Rob introduced the key ideas in our seminar handbook. They key points were:

- Campus police are the people to contact after hours if you lock yourself out of your office so it is a good idea to have their number in your phone. Contact Claudia if you lock yourself out during hours.
- SHAC has a pharmacy, doctor's office, one free massage per semester for graduate students, and your first two appointments with a psychologist for free.
- Before class procedures including conduct, attire, and the importance of using a webpage.
- Johnson gym
- Set course policies and stick to them

2:43-3:05 Break

3:05-3:11 Rob finished the discussion of proper conduct and attire and we clarified the lottery scholarship.

3:14-4:00 The seminar broke into two sections and we had new students give a 5 minute teaching presentation with board work. We wrote down feedback to give to the presenters later via email, and followed the presentations with a brief discussion of the good and bad things we saw. Key ideas were:

- Use color when available and appropriate.
- Check whether your board work is visible to students in the back of your class by walking to the back of your class while they are writing.
- Speak up and make sure you annunciate.
- Don't talk into the board.
- When you are explaining things not he board, gesture to them, and then look at your students while you talk.
- Make eye contact early and often.
- Check students' faces for understanding.
- Break your board into sections and plan the order in which you present information to avoid running out of room and to make notes clearer for your students.
- Use headings.
- Use notes, but don't be afraid to step away from your notes to address issues that come up unexpectedly.
- Use examples that do not look like ideal cases, and exaggerate differences in dimension when drawing shapes.
- End your sentences as loudly as you begin them.
- Write your email and office hours on the board often

4:00-4:35 We broke into groups and discussed the best and worst teachers that we had and what made them good or bad. Then we got together and wrote those observations on the board, noting that we should

focus on doing the things that good teachers do.

Good Teachers	Bad Teachers
Engaging	Subbornness
Clear expectations	Lack of subject knowledge
High expectations	Lack of preparation
Knowledgeable	Making a lot of errors
Competent	Laziness
Passion ate	Unwilling to admit mistakes
Willing to learn	Lack of interest
Care about your success	Unethical behavior
Approachable	Condescending attitude or comments
Patient	Too much time spent off topic
Adaptable	Lack of explanation of underlying concepts
Responds to emails	Me vs. You mentality
Well prepared	Provides insufficient feedback, if any
Clear board work	Blaming students for not understanding the material
Professional	Boring
Learn their students' names	Lack of energy
Implemented group work effectively	Bad communication
	Unapproachable
	Having low expectations

CHAPTER 3

Preparing for Class

1. Abstract

1.1. Abstract for Seminar Leaders. This seminar will help instructors get ready for class. It will be beneficial to have instructors sitting with others teaching the same course/recitation.

Even though some things seem just like common sense, we want to make sure that we're all on the same page. Know where the supply drawer is in the office (check to make sure it's still in the same place), the copier policies, and what to do if your classroom is locked.

Instructors often like to just use examples from the book, but it's good to have other examples so that students can still turn to the book if they need even more examples to study. However, when creating one's own examples, it's important to avoid potentially confusing aspects - e.g. make sure to have examples with "ugly" number answers so that students don't think they're wrong if they get a non-integer solution; exaggerate differences in diagrams so students don't think something is supposed to always exhibit some geometrical property that isn't inherent; exaggerate algebraic or arithmetic differences as well.

While we all know the mathematics behind the courses we're teaching, we can't just go into class without preparing. Planning lectures ahead of time saves stress and fumbles during lecture and helps keep you on track. Reviewing your lecture notes after class for timing can help improve time management for subsequent classes.

Group work takes up a significant amount of time. Some ways to work around losing too much breadth while focusing on group work include assigning pre-reading and reading quizzes, and focusing on key topics during lecture.

1.2. Preview for Students.

- Know your classroom
- How examples can sometimes convey the wrong information
- Time management in the classroom

We will discuss the importance, preparation and use of lecture notes, how to prepare appropriate examples to do with your class, and time management.

1.3. Pre-Assignment. Please come prepared with an example you intend to use in an upcoming lecture. If you are teaching a recitation section, prepare an example problem for a topic your students will be covering in lecture. If you have an example that tends to confuse students or may be misleading, bring that example as well.

1.4. Homework. We will send out a couple of example problems. TAs should grade these example problems before the next seminar. During the next seminar, we will discuss the breadth of grades assigned to each problem and why different TAs grade the same problem differently.

2. Seminar Outline

2.1. Schedule.

- (15 min, Large Group Discussion) How is your class, what is going on, what issues are you having, is there anything you need to address now?
- (< 5 min, Short Lecture) Know what supplies you need for class, how to get into your classroom if it is locked, how early should you get to your classroom, do you have enough copies of quizzes etc., have you planned for how long it takes to hand back quizzes/homework?

- (< 5 min, Large Group Discussion) Talk to them about common issues with examples and briefly present a few good examples, explaining what misconception or misunderstanding they help students understand.
  - Midpoint formula presentation
  - Using fractions in long division problems
  - Pre-calc example that Rob will find illustrating a common mistake students have with identities.
- (10 min, Small Group Discussion) Students should have brought in example problems that they plan to use in class that week. They will talk in small groups about how to present those problems, and what issues they may encounter. Instructors should briefly visit groups to make sure they are actually on task and to help them identify possible issues with their examples. Try to remember which groups had ideas that the whole group could benefit from discussing.
- (5-10, Large Group Discussion) Recap as a group things the small groups noticed about their example problems. Ask groups to share their ideas and call on groups that you noticed had really good ideas during the small group discussion.
- (10 min, Small Group Discussion) Lecture Notes. Instruct small groups to discuss how they write lecture notes, how detailed they should be, how they use them etc. Be sure to emphasize the importance of lecture prep.
- (10 min, Large Group Discussion) Recap with full group on lecture notes.
- (10 min, Large Group Discussion) Time Management.
  - If you're doing group work, how do you stay on track? How do you give them enough time to do group work, while not wasting time? How do you get them to work through the problem in the allotted time, instead of slacking off during that time? Make sure to plan enough time for the quizzes you give.
  - Check if your clock in your classroom is accurate. If it is not, you dont have a clock, or you have a hard time remembering to end on time, bring your own clock, set an alarm etc.
- (10 min, Large Group Discussion) Questions and grace time.

2.2. Post-Seminar Notes.

- What went well:
  - Examples. It was a very good idea to have the TAs come up with their own examples of things that may be misleading, or common misconceptions that they see.
  - The TAs were generally pretty open to talking in front of each other and showing examples on the board.
- What did not go well:
  - We did not necessarily stress the importance of lecture preparation enough. It is essential that TAs know they must be prepared. If they have to wing it once and it works out for them (from their perspective) they will be more likely to fall into that habit. We did not all emphasize this to the same degree.
  - We spent a good deal of time debating whether you should prepare example or come up with them on the spot. The discussion was productive but we did get behind.
- Proposed changes for the future:
  - Really emphasize, without patronizing, the importance of always preparing for class and learning students names.
  - Come up with specific strategies for learning names. We presented some ideas, but because this is so important we may want to work on that more. We can probably just set the precedent that examples should be prepared ahead of time (though you can come up with new ones in response to questions) and save some time avoiding that debate.
  - If possible this should be moved into the expanded in-service time so that we can talk about it before TAs see their students for the first tim

3. Summary

- Know what supplies you need for class.
  - There is a supply drawer in the admin office.
  - If you are teaching in a classroom with a white board, it is strongly recommended that you take your own markers and eraser.
  - Get to class early enough to take care of any issues (like a locked room) without losing class time.
  - Keep the phone number for security handy in case your classroom is locked.
- It is essential that we choose good examples to do with our classes, as students can focus on unimportant or misleading details. We talked about different ways to pick good examples.
  - When illustrating examples, make sure differences are exaggerated in your drawings. For example, dont draw something as a square if its really a general rectangle. Some student will fixate on the fact that its a square and try to use that information on future problems.
  - Do difficult examples even though they take more time. For example, if you are teaching polynomial division, make sure you do examples where there are fractional coefficients in the quotient. You dont want to any of your students with the impression that the quotient will only ever have integer coefficients.
  - Be careful with textbook definitions and carefully use examples to show how/why those definitions can be misleading.
    * Some texts define tangent lines as lines that touch the graph of the function at one and only one point; however, this is often not true. You can use a representative cubic function to show the falsity of this statement while illustrating the intended meaning of the definition.
    * Some texts state that horizontal asymptotes, like vertical asymptotes, cannot be crossed, which is also not true. Use an example that violates this to talk about the differences between horizontal and vertical asymptotes.
  - There are many topics that students commonly make mistakes with (e.g. forgetting the absolute value when taking the square root of both sides of an equation or distributing a power over a binomial instead of multiplying out). Use a specific example to show why this fails.
    * $(4-\frac{9}{2})^2 = (5-\frac{9}{2})^2$, but if you take the root of both sides, you are left with $(4-\frac{9}{2}) = (5-\frac{9}{2})$ which implies that $4 = 5$. This is clearly absurd. Make sure you show why the initial equation is valid and how that leads to the necessity of the absolute value. If you do anything mathematically incorrect on the board, do not just say it is wrong and erase it. Cross it out on the board, and write THIS IS WRONG next to it. Students write down what is on the board and not what we say, so dont let them leave with illegal mathematics written in their notes.
    * When solving inequalities with algebraic fractions, students often want to multiply by the denominators to get rid of the fractions. This is not reasonable, so use an example like $\frac{1+x}{1-x} \geq 1$ to show what happens when you do that, contrast it with the correct solution, and again cross out the incorrectly worked problem.
- We all have to prepare our lectures. We discussed some strategies for preparing well.
  - Have two lectures worth of prepped notes ready every time you enter the classroom. That way if you have time at the end, you can fill seamlessly.
  - There was some debate about making up problems on the spot. Consensus was that for some topics in some classes this is reasonable, but in general you want to have examples prepped beforehand. This is a way to make sure that the linear system youre working with (for example) is consistent or inconsistent depending on your desire.
  - Dont use power point slides. Ok, if youre in a classroom with a smartboard it can possibly be done well, but really, its best to avoid them.
  - Get to know your students so that you can tailor lectures and examples to them. Do you have a bunch of humanities students? Soccer players? You can write examples that speak more to their interests that will get them more engaged in class.

- At this point, we were running a little behind, so it was a great time to talk about time management.
  - Check the accuracy of the clock in your classroom.
  - If you dont have a clock, find an unobtrusive way to keep track of the time. DO NOT pull your cell phone out of your pocket in front of your class.
  - Set a watch or phone alarm if you absolutely have to so you can let your students go.
  - When you write your lecture notes, put estimated times down so you can stay on track.
  - Make notes about what took more or less time than expected so you can adjust in the future.
  - When planning lectures, always give yourself a little bit of grace time in your estimations.
- We ended with a short discussion of the importance of learning students names. This is important because they believe you care about them and because you can keep a better eye on which students, if any, are leaving class early or behaving badly.

Grading and Notation

1. Abstract

1.1. Abstract for Seminar Leaders. Harshness and leniency definitely vary between instructors, and some variance is acceptable; however, too much variance leads to inconsistency between sections and rude awakenings for students when faced with different instructors. The problems assigned for the TA's to grade will help draw out differences in grading and highlight when people are being too harsh or too lenient. The group discussion should get people talking about the importance of determining the point of particular homework problems as a place to focus grading. This discussion should also highlight strategies for grading consistently.

It is important to employ both summative and formative assessments in class so that instructors can assess students' progress and also assess their own practices and tailor teaching practices to the specific section so that students get the most of of the class.

Notation is important. One of the goals of this seminar is to help establish department-wide notation expectations. Homework in particular should be graded not only for content but also for presentation.

1.2. Preview for Students.

- What to do before you start grading
- Getting back HW and Exams on time!
- Summative vs. Formative assessment.

Next week in our teaching seminar we are going to be discussing grading. To kick start the discussion, you have been emailed problems to grade. We will discuss good grading practices, how to decide point distributions, how to grade consistently, and why different TAs grade the same work differently. Be sure to bring your graded problems and your key/rubric or a written blurb on what method you used and how you established the given grades.

1.3. Pre-Assignment. To kick start the discussion on grading, you have been emailed different students work on the same problem to grade. Please grade each of the problems as you would if this were a homework assignment you would return to the students. You should grade the problem out of 10 points, but it is up to you to make your own key and/or rubric for grading. Bring the graded sheets with you on Tuesday.

Please also bring your key/rubric if you use one. If you don't, write a blurb on what method you did use and how you established the given grades. Thanks.

1.4. Homework. None.

2. Seminar Outline

2.1. Schedule.

- (15 mins max, Large Group Discussion) Current problems, concerns, questions, frustrations etc.
- (Before Class) Make a chart on the board with the scores that everyone gave on the homework problems. Have them do this as they come in.
  - (10 mins, Small Group Discussion) Have mixed groups. Ask them to decide what the major disparities in grades are based on.

- – (10 mins, Large Group Discussion) Recap and discuss whether groups came to a consensus, or why not? What were the most important ideas in the problem and did the grading reflect that.
  - – *We all noticed that, more or less, everyone agreed on how to grade the particular problems. There were some outliers and those who gave those either extremely good scores or extremely bad scores were asked to defend their positions. A good discussion ensued.*
- (5 mins, Large Group Discussion) Write ideas on the board as students offer them. What to do before you start grading? Point distributions, look at several papers before you make those decisions and start grading.
- Brief Disclaimer: Promptness, the importance of getting papers back early. You should not have outstanding homework when you assign new homework. It should never take more than a week. Now, of course, you may have someone else helping you with your grading. This person may also have four other classes to grade for. Hence, it may not be possible to get exams/quizzes/hw back to a student as promptly as you would like. In such an event, providing solutions before the work is passed back would give students and opportunity to check the solutions against their memory of their work.
- (10 mins, Small Group Discussion) How to establish these: consistency, fairness, efficiency.
  - – (5 mins, Large Group Discussion) Recap ideas from small group discussion.
    - ∗ Some graders give points for ANYTHING. Unless one perhaps uses this as a book keeping technique, such a practice should be avoided. For example, the grader gives 1/10 points for attempting a problem so that if they are looking at the grade book, they know 0/10 indicates the problem was not attempted at all. This is particularly useful practice when it comes to grading quizzes. A zero would indicate the student did not show up for the quiz, but 1/10 indicates he/she was present for the quiz.
    - ∗ Grade one problem at a time. That is, grade every No. 1 first and then grade every No. 2, and so on.
    - ∗ Establish consistency. Look over all of the problems of every exam/quiz/hw and figure out what the general errors are. Did students figure out how to do a problem differently? Coming across a different solution may throw you off, especially if you're sleepy and been grading a lot already.
    - ∗ Try not to let your (positive or negative) opinions of a student influence how you grade; most of all, your negative opinions. We do not always know what a student is going through, so try to remain unbiased. A great way to prevent any bias from entering your grading, ask students to put their names on the back of the first sheet or last sheet so that you don't automatically spot the name at the beginning.
    - ∗ Make sure that poorly written work is not mistaken for incorrect work.
      - · You may want to warn a student that if they do not do something to improve their writing, you will have to take off points in the future.
- (5 Big Group Discussion) How to give comments when grading.
  - – Should explain points taken, but comments should be brief.
    - ∗ Some of the reasons for how graders allocated points:
      - · Different perspectives on what the problem was testing
      - · Different perspectives on what was important and the different weights placed on particular parts of a solution.
      - · What constitutes an appropriate level of justification when giving an answer
      - · Was the problem not worded correctly or was it ambiguous, hence more points given than earned.
  - – The derivative problem: does the student understand the first derivative, can he/she calculate it, are there any problems with reasoning?
  - – $(a + b)^2 = a^2 + b^2$. A situation like this clearly demonstrates a lack of understanding (well, there are different settings in ring theory for which this is true, but this is trigonometry and

precalculus). But an error like $2*3 = 5$ is just an honest mistake that should not be penalized much (if at all), so long as the error does not indicate a larger problem with understanding.

- Brief Disclaimer: Promptness, decide when to schedule exams and be consistent. Thursdays and Fridays are good so students have time to meet with you for help in the days leading up to the exam, and so you have time to grade and they can decompress over the weekend.
- (2-3 mins, Small Group Discussion) How does it differ from homework grading? How should it relate?
    - (2-3 mins, Large Group Discussion) Recap.
        * Exams can be harder to grade than homework or quizzes, because they are naturally longer. Hence, leave yourself plenty of time and make sure you are refreshed when grading exams.
- (10 mins, Lecture) Summative vs. Formative Assessments (introduce summative and formative assessment, ask them how they would do that assessment, and just do a chart on the board)
    - Formative: Use homework, quizzes, to evaluate your teaching
        * Martha's Idea: at the end of every class have a "quiz" about what students think was most important that day and what they are still confused about
            · This is also a great way to take attendance and get to know your students better.
        * Mid-semester evaluations (just mention)
            · You can even give these twice.
    - Summative: Exams and quizzes that check student knowledge
        * When giving comments, try to be constructive. Simply circling something that is incorrect may not get your point across. Of course, your reasoning may be that you want students to come and ask you why you circled that and why they lost points. However, some students may not be that motivated and actually more frustrated by the fact that they don't even understand the comment. So, use that technique wisely.
        * Don't want to write on their exam? Use post-it notes. Very useful.
        * General comments may be something you can address in class. If you circle everyone's similar mistake and then address it in class, this can prove to be a big time-saver and helpful for the students.
    - Only curve at the end of the semester, if you can curve at all.
- (15 mins, Large Group Discussion) Questions and "grace" time.

2.2. Post-Seminar Notes.
- Dusty's Comments
    - We talked about what the discrepancies in grading could be from, but we didn't really get down to the point in our groups. TAs should have come out of this exercise knowing what they took off too many points for or what they let slide that they shouldn't have. We covered most of the material in our outline, but some of it was very redundant. The discussion on grading discrepancies already explored some of the things we wanted them to identify in the next discussion. That we all grade very differently was well established, but I don't think we established that those TAs whose grades for the assignment differed dramatically from the median are grading "wrong" in some sense. So the discussion may not have been corrective of bad grading processes.
    - You may want to combine topics, merging the discussion of consistency, fairness, etc. with the discussion about the distribution of grades on the homework. What to do before grading, and how to grade homework relates well with how to grade exams and quizzes. You may also want to pair TAs up by how they graded the homework so we know they are discussing the grading specifically with someone who graded very differently. This forces them to defend their grading and listen to an opinion that justifies grading very differently. This may have more potential for correcting bad grading than larger group discussion.
    - When we asked the TAs to form groups with people that graded the homework differently, they pretty much just discussed with the people around them rather than searching out peers who graded differently.

- The evaluative assessment portion could be expanded, or removed from this seminar and discussed with formative assessment during the seminar on evaluations.
- I think we need some way of letting people know that their grading was too harsh or too easy. This is a hazy area because it comes out as us telling people how to grade. But if the majority of TAs give an assignment a grade in the 6-8 range and someone gave the same assignment a 2, that needs to be discussed frankly. It should be explicit that this kind of discrepancy is symptomatic of inappropriate grading. To do this we need a consensus on the acceptable range of grades before the meeting. You could ask the coordinators to tell us what they think is an acceptable grade range for the problems. Then you have some power to explicitly say to the outliers that they need to revise how they grade. Knowing that their coordinators would grade something much more harshly or much less harshly will be more convincing to those with strong grading convictions than our opinions or the popular opinion in our group.
- Another tactic for correcting bad grading practices would be to actually collect all of the graded examples, then go through and write feedback for each person on how their grading relates to some rough standards that you set with the coordinators. That way you can privately let people know where their grading is not appropriate. If you do this you will want to make sure the TAs know that your comments are based on a consensus amongst the coordinators, rather than your opinions alone. They will probably not respond well if they think you are telling them how to grade. You want them to think that we are helping them match their grading with a standard.

- Rob's Comments
    - Generally, it is helpful that everyone who is grading a particular exam reach a consensus beforehand on what constitutes an appropriate rubric. If everyone agrees that certain mistakes are more indicative of a lack of knowledge than other mistakes, then grades can be assigned in a consistent fashion. Of course, the hope is that when the group of graders reaches a consensus, the grades are also relevant.
    - Uniformity in grading is very important. A lack of uniformity can lead to complaints and a general breakdown of student morale if one is not careful how he or she grades particular problems.
    - Regarding Dusty's last comment beginning "Another tactic...", I am proposing the following. We could have TA mentors. These would be TAs in their 2nd year of TAing. They would be in charge of making sure 1st year TAs aren' stumbling over some of the hurdles they run into the first time around. The idea of having TA mentors is part of a larger idea I have for the seminar. These TA mentors could then review the grading rubrics of their mentees and provide guidance on how to more appropriately grade. This would then spread out the work of commenting on the graded problems and still bring the 1st year TAs to a consensus on what is considered a more appropriate grading style.

- Martha's Comments
    - I want to add my support for talking about formative and summative assessment in the mid-semester eval seminar, and maybe the writing exams seminar. We could emphasize summative when we're talking about writing exams and emphasize formative when talking about evals. That way the terms would not only be introduced but also explained more fully with direct application.
    - Also, having fewer TAs in the seminar due to changing the participation requirement to first time TAs will greatly facilitate better discussion about why people graded how they did.

3. Summary

Motivating Students

1. Abstract

1.1. Abstract for Seminar Leaders. Have instructors sit in small groups according to what they are teaching.

We all know that motivated students perform better and learn better than unmotivated students, but we should not leave all the motivating up to the students. It is vital as instructors that we actively pay attention to our students' motivation level and work to increase it.

A particular challenge for this seminar is motivating the unmotivated TAs. Some people are motivated to teach well, and others are not. Use the TAs' responses to what motivates/demotivates them as students and as instructors to tailor this seminar. This is a seminar about not only how to get our students excited about class but how to get ourselves excited about teaching.

1.2. Preview for Students. Motivated students learn more and are more fun to teach than unmotivated students. We'll talk about why one of your responsibilities is to engage and motivate your students as well as strategies for doing so.

1.3. Pre-Assignment. None.

1.4. Homework. None.

2. Seminar Outline

2.1. Schedule.

- Write on the board and tell people as they come in to sit at tables with other recitation instructors or other lecturers.
- (15 mins, Large Group Discussion) Current problems, concerns, questions, frustrations...
- Motivating Students Video- "An Open Letter to Students Returning to School (vlogbrothers)"
  - http://www.youtube.com/watch?v=x78PnPd-V-A
- (5-10 mins, Lecture) Why is it important to motivate students?
  - What do we mean by motivation?
  - Because we are here for our students.
  - Because math is awesome.
  - And yes, because evals are important and we do want to get jobs later.
- (5 mins, Large Group Discussion)
  - Pay attention.
- (10 mins, Large Group Discussion) Demotivators
  - What makes you less motivated as a student.
- How to motivate your students:
  - (5 mins, Small Group Discussion) What do you do now to motivate them?
  - (5-10 mins, Large Group Discussion) What were the unusual things that came up in your small groups?
  - (15 mins, Individually or in Small Groups) Pick one of the motivation tactics listed on the board and figure out how to employ it in your classroom.
  - (briefly, Large Group Discussion) How to get students to come to your office hours.
- (15 mins) Grace time and questions (and Infinity Elephants (vihard) if there is time)

– http://www.youtube.com/watch?v=DK5Z709J2eo

2.2. Post-Seminar Notes.

- What went well:
  - Our motivation video
  - Group discussion was particularly productive in this seminar. When I went around to check on the groups a lot of them were talking about very specific and positive things that they do to motivate students.
- What did not go well:
  - Our motivation video (some people got it, some people didnt, which was disappointing)
  - It seems like we really boosted the motivation of our motivated TAs, but left some of our non-motivated TAs nonplussed.
- Proposed changes for the future:
  - We need some way to connect with the TAs who are unmotivated. I have no idea how to do that. Even if we know who they are, we cant exactly call them out on it. One thing we could try is to have the TAs write us blurb on what motivates them in their teaching, or what de-motivates them in their teaching. If they are honest and we collect this before the motivation seminar, then we can deal with the specific issues that have some of our TAs de-motivated.
  - Rob thinks we should emphasize to the students who lack enthusiasm that their mild apathy can lead to a stronger apathy. A continual decline in their performance as a TA will only reflect negatively on the math and stats department. If the math and stats department continues to develop a reputation as a department with apathetic TAs (and maybe even, in general, instructors), then we begin drawing the attention of deans, etc. That is negative attention does not do any good for the math and stats department and raising this point on multiple occasions and perhaps motivate the less-than-enthusiastic TAs to make sure they at least behave responsibly and strive to do a solid job of teaching, even if they dont feel like they are required to.
  - Martha thinks that in addition to pointing out that apathetic teaching reflects badly on the department, we need to really emphasize that apathetic teaching is harmful to students and that we have a responsibility to our students to do a good job. I really like the idea of having the TAs get us info on what motivates and de-motivates them before the seminar so we can address specific things.

3. Summary

- Students with disabilities remark: You can call accessibility services if you are concerned about a student. Ask for the student's case worker, which is listed on the blue letter you received from accessibility services.
- Brief discussion regarding political pins/shirts/etc.: It's hard to get students to open up and come to office hours If you portray a message contrary to their personal beliefs or political opinions, it makes it even less likely that they will feel comfortable approaching you for help. You are their math teacher and they already fear you.
- We watched this video about the purpose of school, because it is very motivating/inspirational. http://www.youtube.com/watch?v=x78PnPd-V-A&feature=plcp
- What motivates students?
  - Grades
    * This is why they always want to know what is on the test, rather than how to understand a specific topic
  - Wanting to go to class
  - Wanting to actually learn the material No student will want to be there every single day, but you should look like you want to be there every day, and actively work to get students excited about going to class.
- Why motivate students?

- We are here for our students and it is our responsibility to motivate them.
- Motivated students learn more and learn better than unmotivated students
- Teaching motivated students is more fun for us! It can be hard to want to teach a bunch of students who don't want to be there. But if your students want to be there, it can create a motivation loop.
- Math/stats/biomath are awesome!
- Motivated students write better evaluations of their teachers
- How do you know if/when your students are not motivated?
  - They don't go to class
  - They don't ask/answer questions
  - They don't pay attention or spend their time in class looking at their phone, their laptop, a window, etc.
  - There is no dialog, no email communication, etc.
  - They don't catch your mistakes (which are of course few, far between, and always intentional)
  - They don't turn in their homework
  - They stop doing work, participating, and turning things in even though they used to
- What are de-motivators for teachers?
  - We may be required to teach things in a manor we disagree with
  - We may have a lack of control over our class, the material, assignments, and/or exams.
  - WebAssign
- How can you motivate students?
  - Learn and remember their names/favorite color/other classes they are taking and other random information they share with you
  - Write positive comments when grading
  - Be humorous. Have a sense of humor about your own mistakes or idiosyncrasies (without ignoring mistakes)
  - Explain things well and thoroughly
  - Make the material relatable. Draw connections between class work and the real world.
    * Ex. How the moon was created, satellite dishes, soccer problems
  - Candy. This is especially good for office hours.
  - Demonstrate a mastery of your subject, without alienating your students or diminishing their struggles
  - Admit when stuff is hard. Your students well be motivated by knowing that you found this stuff hard too once, but look how far you've come.
    * "When I was learning this, I really struggled with this bit."
  - Provide examples showing when certain techniques might not work out (try by parts, even though you know it may not help) to show them both the problem solving process, how to recognize when an attempt is not fruitful, and that it is not the end of the world when the first technique fails.
  - Foster more interaction in class
    * Have students "guide" you through problems in class
  - Actually believe in each and every one of your students
  - Encourage questions
  - Provide students with extra cool math stuff that complement the class, or may be outside the scope of class, but still very interesting and accessible.
    * Ex. vihart on youtube.com
  - Take pride in what you do and how well you do it
  - Care about what you are teaching

Evaluations

1. Abstract

1.1. Abstract for Seminar Leaders. This seminar is designed to help the instructors create mid-semester evaluations to administer to their classes. It should address the benefits of mid-semester evaluations and stress the importance of administering them. Try to draw out positive anecdotes from your more experienced participants or from your own experiences.

Be sure to budget significant time for the TA's to write their own evaluations and discuss them with others. But leave time for them to evaluate the GSTTS. You will need to address these evaluations at the next meeting.

1.2. Preview for Students.

- Benefits of administering mid-semester evaluations
- How to write good evaluations
- How to effectively administer evaluations

At the end of this seminar you will have a rough draft of a mid-semester evaluation you want to administer and a plan for using it to enact positive change in your classroom.

1.3. Pre-Assignment. None.

1.4. Homework. Administer a mid-semester evaluation to your class. Write a brief summary of your experience with mid-semester evaluations. You do not have to address the criticisms you received, what changes you are making, etc. Ultimately, that information is for you and you alone. We would like to know what challenges you had with mid-semester evaluations, to what extent you found them useful, and what you want to do differently the next time you administer them.

2. Seminar Outline

2.1. Schedule.

- (15 mins, meet in pairs) Meet with your classroom observations partner.
- (10 mins) Mid-semester evaluations of us.
- (Briefly) State the purpose of mid-semester evaluations
  - They give you the feedback you need to improve your teaching and they communicate to your students that you care about their learning and how you teach.
- (15 mins, Large Group Discussion) How to administer mid-semester evaluations i.e. what sort of things do you need to consider:
  - How do you minimize time?
  - What part of your class should you designate for this?
    * If you do them at the end of class, students will rush to finish in order to leave early, meaning you get less feedback. But this also means you can control how much class time is given to evaluations. If you do these at the beginning of class you will get more feedback, but the students may take more time than you anticipate filling out evaluations.
  - What instructions should you give them?
  - Should you tell them why you want evaluations, what you do with them, etc.? (maybe write on evaluations)

- Be very encouraging, emphasize that you are doing this to make their lives better in the rest of this class
- Explain to them the things that you dont have any control over.
- (10 mins, Small Group Discussion) Brainstorm specific questions to ask on evaluations.
- (10 mins, Large Group Discussion) Write their answers on the board and discuss.
  - How many of these can you ask?
  - Which questions will give you the most/best information?
- (5 mins, Small Group Discussion) Have them write their mid-semester evals or choose which questions to use.
  - Share your chosen evaluation questions with your small group and in particular the person who observed your class, and critique.
- (Briefly) Statement of things to consider when writing evaluations (write these on the board, or project them)
  - Ask specific questions that you need answered vis a vis loudness, homework relation to lecture, etc.
  - Ask open ended questions that don't really imply an answer and leave lots of room for writing
  - Have a space for extra comments
  - Want to keep it a reasonable length, so prioritize the questions you want to ask in case you need to eliminate some of them
  - Copy them for your students, not write questions on the board
    * For anonymity and to encourage lots of feedback
- (10 mins, Small Group Discussion) What should you do with mid-semester evaluations after administering them? What is your plan when you get these back from your students?
  - How will you choose what to focus on?
  - How many problems can you address?
  - How do you enact change?
    * Read them
    * Make a list of all the criticisms
    * Decide which ones are most important
    * Pick one or two at a time to focus on
    * Devise a plan, talking to your colleagues, for implementing positive change
    * Tell your students that you read them, and that you want to fix all the problems. Say what you are focusing on, and why. If there is something you are not going to change (ex. students think a project doesn't actually pertain to the class) explain why.
    * Thank your students for helping you improve
    * Address criticisms that are outside of your control
    * Keep your evaluations to reflect on in the future, and in particular keep the really good ones for portfolios
- (Briefly) Ask the students if there is anything going on in their classes that they want to talk about?

2.2. Post-Seminar Notes.
- What went well:
  - We got a lot of feedback on the evaluations we administered. The TAs were very willing to take time giving us comments.
  - The small groups came up with good questions to put on evaluations, and the big group discussion was very effective for listing those and then making them better/more effective.
- What did not go well:
  - We did not have solid information on when to expect IDEA forms, what to do if you dont get them and when you should worry, etc.
  - We did not address a solid game plan for dealing with evals once you collect them. I also sent out a supplemental email on this, but it is worth covering in seminar.
  - Debate about how open-ended evaluations should be. Some TAs were not comfortable with having qualitative data rather than quantitative data. Most of the debate about this was not

very productive. I ended up emailing them supplemental stuff on this later. This is in the appendices.
- Proposed changes for the future:
  - Talk in detail about formative assessment here and leave most of the discussion of summative assessments to the seminar about writing exams.
  - Have and provide solid information on the IDEA form protocol. It would be great if we can procure an example form so TAs who havent seen them can see what they are all about and why it is a good idea to have supplemental evaluations.
  - Budget more time for students to fill out evaluations (only a bit more time).
  - The question on our mid-semester evaluations asking students if they have been able to implement changes as a result of this seminar and what those changes were was less informative than I had hoped. We can probably eliminate or replace that question.
  - Provide a list of topics we have covered when administering evaluations. It may jog their memories and prevent students from listing topics we have covered as topics we havent covered that they would like us to cover (some did this).
  - Talk about the value of qualitative data and how to analyze it. We dont want to give the impression that quantitative data is superior and can be used just as effectively in mid-semester evaluations (unless that is what the new team believes). Instead of arguing about qualitative vs. quantitative we have the opportunity to teach the TAs about qualitative data in order for them to get the greatest benefit from their evaluatio

3. Summary

- The students took the full time and then some to do this. In the future, perhaps try to leave more time to complete these by either starting earlier or ending later.
- Regarding end-of-semester evaluations, we talked a little about when the IDEA sheet would become available. Be checking your mailbox!
- We then discussed formative vs. summative evaluations and their pros and cons.
- With regards to administering evaluations, some of the comments made by the students include:
  - Be honest that evals do not affect grades. Be explicit about this.
  - Be reasonable in the amount of time you give students to ll out an evaluation. 10-20 minutes
  - Try not to induce bias.
  - Some prefer to administer evals at the end of the class/lecture/recitation and some at the beginning. The argument is that administering at the beginning will prevent students from rushing through them.
  - Be efcient: minimize time spent and maximize the quality of the response.
    * Be effective in your question asking.
  - It may be a good idea to preface by stating what it is you may or may not be in control of (e.g., class time, HW problem selection, etc.).
  - Provide clear instructions, especially if you are asking multiple-choice type questions. You may want to allow more than one selection, which may not be clear if not instructed.
  - Mix open-ended and specic questions.
- We then had a small group discussion on why it is you may want to ask some questions and what questions you should ask. Some response from the students:
  - What portion of the material did you understand?
  - What material do you feel needs more time?
  - What topics have been the most challenging?
  - What topics are you most comfortable with?
  - Do you spend too much or too little time on problems?
  - Does my recitation correspond well with the main lectures?
  - How is my board-work and handwriting? Can I change something?
  - What is the least helpful thing I do?
  - What is the most helpful thing I do?

- How much of the homework do you usually complete?
- How much time do you spend on the homework?
- How do you like my teaching style?
- How do you feel about the grading standards?
- Are there any comments you would like to make that I havent addressed in the above questions?

- Some things that one should consider:
  - Introducing bias
  - Make sure the questions are appropriate
  - Make sure you use multiple choice type questions appropriately (ask your stats neighbor for help!)

CHAPTER 7

Writing Exams and Using Technology

1. Abstract

1.1. Abstract for Seminar Leaders. This seminar needs to occur early enough in the semester for TAs to be able to apply it before the first exam. Group participants by what they are teaching. Recitation instructors can focus on writing quizzes, but as they will undoubtedly be writing exams at one point, don't allow them to discuss only quizzes.

Focus on the problems that typically come up with writing exams such as difficulty level and length. When creating different versions of exams to limit cheating opportunities, there are many different strategies that can be employed such as changing problem order or changing answer order for multiple-choice questions. If you are writing distinct problems, make sure difficulty level is the same. It is important to write exams far enough in advance to proof-read thoroughly.

However, things inevitably go wrong at some point, so be sure to discuss how to handle sticky situations.

Discuss how to choose exam questions. What are the main points of the course that need to be assessed? What do the different letter grades really mean? Think about what it means to have a B in a course and be able to take the follow-up course. What level of knowledge is really needed for continued study? Do you want to pose stretch questions to distinguish the exceptional student in the course?

This seminar was originally intended to cover writing exams and using technology, but it will probably work better to restrict this seminar to writing exams and leave the technology bit for some other time, possibly the last seminar.

1.2. Preview for Students.
- What we learned from our evaluations
- writing/administering/proctoring exams
- LaTeX template for quizes and exams

  We will review some of the comments made by the graduate students and indicate how we will address many of them. After that, we will begin discussing how to write exams, so think about any questions you may have about that. This will include midterms and quizzes, with many of the techniques adaptable to writing a final exam (when you eventually have to do this, if at all). In addition to this, we will also mention that there is a Latex template available for quizzes, which is adaptable to midterms and other types of exams.

1.3. Pre-Assignment. None.

1.4. Homework. None.

2. Seminar Outline

2.1. Schedule.
- (10 Minutes) Address the mid-semester evaluations
  - Collaborative Learning
    * We are covering this next week. Unfortunately, all of the stuff we are covering this semester is stuff it would be great to know before your first semester of teaching. But that obviously wont work, so we hope that the stuff we cover towards the end of the semester is at least helpful for you in future semesters.
  - Our expectations

* We are grading this class on a credit/no credit basis.
* We are still working on figuring out how formal this should be. Because of your feedback we will clarify this from the beginning and have a syllabus.
* We expect:
    · You are here every week on time. If you miss a seminar, contact us ASAP.
    · Actively participate in discussions every week.
    · Complete the assignments that we ask you to. The purpose of assignments is to get you thinking about how to use what we discuss to improve your teaching.
    · Take this seriously. This seminar exists to make you all better teachers. And we need you to take this seriously. There is a lot of money and time going into this seminar because we have a very real problem with low quality teaching in math.
    · If you have other questions about expectations, please just ask us.
  – We will work to include more recitation specific information if every seminar. We recognize this problem and are working on it. Next year we will have this resolved from the get go.
  – Discussion style of instruction for this seminar. There are many different teaching philosophies, and we do not want to tell everyone what their philosophy should be. Discussion allows us to provide you with the most diverse selection of approaches to teaching. Discussion can be frustrating, but we think that everyone has something to offer. There is no one golden way to teach. Also, this helps build a dialogue between TAs so they have a social support structure once the seminar is over.
• (10 Minutes, Large Group Discussion) Have recitation instructors sit together and have instructors of record sit together. Have recitation people talk about writing quizzes, keep in mind they may be writing exams in the future. Talk about problems theyve had in past writing and administer.
  – How should exam questions differ from homework questions and quiz questions?
    * Include a question that expands on the homework to differentiate A-students from B-students.
• (20 Minutes, Small Group Discussion) Have people sit with people teaching the same class that they are teaching.
  – How do you decide what is most important to test on?
    * What continues in future classes? Derivative as a limit is less important than what a derivative is and what a limit means. What sets the stage for future stuff? Bigger picture questions.
  – How do you check that the problems you wrote are well written, unambiguous, and your exam is not too long?
    * Have your coordinator read your exam. Let them know well ahead of time.
    * Compare wording with that in the book, homework, and review sheets.
    * Take your exam!
  – What should you do if you find an error in your exam while your students are taking the exam?
    * Skip the problem. Tell them to skip it as soon as you notice, write it on the board, walk around and check if students are working on that problem.
  – What should you do if the majority of your students cant solve the same problem or all do it wrong?
    * Not grade that problem (have test be out of fewer points).
    * It is an indication that you didnt cover the concept well. When you hand the exams back talk specifically about that problem, and cover the topic that day. And have a mini-exam on that question in the next class.
    * Make sure you LET YOUR COORDINATOR KNOW. Make sure communication is really clear. If there are students who missed class, make sure they know. Cant give same problem.
• (10 Minutes, Large Group Discussion) How do you reduce student anxiety?
  – Phrase questions similarly to homework, book, and review problems.

- Write your exam with questions roughly in ascending order of difficulty.
- You dont have to make all numbers pretty (and shouldnt) but write your test so that students dont get bogged down by pointless computations.
- Be clear about your calculator policy well ahead of time. Make sure your exam is written in a way that is consistent with this policy.
- Tell students what good study strategies are.
  * Should be able to solve homework problems in a reasonable amount of time without using the book. Then they are ready.
- Review properly
- (15 Minutes, Small Group Discussion) How do you review for exams?
  - Can give a list of all the topics you have covered
  - Can give a list of the definitions they need to know
  - Be sure that they know the exam covers all the material covered in class
  - Have students ask questions so they lead the review rather than you
  - Dustys Opinion: Do not hand out a review sheet with problems
  - Pay attention to what topics students struggled with on homework and review those topics
- (15 Minutes, Large Group Discussion) Proctoring
  - How do you proctor exams?
    * No phones, book, etc.
    * Look at your students.
    * Walk around, but let them know ahead of time you are looking around.
    * Pass out different version of the exam so students have different exam than people on either side of them.
  - How do you identify cheating?
    * Look at students eyes
    * Look for phones, notes, etc.
  - What do you do if you think someone is cheating?
    * If the cheating is blatant and out in the open (using a phone, notes, etc.) ask them to leave.
    * If you think they are looking on someone elses paper
      · Stand next to them.
      · Note who they are and who they are sitting next to.
      · Check exams for evidence of cheating.
      · Talk to Tamara and your coordinator if you suspect cheating
      · Consequence: 0 on exam is a good one

2.2. Post-Seminar Notes.
- Dusty's Comments
  - What went well:
    * We ended up discussing a bit of philosophy about how to choose exam questions. Some people thought the exam problems should be very similar to homework problems and some thought at least one of the exam problems should stretch. This was actually a really productive discussion that we may want to encourage. There are benefits to both, and it is worth talking about what information you get from each type of exam and how the differentiate students.
    * The small group discussion on reviewing for exams was very productive. It seemed like the TAs had a lot of strong opinions they were willing to share and justify.
  - What did not go well:
    * We discussed some ways that people may use multiple choice problems, but I dont think we discussed enough how limiting and possibly damaging multiple choice exams can be. I would be interested to see whether the coordinators agree with my opinion that the vast majority of the time, multiple choice questions can and should be avoided. We should have a solid idea about whether they are and when they are appropriate.

∗ We had a bit of a debate about not including extraneous calculations in exams. For stats people, calculations are not extraneous. But they thought that was what we meant when we said not extraneous calculations.
　　− Proposed changes for the future:
　　　　∗ Be very specific and directly address multiple choice questions and exam reviewing techniques, including coordinator opinions and policies for both.
- Rob's Comments
  - Given that the title of the folder containing the summary of Meeting 5 and the reflections also includes technology, I would really like to see us incorporate this next time.
  - I think we could talk about ways students can increase the students access to grades, notes and other things related to the course. I think one goal of our teaching seminar should be helping graduate student TAs and instructors figure out how to streamline their teaching. Doing more on the front end can prevent problems down the road. For example, posting to a webpage the course syllabus (either their own or from the coordinator), schedule of lectures, course notes, supplementary material and special links can help students stay on task and keep the instructor from getting overwhelmed mid-semester.
  - One thing that I am trying out this semester is writing all of my course notes on my iPad by hand and then uploading them to my math website. Granted, one can write notes by hand, scan them in the copier and upload them that way, but there is something more efficient about using a purely electronic medium. In addition, I am able to use multiple colors, erase mistakes (instead of scratching them out or the erasures being visible).
  - In addition to this, I am able to use my iPad to record my voice OVER my notes. Granted, the particular app I use does not create a slide-show of my notes and voice, but Im trying to see if students have a recording of my lecture along with the notes, does it help them?
  - I think some research among the group into whether or not certain technology in the classroom is more helpful than other forms would be helpful and then a seminar on this could help the graduate student TAs and instructors formulate their own opinion on technology in the classroom.
- Martha's Comments
  - While discussion about what a tablet could be used for might be nice, such things should be kept to a minimum as many TAs wont have access to one.
  - I think this is a good seminar to talk about summative assessment and what the purpose of it is. In fact, if preparing for lecture gets moved to in-service, we could very well have time to add an extra seminar topic and get a separate discussion about using technology in the classroom, although we will need to do research beforehand on what it available to TAs and what coordinators will allow.

3. Summary

- Things to Address in Class
  - We addressed many of the comments made by the graduate student TAs regarding the seminar. This was very useful. We went over our expectations of the students and exactly howe we would implement a lot of the suggested changes.
    - ∗ People wanted to know how to do group work and we said that wed be doing that next time.
    - ∗ Some TAs indicated that they would like to have more structure in the seminar and be clear on exactly what our expectations are.
    - ∗ Others were not clear on what the goal of the seminar. It is to make us all better teachers. Some people are lazy while others simply are clueless on different class-room strategies. For the former, we simply say that this is unacceptable behavior and they have an obligation to their professional peers to teach their subject sufficiently well. For the latter, we try our best to provide support in the form of additional references, suggestions in particular situations and general teaching philosophy.

* Some indicated that not enough of the seminar pertained to recitation. We will try to fix this in the future and in the seminar next fall.
  - To address other comments and critiques, we sent out an email with more information.
  - So that we can continually address other areas of interest pertaining to a particular seminar, we will send out an email after each seminar discussing some things in a broader context or in more detail.
* As a large group, we talked about creating exams.
  - How should exam questions differ from homework questions and quiz questions
    * Include a question that expands on the homework to differentiate A-students from B-students.
    * Exams should test multiple concepts in the same problem.
    * Quizzes should be more like homework problems.
    * Homework problems can be tough, because students have more time to solve them.
    * Exam problems should have varying difficulty.
  - Types of problems
    * One should choose problems that test general knowledge AND specific knowledge.
    * A general guideline mentioned by some of the students is that A students should be able to attack successfully every problem (maybe not necessarily finish every problem); B students may not attempt and finish every problem, but have a solid understanding of most of the problems (8/10 of the problems, at least).
    * Multiple choice problems can be a bad idea when testing knowledge of mathematics. However, there are settings in which multiple choice type problems are appropriate. Testing knowledge of historical facts in math, definitions, graphs that correctly correspond to certain functions. In statistics, multiple choice problems can be a good tool for testing a students knowledge. Another technique that might be useful is giving the students a proof and leaving certain parts out. Using a multiple choice problem to test what fills in the blanks can be useful.
* The students then formed small groups to discuss the following.
  - How do you decide what is most important to test on?
    * Whats on the syllabus? Thats a good start!
    * Can one problem build on another?
    * Can material from one midterm build on material from another?
    * Try to limit unnecessary calculations when the concept is more important.
  - How do you check that the problems you wrote are well written, unambiguous, and your exam is not too long?
    * Have your coordinator read your exam. Let them know well ahead of time.
    * Compare wording with that in the book, homework, and review sheets.
    * Take your exam!
    * Clarify words like describe, show, determine, etc.
    * When in doubt, use problems from the book. If you change numbers, make sure it can still be solved.
    * Students should have 3-4 times as much time to complete the exam.
  - What should you do if you find an error in your exam while your students are taking the exam?
    * If the mistake is REALLY BAD, tell them to skip it as soon as you notice. Throw the problem out.
    * If the mistake is a small typo that makes the problem impossible, but not too hard to correct, then write it on the board.
    * Walk around and check if students are working on that problem. If they are and they havent made the change, remind them.
  - What should you do if the majority of your students cant solve the same problem or all do it wrong?

* Talk to you coordinator if you have one.
* Not grade that problem (have test be out of fewer points).
* It may be an indication that you didnt cover the concept well enough. When you hand the exams back talk specifically about that problem, and cover the topic that day. And have a mini-exam on that question in the next class, if possible. Or put the question on a future quiz/midterm/final, if possible.
* Make sure you LET YOUR COORDINATOR KNOW. Make sure communication is really clear. If there are students who missed class, make sure they know. Cant give same problem.

- **Large Group (10 minutes)**
  - How do you reduce student test anxiety?
    * Anxiety is something that typically does not show any signs to the on-looker. If someone is anxious, you may not know it. Since it is clinically proven that anxiety affects ones ability to process logical thought, it is considered courteous and helpful if you can find ways to reduce the anxiety of your students.
    * Phrase questions similar to homework, book, and review problems.
    * Write your exam with questions roughly in ascending order of difficulty.
    * You dont have to make all numbers pretty (and shouldnt) but write your test so that students dont get bogged down by pointless computations.
    * Be clear about your calculator policy well ahead of time. Make sure your exam is written in a way that is consistent with this policy.
    * Tell students what good study strategies are.
      · Should be able to solve homework problems in a reasonable amount of time without using the book. Then they are ready.
    * Review properly
    * Tell a joke before the midterm. Laughter reduces stress and anxiety.
    * Know the calculator policy before an exam. If students think they can use calculators and you tell them otherwise (and contrary to the policy), this could cause some stress.
    * Play some relaxing music as students are entering the room. Do not play music during the exam. Not everyone likes music while testing.
    * Remind students to skip around and answer problems in any order.

- **Small Groups (15 Minutes)**
  - How do you review for exams?
    * Can give a list of all the topics you have covered
      · List sections/chapters covered and what is important in each.
    * Can give a list of the definitions they need to know
    * Be sure that they know the exam covers all the material covered in class
    * Have students ask questions so they lead the review rather than you
    * It may not be a good idea to hand out a review sheet with problems. This could have the adverse effect of students memorizing solutions and not thinking about the concepts.
    * Pay attention to what topics students struggled with on homework and review those topics.

- **Large Group Discussion**
  - How do you proctor exams?
    * No phones, book, etc.
    * Look at your students.
    * Walk around, but let them know ahead of time you are looking around.
    * Pass out different version of the exam so students have different exam than people on either side of them.
  - How do you identify cheating?
    * Look at students eyes
    * Look for phones, notes, etc.

- What do you do if you think someone is cheating?
  * If the cheating is blatant and out in the open (using a phone, notes, etc.) ask them to leave. If they refuse to leave, call campus security. Never take a risk you dont have to.
  * If you think they are looking on someone elses paper
    · Stand next to them.
    · Note who they are and who they are sitting next to.
    · Check exams for evidence of cheating.
    · Talk to Tamara and your coordinator if you suspect cheating
    · Consequence: 0 on exam is a good rule of thumb if they are cheating. Less paper work and student learns a lesson without going through some judicial process. Again, check with coordinator.

CHAPTER 8

Collaborative Learning

1. Abstract

1.1. Abstract for Seminar Leaders. Not all group work is created equal. Just grouping people and telling them to work together is often ineffective and damaging. This seminar should be about how to effectively employ group work in class. There are informal and formal strategies, and both can be effective. Teachers are often very reluctant to use group work in class because of bad past experiences, so gather positive experience stories before the seminar.

Formal strategies are much more time consuming (before and during class), and TAs are probably more likely to employ informal strategies. Bring specific examples, and use some throughout the seminar so that students can see such strategies in action.

1.2. Preview for Students. This week we will discuss various approaches to get students to work together, in pairs or groups, and its potential benefits and pitfalls.

1.3. Pre-Assignment. In order to facilitate discussion, please read the papers emailed to you before the seminar, write a response to the articles and bring it to class. The response should be about all three readings and 1-2 pages long.

The first two papers are chapters from Small Group Instruction in Higher Education: Lessons from the Past, Visions of the Future edited by James l. Cooper, Pamela Robinson, and David Ball. The third is an article published in Science about a study that was run in a large-enrollment physics course about the impact of active and cooperative learning strategies on the students' learning. It's a remarkable study with rather astounding results.

Here are some things to think about as you're reading and to perhaps help you form your response:

Pairs) How might you be able to incorporate the outlined strategies into the course you are currently teaching and/or courses you want to teach in the future? What difficulties can you foresee in trying to implement such strategies?

Base Groups - Chapters 19 and 20) How have the various stages of small-group development affected groups you've observed (this can be as a group member, as an instructor, as an outside observer, whatever)? How do you think you might be able to help groups get through these stages? What use can you see for Base Groups in the course you are currently teaching and/or courses you want to teach in the future? It is strongly recommended in the research literature that groups are heterogenous in as many dimensions as possible. What do you think of this recommendation? How do you think it may enable groups to work more effectively together? How do you think it might hinder their efficacy?

Science) Why was it important to collect data on the students in the two sections prior to the experiment? What did those data show? How did the two sections differ during the 12th week of instruction? Why was a test administered at the end of week 12? What were the results of that test? Which section covered more material during class time in week 12? Was that apparent on the test? What do these results mean to you? What do they tell you about the potential impact of active and cooperative learning strategies on students?

1.4. Homework. None.

2. Seminar Outline

2.1. Schedule.

- Brief Disclaimer: We are assuming most of you do not have a lot of experience in designing group work, so there will be a bit more talking at you than usual, but do not hesitate to jump in and share your experiences.
- (5 Minutes) Research Basis for incorporating group learning
  - Because students hate it, we hated it as students, and it is difficult to implement
- (10 Minutes) Discuss papers - general response
  - "Science" study
  - informal
  - formal NOT ALL GROUP WORK IS CREATED EQUAL
- Different Types of Group Work
  - (20 min) Less structured: Pairs, Outside of class
    * 10 min small
    * 10 min large
  - (25 min) More structured.
    * Consistent vs. inconsistent groups
    * Heterogeneous vs. homogenous
    * Specific roles
    * The role of competitiveness amongst groups??
    * Classroom layout, and assignment form
      · 10 min small
      · 10 min big
  - (quick summary) What you are supposed to get out of this weeks seminar, explicitly, and how it will benefit your students.
- (Up to 30 min) Common mistakes people make while trying to implement group work and how to avoid them. At the end, ask people who have struggled implementing group work what the issues were.
  - Level of the task is inappropriate
  - Not addressing the social skills that you need to work in a group
  - Not leaving enough time, not telling them how long they have. Not being willing to give up lecture time.
  - Assigning pertinent prep work is important for not giving up info when you give up lecture time, and for preparing students to get involved in group work. AND MOTIVATING STUDENTS TO DO IT
  - Not having a formal way of finishing your group activity
  - Not monitoring how well your groups are working and helping them to get beyond road blocks. And you need to get to all groups.
  - Letting your quiet group be quiet
  - Having groups turn in a single assignment can be dangerous because it encourages students to just have one person do all of the work.
    * Have everyone write it up, and pick one randomly to grade.
  - As an instructor, not planning WAY ahead.

2.2. Post-Seminar Notes.

- Dusty's Comments
  - What went well:
    * Our discussion about how to choose groups was good and raised some interesting questions.
    * The discussion on the readings was also particularly good.
    * Time management for group work. Though a couple of students had criticisms of the physics class article, it was somewhat convincing about the utility of group work even when you dont cover as much material. We also talked about how to make group work more time-effective. This was super important, as it is a primary concern for many TAs.

* This discussion tends to jump all over the place given the diversity of topics within group work. Martha kept it from spiraling all over the place. So even though having one person lead has in general been a good idea in these seminars, it was particularly important in this one, both for organizational reasons and for her expertise. Some TAs were more resistant to collaborative learning than I thought they would be, but I think knowing that Martha is very well qualified to discuss this topic helped them to be a little more receptive to the idea.
- What did not go well:
    * We did not have an organized cohesive collection of common types of group work. We certainly discussed this, but I think some of the TAs got a little overwhelmed with all of the ways to establish and run groups.
    * The readings were great, but if we are going to use the physics example again we should be prepared for criticisms about the experimental conditions that one of the statistics students noticed. If they dont believe the study was run well, they may be more resistant to the message.
    * We spent a lot of time on more formal ways of incorporating group work, whereas the TAs might be more likely to implement less formal techniques.
    * The lecture portions of the seminar werent separated by group exercises.
    * While I think this seminar convinced some people, I could tell there were still people who felt that for time reasons they really just cant incorporate much group work into their classes.
- Proposed changes for the future:
    * Focus more on the less formal collaborative learning methods
    * Directly address how to prepare your class for group activities, given that some TAs only know for a few days before the semester what they are going to teach.
    * Have a handout with a list of recommended group formats/activities. We discussed a lot, but I think if they have a physical list they will be more likely to look at it and consider which is most applicable to their class.
    * I think this seminar was and should be heavily lecture-based. But we need something around the mid-seminar mark to break up the lecture. I noticed a lot of TAs having a hard time paying attention towards the end.
    * Find volunteers among experienced TAs and lecturers who are willing to let TAs observe their interactive classes. One of the TAs suggested that she would feel more comfortable implementing group work and that she would do it better if she could actively observe it being implemented in a math class.
- Rob's Comments
  - I really like the third item of the proposed changes. I think that could be very useful and something we could also post on the MCTP website, perhaps. Making it freely available will maybe draw some TAs to the MCTP website and allow them to implement group learning techniques when they feel comfortable.
  - While in Dustys second to last comment, she indicates that this seminar should be largely lecture based, it may be possible to have the class break into small groups like we usually do. We could have as an assignment prior to this seminar involving the students implementing group work in their own sections or having them observe someone implementing group learning in their own class.
- Martha's Comments
  - I agree with Dusty that my expertise and background in group work helped staunch some of the skepticism. We may want to bring in someone to lead this seminar next semester who is not one of the regular instructors depending on the experiences the instructors have with collaborative learning.
  - I dont think an assignment asking the TAs to implement group work before the seminar is a good idea. The first time group work is used in a class is often not very productive, and I think

it could turn off the TAs. Also, group work needs to be done right and without introduction and support, I would worry about the implementation. However, I do agree that we needed more small group discussion and activities; there was some in the plans, but I was reluctant to break up the large group discussion.

3. Summary

This time, we discussed collaborative learning. The take-away message is that in-class collaborative learning can have tremendous benefits for your students, but takes some time setting up. Of course, investing some time at the beginning can pay off in having to spend less time re-explaining concepts in office hours and students performing better on exams and quizzes.

We have assumed many of the graduate students do not have experience in organizing in-class group learning exercises. The thing to keep in mind is that students may be at first resistant to the idea of group learning. You may have a bimodal distribution of such students: those that dont want to do it because they know they will get stuck doing a majority of the work and those that dont want to do it because they dont want to do work. The goal of this seminar was to show the graduate students how to motivate all of the students to be involved and improve the overall understanding of the material.

- Groups can be organized as follows: in pairs or in groups of four.
  - The benefit to pairs is that there is increased accountability. No one can slack on their work without the other group member knowing. Also, its much easier to arrange meeting times outside of class if the in-class work requires out-of-class work, as well. If pairs change each time, then one does not have to worry about someone dropping the course and leaving someone without a partner for the rest of the semester.
  - The benefit to groups of 4 is that over the course of the semester, if one of the group members drop, then the group is not diminished to just one person. Also, a larger group can sometimes have more productive brain-storming sessions.
  - We had a few articles describing how to establish bonds between group members and the various ways to increase positive/productive group dynamics over the course of a semester. Such techniques are useful for base-groups (groups of 4 or so).
  - When forming base-groups, it helps to have a diverse mix of people. As mixed as possible: ethnicity, skill, gender (studies show that having at least as many females as males provides for a setting where females feel more comfortable and perform better than more males than females in a group.) Also, it helps to not have skill levels among group members be too far apart.
- Group skills
  - Help groups establish roles and identify the skills of each member. Some people are more comfortable with certain tasks and each group member should feel as if they are making a significant contribution.
  - Help groups establish positive interdependence and personal accountability.
- How to grade group work
  - Everyone can turn in his or her own write-up. Then, you can either grade each one individually and assign and individual grade to each person, or you can pick one of the write-ups from one of the group members and grade it. Then assign this grade to every group member. The latter grading technique, if told to the students before hand, can potentially lead to everyone doing a better job on his or her write-up because they dont know whose write-up will be chosen as the representative write-up.

Teaching Philosophies

1. Abstract

1.1. Abstract for Seminar Leaders. Everyone has their own philosophy about teaching, but new TAs have not necessarily taken the time to ponder their philosophy and what motivates it. This seminar, occuring towards the end of the semester, affords TAs the opportunity to reflect upon their semester and their teaching practices in order to form their philosophy. They should think about what teachers should do, what they shouldn't do, how they can learn and become better teachers, and what responsibilities they have for their students. Additionally, their teaching philosophy should include their opinions on grading and notation, motivating students, administering and using evaluations, writing exams, and using collaborative learning; they should establish both their opinions and how those opinions were formed.

A teaching statement professionally displays the key components of a teaching philosophy. It should be specifically written for an audience interested in teaching, not research. As such, material on TAs research, publications histories, etc. should not be included in a teaching statement. The target audience for a teaching philosophy will want to know how you teach, view your role as a teacher, interact with students, evaluate your teaching, improve your teaching, and stay motivated.

1.2. Preview for Students. We will be discussing teaching philosophies. Understanding who you are as a teacher is important. For one, you understand your strengths and weaknesses. Moreover, it gives you an opportunity to reflect on how to improve. The eventual goal of this seminar is to help you learn how to write a teaching statement that concisely expresses your teaching philosophy.

1.3. Pre-Assignment. Please read and consider the teaching philosophies emailed to you.

1.4. Homework. For this assignment you can do one of three things(1-2 pages):
- Write a teaching statement
- Outline a teaching statement
- Write a thoughtful statement answering these questions:
  - What is your role?
  - What do you expect from your students?
  - How do you think your students learn, and how can you facilitate learning?
  - What types of assessment do you use in class and how do you use them?
  - What shaped your teaching philosophy?

2. Seminar Outline

2.1. Schedule.
- (15 Minutes, Large Group Discussion) Why write teaching statements?
  - Writing it will help you figure out what your teaching philosophy is
    * It motivates your classroom policies etc.
  - You need a teaching statement for university jobs
  - Even outside of academia you often have to instruct other people
  - If you are nominated for a teaching award you will definitely need to submit a teaching statement.
- (10 Minutes, Small Group Discussion) How does your teaching philosophy affect your class and what aspects does it affect?

- (5 Minutes, Large Group Discussion) How does your teaching philosophy affect your class in terms of...
  - Lecture
  - Assignments and Exams
  - Student activity in class
  - Class policies
  - Interaction with students in class and otherwise
  - Availability outside of class time
- (20 Minutes, Large Group Discussion) What are the primary components that should be included in a teaching statement.
  - What is your role?
  - What do you expect from your students?
  - How do you think your students learn and how can you facilitate learning?
  - What types of assessment do you use in class and how do you use them?
  - What shaped your teaching philosophy?
  - Specific examples of things you do that reflect your teaching philosophy
  - If the teaching position you are applying for differs from your current teaching position, make sure your statement reflects how your teaching philosophy adapts
    * If you had more freedom over classes, what would you do that you are now allowed to control now?
- Brief Statement: What types of language and voice should you write your statement in?
  - It depends on your audience and the type of job for which you are applying
    * Research vs teaching universities vs high schools etc.
  - Random writing tip: Readd your statement out loud, have someone else proofread etc. Don't proofread immediately after you write it. Seminar leaders share their answers to the most important things that are included in their teaching statements.

2.2. Post-Seminar Notes.

- Dusty's Comments
  - What went well:
    * What to include in a teaching statement went well. I think that sending the TAs the examples to read ahead of time was also a great idea. They were able to discuss their ideas about teaching philosophies and statements using those examples.
    * I still dont know how interested they were in hearing about the most important things included in our statements, but it seemed like it gave them ideas for their own teaching statements.
    * Having more large group discussions. We spent the majority of this seminar in large group discussion and that seemed most appropriate for the material that we discussed, and worked very well in covering everything we intended to cover.
  - What did not go well:
    * The discussion on how your teaching philosophy affects your class seemed a bit redundant in relation to everything we had already discussed during the semester.
    * I dont think we discussed enough how the institution to which they are applying should influence their teaching statement.
  - Proposed changes for the future:
    * We can probably add more to this seminar, either in this topic, or a short discussion from another topic. We moved through the discussions pretty quickly and we ended a bit early.
    * Eliminate the section on how your teaching philosophy affects your class and instead cover that as examples when discussing what to include in your teaching statement. We also covered some of these examples when talking about our own philosophies.

∗ Be very explicit about the difference between a teaching statement and a research statement, how they should differ, and why you should not put your research on your teaching statement.

∗ Since we had extra time, if we want students to consider their teaching philosophies and really solidify their opinions, it might be interesting to have them discuss and defend their teaching philosophies in pairs. We can give them guided questions to get them discussing issues of philosophy that people sometimes disagree on. This will have them evaluating their philosophy and their reasons for having that philosophy. The only problem I can foresee is that the debate might get quite heated.

- Rob's comments
  - Regarding What did not work, I agree whole-heartedly with Dustys second point. I'm hoping to address the general job application process in the spring. When I do that, I will definitely include that material 1) on the MCTP website and 2) in the course pack. I think students should know that there is a difference between a teaching statement for a postdoctoral position and a teaching statement for a liberal arts college. These may be two ends of a particular spectrum and I think we should address as many flavors of teaching statements as possible.
  - The last item of Dustys proposed changes for the future is an excellent idea. I think this will challenge people to really get at the core of their teaching philosophies.
- Martha's Comments
  - I love the idea of having students debate and defend their teaching philosophies in pairs as long as careful monitoring is done to make sure discussions remain civil.
  - I know its a teaching seminar, but as an additional topic, a short description of and discussion of research statements would be a nice complement.

3. Summary

Beliefs about your role as a teacher. As an instructor, you should form some type of teaching philosophy. Where do you stand as an instructor?

- Why have a teaching philosophy:
  - To have direction
  - To be consistent in your teaching
  - To maintain motivation
  - As a means of self-reflection
  - As a way of identifying why it is students may be struggling

What is a teaching statement? It is a written statement that clearly (and concisely) expresses your teaching philosophy. Even if you are going to be going into industry after you graduate, being able to express how it is you may one day mentor a new-hire or how it is you can instruct other colleagues will be helpful. A teaching statement is essential in academia, but may be written differently depending on where you are applying.

- Why write a teaching statement:
  - To inform on course policies
  - To inform on course materials
  - To know what to write on your teaching statement you will one day submit as part of a job application
  - Provides an identity
  - Nominations for awards and promotions
- Some questions you may want to address when writing a teaching statement:
  - How does your teaching philosophy affect:
    ∗ Lecture
    · More emphasis on applications and data collection than theory?
    · Link topics to real-world problems
    · Do you ask a lot of questions of the students to prompt interaction?
    ∗ Assignments/exams
    ∗ Student activity in class

- · Student led discussions or primarily lecture-based instruction?
  - ∗ Class policies
    - · Require attendance?
    - · Do you award partial credit or not? What philosophies do you have on grading.
  - ∗ How you interact with your students
    - · Do you treat your students like equals or do you maintain a strict and formal teacher-student relationship.
  - ∗ Your availability in class and out of class
    - · Do you give out your phone number? (generally, not a good idea at larger schools)
    - · Do you hold office hours in non-traditional places (outside, in cafes, etc.)?
    - · Do you allow students to make appointments?
  - ∗ Which students opt to take your class
    - · Do you attract a broad spectrum of students or a narrow group of students?
- What are the components to be included in a teaching statement?
  - – Courses taught
  - – What you see your role being in your next position.
  - – What is your role as an instructor, mentor, course-planner, etc.
  - – Express an interest in running/designing certain courses.
  - – Describe the types of courses you would like to teach.
  - – Your expectations of students (and what they can expect from you).
  - – Cite specific studies if you are going to discuss the importance of certain teaching techniques and whether or not you have implemented said techniques in your class.
  - – Keep in mind that what you discuss and how you discuss it depends largely on where you are applying for a job. Try to have multiple teaching statements for this reason.

Looking Back, Looking Forward

1. Abstract

1.1. Abstract for Seminar Leaders. Over the course of the seminar, TAs are exposed to a wide range of ideas and it can be a lot of information to absorb. It is often beneficial to review key concepts and how those concepts interact with each other. This seminar should remind the TAs of the most important things we covered, so they can utilize that information to improve their teaching going into the next semester. It also offers TAs and seminar leaders the opportunity to revisit topics or to discuss topics weren't covered. This seminar should focus on what the TAs learned and what they can do with that knowledge in the future. They are not just looking back; they are look forward to the changes they intend to make and the skills they want to improve.

If time allows, this may be a good seminar in which to add some "Using Technology" material. There are not a lot of technology options available to TAs, but there are some. Most students have constant access to YouTube, WolframAlpha, graphing calculators, and a broad range of tutorials, examples, and lectures online. These tools can be of great use to us as teachers if we know how to distribute them and vet them for accuracy and notational consistency.

Using technology does not mean making PowerPoint presentations and this use of technology is often ineffective. Technological resources, however, that can be used as a supplement can be of great value to both TAs and students.

1.2. Preview for Students. We'll look back over what we discussed this semester, address questions and topics we haven't already covered, and talk about how to apply what we've done to the semesters ahead.

1.3. Pre-Assignment. Consider this semester and bring a list of things we didn't address or any questions you still have.

1.4. Homework. None.

2. Seminar Outline

2.1. Schedule.

2.2. Post-Seminar Notes.
- Martha's Comments
  - What went well:
    * When the TAs discussed surprising situations that had come up this semester, we had some good discussion and TAs shared good information about how to deal with sticky situations.
  - What did not go well:
    * There was miscommunication among the three of us before the seminar and had different priorities for the seminar.
  - Proposed changes for the future:
    * Seat students by topic/type of class
    * Have students discuss at their tables how they think the semester went, what they think their successes were and what didnt go as well as they wanted. They should also talk about why they think those things went well or not.

* Also have students discuss what theyd like to do for the following semester. They may or may not know what theyre teaching the following semester, so they may not be able to tailor it as much as Id like to see.
  * Dont forget about the evaluations of our seminar.
- Rob's Comments
  - I agree that I took the wrong perspective on this seminar. It definitely needs to be geared much more towards reviewing what weve talked about and how each of us is going to implement that which we learned in the seminar.
  - As far as the success of the seminar goes, I think we did a great job! I went into with no expectations and, while anything positive is better than nothing, I am thoroughly impressed with the level of interaction we had from many of the students as well as how well we were able to organize the seminar.
  - Next time, this seminar should definitely solely focus on the teaching aspects of the seminar and not talk about the qual prep seminar next semester (except for maybe a brief mention). We can also use this seminar to fine tune things for next Fall.

3. Summary

CHAPTER 11

Appendices

1. Reflections on the Seminar as a Whole

Dustys Reflections on the Teaching Seminar in General These are all just my opinions on what we should do in the future. They are all things that the team can discuss and decide on together.

- The seminar covering how to write exams should happen early in the semester so TAs have it before they write their first exam.
- We should have a syllabus for the seminar to be given out on the first day. Make sure the seminar is credit/no credit.
- In each seminar dedicate an amount of time to review the things from that seminar that TAs can use to change their classes. Some TAs on the evaluations did not think it was clear enough how to apply this seminar to their classes, and also felt that they have no power in coordinated classes. Most of the stuff we cover is within their control, even in coordinated classes.
- Make sure that every topic includes a portion/discussion that is relevant for recitation leaders. Sometimes we focused a lot on coordinated classes and not enough on recitations. There are concrete and important differences between the two that we should consider when preparing for every seminar.
- I thought having a primary leader for every seminar worked well and helped us stay on task and move through the material we wanted to cover.
- Throughout the semester we tended to budget less time for big group discussions than we ended up using. Future seminars should be more liberal with the time budgeted for these as the big group discussion tend to spark debates. As these debates are often very productive, it is better to budget time for them than to avoid them altogether.
- Be very clear on the syllabus and on the first day as to
    - The purpose of the seminar
    - Our mission
    - What we expect of the TAs in regards to participation, attendance, and actually implementing changes in their classes
    - What we will cover
    - When they are expected to turn in assignments
- Have some sort of written work due every seminar. This may help get the TAs in the habit of turning their work on time rather than during the last week of classes. We should also read, comment on, and then hand back this written work. It gives us a chance to learn their names better, and I think will also send the message that we are interested in their ideas and what they are doing, and that we recognize and care about the effort they are putting into the seminar. We should, however, keep these assignments reasonably small, and specify whether we want them turned in via email, hard copy, or if either is acceptable.
- We always discussed in detail what was going to be covered in each seminar. Then one person would present what we discussed and wrote together. This seemed like a really good method for preparing lectures, but sometimes the presenting team member would say something that we had not discussed and that the whole team may not agree with. This creates a dilemma because then we have the choice of publicly disagreeing with a team member, which may negatively affect student confidence in us, or letting potentially important philosophy and/or policy discrepancies slide. Im

not sure how to best prevent this except to make more detailed schedules for the seminar so that everything discussed is something that the entire team has discussed and reached a consensus on.

- We also had an issue with attendance. A huge portion of the TAs got in the habit of being ridiculously late to seminar. This may be because they view the seminar as more of a talk that they go to and less as a class. Having a syllabus may help with this issue, and it should be very specific about our expectation that everyone attend seminar and that they get there on time. The tardiness issue was largely resolved when I talked to them about it at the end of a seminar and made it very clear that we expect them to be there on time. We should head this issue off from the beginning.

- I think the TAs underutilized the website. I dont know if we can get funds to print out handouts, but they may use the written material more if we hand it to them at the end of each seminar, or have a big packet of all of the written material to give them at the beginning.

- Quiet people tended to organize themselves into one quiet group that didnt participate a lot. We may want to consider giving more structure to the groups so this doesnt happen, or adding an in-class participation requirement to the syllabus. If we do this, we can let TAs know halfway through the semester if they are not meeting this requirement, hopefully giving them the push they need to engage a bit more.

- Team members should make every effort to discuss responses to student emails/issues/etc. with the rest of the team before making important decisions. We do not want TAs getting one response from one of us, and a different response from another. In order to increase TA confidence in us, we want to appear as a very cohesive unit. If a team member disagrees with another team members decision, this should be discussed amongst the team before contacting the TAs.

- Martha tended to keep track of all of the assignments this semester and that worked out very well. Designating one member for this is probably the best way to make sure we know who has turned in what.

- Unfortunately, many of the grad students do not read all of their emails. If we want them to read ours we should work to minimize the amount of email we send them and maximize the effectiveness of each email. For this reason, it may be a good idea to designate one person as the primary email sender. The whole team can provide that person with everything they want sent out in that weeks email, so that in general we send out only one email a week. This may increase the likelihood that they will read our emails, but it does come at the cost of presenting the appearance that the students are only communicating with one of us via email. Certainly if this is the route the team wants to take, things that need to be sent out to subsets of the whole group can be sent by anyone in the team.

Marthas Additional Reflections on the Teaching Seminar in General

I agree with all of the above, but Id like to add a couple things

- I would like to have more time during in-service (We have discussed having two, 3-hour afternoon sessions.) To be able to more fully address particular parts of the handbook and cover important points prior to the TAs first classes.

- I think changing the requirement so that only first time TAs need to attend will help lessen resentment and also help create a better discussion environment because there will be fewer people attending.

- Several students mentioned on the mid-semester evaluations that theyd rather have shorter meetings weekly. This is something that should be considered.

Robs additional comment: none.

2. Evaluations

2.1. What to Do With Mid-Semester Evaluations. After administering your mid-semester evaluations, you will need to consider the following. How will you choose what to focus on? How many issues can you address? How do you enact change in your classroom while being consistent with your course policies and syllabus? Here is one approach you might take.

- **Read your evaluations.** I would recommend reading through them question by question, rather than evaluation by evaluation, so you get a good general sense of the response to each question.
- **Make a list of the criticisms that you received.** If you received the same or similar criticism on multiple evaluations, keep track of that so you know what issues arise most frequently.
- **Evaluate the criticisms.** Decide which issues are most important, whether it is feasible to address them before the end of the semester, and whether making changes will help your students at this point.
- **Pick one or two issues to focus on.** Enacting change can be difficult and time consuming. To have the most positive effect, pick your priorities and really focus on those (while not forgetting other issues).
- **Respond to your students.** Students want to know that you care, that you have seriously considered their suggestions, and that you are going to work to implement positive changes. Briefly tell them what you are going to change, how you are going to change it, and what you hope to achieve by doing so. You may also want to explain why you are not changing certain things, while acknowledging that you are thankful for all of the criticisms and consider them all to be valid.
- **Relay important information to your coordinator.** Your students may have mentioned issues that are outside of your control. You should let them know that you are passing the information on to people who do have the power to make those changes. Just because you cannot directly change something does not mean it is unimportant. Coordinators can use the information you give them to better design courses the next semester. They may also be able to work with you to address some issues for the remainder of the current semester, and can advise you on how to respond to those criticisms.
- **Keep your evaluations.** Your evaluations can inform your future teaching experiences and course policies. They are useful to reflect on, and some may be worth including in teaching portfolios, information for teaching awards, etc.

2.2. Qualitative Data and Conflic Between Criticism and Philosophy. We talked quite a bit today about the usefulness and drawbacks of open ended vs. quantitative questions. It is important to remember that quantitative and qualitative data are both useful. We are often accustomed to working with more quantitative data in Math and Statistics, but the science of evaluating qualitative data is well established in the social sciences. It is, however, a foreign process for many of us. If you would like some advice on how to analyze the qualitative data you receive from your students, please contact us. The information from your students can be invaluable if you have to tools to analyze it, even though it may seem ambiguous at first. As a suggestion, one can do a content analysis of the responses. Such a process involves counting key phrases and words.

We also received a question about how to deal with criticisms you may not agree with. To help you answer this question I would like to share an example from my own classroom. In my mid- semester evaluations I received a lot of comments from students saying that my grading was really harsh. I thought about changing my grading policy, but having high expectations for my students is extremely important to me. I really felt that weakening my grading policy would hurt my students in the long run, especially when they get into more rigorous classes that will have high expectations. However, I wasn't sure if my grading really was too harsh. So, I talked to my colleagues, office-mates, faculty members, and anybody else that would listen to me. I told them my grading policy, what I take points off for and why. The conclusion that all of these people helped me reach was that my grading policy was both fair and rigorous. I made the decision not to change the way that I grade. What I did do, however, was explain to my students how I grade, why I grade that way, and how I think it will benefit them in the future. I offered to work with them to explain grades and help them improve their grades without weakening my expectations.

You may receive criticisms that contradict very strong beliefs that you have about your teaching methods. In order to decide whether your policies, methods, etc. really are unfair or ineffective or not, you should take time to do the following.

- Really think about why you are adamant about the specific policy, method, etc. Is your insistence on maintaining the policy or method justified? Is there a distinct purpose for the policy or method, and is it actually accomplishing that purpose?

- Decide if your policy or method is actually helping or hurting your students. This may mean discussing the criticism with colleagues and mentors, or looking into educational research (or both!). If you want some guidance in this area, please let us know.
- Consider the options available to you for addressing your students' concerns. There may be a compromise that you can make to meet them in the middle.
- Make your decision and explain it to your students. In particular, if you are not going to change, explain your reasoning and the justification to your students while acknowledging the legitimacy of their criticisms.

3. Collaborative Learning Readings

19 Using Small-Group Development to Facilitate Cooperative Learning Base Groups

Nancy E. Stetson

Originally published in the *Cooperative Learning and College Teaching* newsletter, Winter, 1996.

Cooperative learning base groups are long-term groups with stable membership that usually stay together for at least a term. Base groups are appropriate when you have large numbers of students in your classes and the subject matter is complex.

When you facilitate base groups, it will help you to understand small-group development. Regardless of size or type, small groups typically go through predictable stages over time. Small-group development experts such as Kent Curtis, M. A. C. Jensen, R. B. Lacoursiere, George Manning, Steve McMillen, and B. W. Tuckman have named and described these stages. According to these experts, small groups move through four developmental stages: forming, storming, norming, and performing. Obviously, it is in the best interest of base groups to move through the first three stages as quickly as possible in order to develop high performance teams. If you, as facilitator, understand the stages of small-group development, you likely will be better able to facilitate base groups moving more quickly toward the fourth, high-performing stage.

Stage I, Forming. According to the experts, when groups first come together and form, they need to deal with the issue of trust. New groups are unclear on their purpose and members don't know what to expect. They are facing a new social situation, with some discomfort and apprehension. Consequently, they likely will be cautious. They'll be trying to figure out what is going to hap-

pen, who's who in the group, where they fit in, and how they will be treated by other group members. They'll also be trying to figure out what is OK behavior, what is the nature of their group's tasks, and how they will deal with each other to accomplish the task. Interactions likely will be light and superficial and mostly directed toward you, the formal leader. At this stage, groups will not have developed any skill and knowledge as teams. When you first form your base groups you can expect them to be cautious, excited, anxious, and to perform at a low level. You also can expect individual members to be anxious, searching for structure, silent, and cautious with you and group members.

Stage II, Storming. Once the base groups have formed, they usually move into a period of storming, when they need to deal with the issue of conflict. In this stage, individual members will react to what has to be done, question your authority, and feel increasingly comfortable being themselves. The groups likely will exhibit conflict and resistance to the task and structure, even as they increase their productivity through increased skills and knowledge. Members may express their concerns and frustrations more openly, and feel freer to exchange ideas. At this stage, they are learning to deal with differences in order to work together to meet their goals. Typically, members will exhibit power struggles for influence. Groups that don't get through the storming stage successfully will exhibit divisiveness and low creativity. After your base groups have formed you can expect them to exhibit conflict over the task and the structure. On some occasions you may have individual members who: confront you, the cooperative learning facilitator; polarize among the team members; test group tolerance; and behave in a fight or flight manner.

Stage III, Norming. This is the stage in which explicit or implicit norms of behavior are developed that are considered essential for the groups to accomplish their task. Order forms, as does group cohesiveness. Members begin to identify with their groups and develop acceptable ways to complete assignments, resolve differences, make decisions, and solve problems. They enjoy meetings and exchange information among themselves freely. Group (or team) productivity increases as skills and knowledge

continue to develop. After your base groups have successfully stormed, you can expect them to reach agreement on roles and tasks, and norms of behavior, including team member and leadership behavior; and to increase their cohesiveness, morale, and productivity. You also can expect individual members to shift from power struggles to affiliation; from confusion to clarity; from personal advantage to group success; and from detachment to involvement.

Stage IV, Performing. The fourth stage, the payoff stage, is performing. If your base groups have successfully moved through issues of membership, purpose, structure, and roles, they will now be able to focus their energies on group performance: completing tasks and solving problems together. They will take initiative and achieve results. As they achieve progress, morale will go up and they will have positive feelings about each other and their accomplishments as a team. Base groups will now be teams that business and industry call "self-directed work teams." They will no longer be dependent upon you for direction and support; instead, members can take on leadership roles as necessary. You can expect your performing base groups to exhibit good communication and teamwork, individual commitment, high morale and group pride, and high team performance. You can also expect base groups to use a wide range of task and process behaviors: monitor and take pride in group accomplishments; focus on goals as well as interpersonal needs; and maintain the values and norms of the group. Individual members will exhibit interpersonal trust and mutual respect, actively resolve conflict, actively participate, and be personally committed to the success of the group.

Your Role as Small-Group Development Facilitator. As cooperative learning facilitator, you can help base groups move through the first three stages of small-group development as quickly as possible so they can reach the high performance stage. According to Manning et al. your small-group development facilitator role in each of the four stages is slightly different.

In the forming stage, you can **reduce uncertainty** by: (1) explaining the purpose of the groups and their goals, (2) providing time for questions, (3) allowing time for members to get to know each other, and (4) modeling expected behaviors.

In the storming stage, you can **reduce conflict** by: (1) hearing all points of view; (2) acknowledging conflict as an opportunity for improvement; (3) adhering to core values, such as truth, trust, and respect; and (4) maintaining democratic and humanistic ideals.

In the norming stage, you can **encourage norm development** by: (1) modeling listening skills, (2) fostering an atmosphere of trust, (3) teaching and facilitating consensus, and (4) providing team-centered learning.

In the performing stage, you can **help groups succeed** by: (1) being prepared for temporary setbacks, (2) focusing on task accomplishments and interpersonal support, (3) providing feedback on the work of the groups, and (4) promoting and representing the groups.

Manning et al. believe it is helpful to view each of the stages in the life of groups from two points of view. "The first is *interpersonal relationships*. The group moves through predictable stages of testing and dependency (forming), tension and conflict (storming), building cohesion (norming), and finally, establishing functional role relationships (performing)."

"At the same time, the group is struggling with *accomplishing tasks*. The initial stage focuses on task definition and the exchange of information (forming). This is followed by discussion and conflict over the task (storming). Next comes a period of sharing interpretations and perspectives (norming). Finally, a stage of effective group performance is reached (performing)."

If you and your base groups have done your jobs exceedingly well, you will have groups that exhibit the "dazzling dozen" characteristics of effective teams described by Manning, et al.:

1. Clear mission
2. Informal atmosphere
3. Lots of discussion
4. Active listening
5. Trust and openness
6. Disagreement is OK
7. Criticism is issue oriented, never personal
8. Consensus is the norm

9. Effective leadership
10. Clarity of assignments
11. Shared values and norms of behavior
12. Commitment

Stage V, Adjourning. If you're an experienced cooperative learning base-group facilitator, you undoubtedly know the fifth stage in small-group development, one most of the experts don't address: adjourning. As your base groups near the end of the term, they typically will begin to think about how they will feel when the groups are no longer groups. They usually will experience some sadness or regret at the idea of separation.

In the adjourning stage, you can **encourage closure** by: (1) acknowledging and honoring the feelings about relationships that have developed; and (2) allowing farewell rituals. If you have super high-performing groups, they may not even need your encouragement. They may perform the task of closure—their final task together—all by themselves.

20 College Classrooms' Lost Gold Mine: The Cooperative Base Group

Susan E. Gruber and Darlene Vanselow Habanek

Originally published in the *Cooperative Learning and College Teaching* newsletter, Fall, 1996.

Included in the list of challenges for contemporary college classrooms is empowering students to become not only successful, but also caring adults who are committed to the academic success of their peers. The popular press enumerates the need for modern-day citizens to have well-developed communication and collaboration skills. Unfortunately, these skills are not generally reinforced in traditional classrooms, which maintain one-way communication flowing from the instructor to the students and the lecture-practice-test sequence for learning. Cooperative-learning structures used in college classrooms provide organized and systematic choices for varied learning experiences which foster the development of social skills needed for collaboration and communication around academic tasks.

One valuable cooperative structure is base groups. In our college courses we begin each class session with a base-group meeting. Base groups are heterogeneous, long-term cooperative-learning groups with stable membership which meet regularly. The purpose of these meetings is to provide each member with support, encouragement, and assistance needed to complete assignments and make good academic progress. Members hold each other accountable for striving to make academic progress.

For faculty members to use base groups, they must understand how to set them up, as well as what activities to use initially, in the middle and at the close of the term. There is a solid research foundation supporting the use of base groups; they are also generally enjoyed by both students and instructors.

Setting Up

Group Size

In setting up base groups, the first decision that must be made is the size of the groups. We have found that it is easier for a group of four students to get together outside of class to work on projects or to build academic support for study and review together. This size also allows for absenteeism or for students who drop the course before the end of the term.

Assigning Students to Groups

The next decision to be made is the assignment of students to groups. There are several methods that can be used to assign students to groups: team-of-instructors' assignment, random assignment, student self-assignment, or individual-instructor assignment. There are two types of classes which influence the group assignments: cohort and regular classes. With a cohort of students who are taking most of their courses together, a team of instructors would meet to assign students to groups based on jointly-determined criteria. These criteria might be based on: a) where students live, b) transportation issues, or c) academic interests. These base groups would then remain constant for all courses for the duration of the program (as long as four years in some cases).

For regular-class base groups, students might be assigned randomly. Students would count off and join students with the same number. For example, in a class of 32, students would count off from 1-8, forming eight teams of four. Another group-formation procedure would be to have students self-assign according to criteria such as living in the same area, people you don't know, different gender and age, and full- and part-time students. After students find each other, a data sheet can be produced as an initial assignment where group members report information based on criteria specified for forming groups. This sheet would be turned in to the instructor for review to assure heterogeneity, and then placed in the base-group folder for future reference by students and instructor.

If the class is small, the instructor might employ other methods to determine group membership, such as a sociogram and/or information gained from informal observations. A sociogram, often used by sociologists, is a method of gaining information about group dynamics and/or interaction patterns among people. When using a sociogram, the instructor asks students to list two or three peers in class with whom they would like to go to a movie or have a cup of coffee (social events) and to list two or three different peers with whom they would like to work on a project or paper (academic tasks). The instructor would then form groups of three or four people around isolated students, always reserving the right to adjust the final group assignment based on academic ability, social skills and other criteria important to the course. To use informal observations for assigning students to groups an instructor would gather data early in the course by observing student interactions during group work and whole-class discussions. For example, the instructor would note which students talk a great deal or seem to pull away from the group, and which students appear to have a solid knowledge base versus those who struggle with the course content. This information is then used to form effective heterogeneous cooperative base groups.

After deciding on group size and composition, decisions must be made as to what the members will do in their base groups. Below are activities that can be used at the beginning, during or at the end of a session.

Activities

Base groups meet at the beginning of each class session. Members pick up their base groups' folders, arrange their desks or sit two-by-two if in a lecture hall (or a room without moveable chairs) and carry out basic activities.

Folders. Groups give themselves names which they write on the tabs of their folders along with their group numbers. Group members also write their names on the outside of the folders. Some groups may choose to decorate their folders with things they have in common or symbols that represent their groups. This might be an ongoing task for the groups. In a class of 100 with 25 or more

base groups, we take pictures of the groups on the day they are assigned to their base groups. During the next session students tape these pictures to the inside of their folders, writing their names across their pictures. This practice helps us learn students' names faster so we can refer to them by name, in and outside of class and when they send E-mail during and after the course.

Routine Tasks. Attendance can be taken in the group. The Membership Grid (see Trust/Self Disclosure Tasks) can be used as the attendance record by having students write absent on it if a person is missing rather than allowing it to be filled in the next time the person attends class. Other records can be kept by the base group as well if this is important in the course (i.e., hours spent in lab or internship or fieldwork since the last session, or interviews completed).

Homework Check. Students check one anothers' homework to see if it is complete, if there were any problems with the assignment or with understanding the material. Arrangements can be made for a time outside of class when the base group can meet to provide academic or cognitive support to group members. Checklists of skills, concepts, processes and procedures can be completed within groups to determine the kind of support members need in order to understand the information in the course.

Other interesting activities to complete at the beginning of class meetings include:

Trust/Self Disclosure Tasks. With this task students share something personal about themselves. This is entered on a Membership Grid which gives the history of the group. Questions can be posed, such as favorite teacher and why, favorite relative and why, farthest place from this room traveled, most dangerous experience, hobby, qualities of a best friend, famous person you would like to learn from, person who had the most impact on your life, where and with whom you learned to resolve conflict, favorite movie, best thing that happened to you since last session, and so forth. These questions provoke self disclosure which facilitates the personal support that group members need to become a connected productive group. (For more information on using and understanding small groups see the previous article.)

Review of Relevant Learning. Periodically, we check what the students have read, thought about, or done that is relevant to the course since the last session. Each member gives a succinct summary of this to his/her base group. Sometimes students are asked to do a One Minute Paper individually before they share with their groups. This can be turned in via the group folder for the instructor to review. Students might bring resources they have found or copies of articles and other work they wish to share with their group members.

Peer Editing of Required Papers. Before papers are handed in to the instructor, base group members can peer edit them. They might check grammar, organization, style and other aspects of the writing process. We find that papers are of much higher quality when students are given some class time for peer editing.

Group Processing. To assist groups to function better, students are periodically asked to reflect on and give feedback to each other and the instructor about working together. Students might answer questions on what they like about each other, what they like about themselves, how they would rate themselves and the other group members on their involvement in their groups. Students might be asked to write about what is going well in their groups, what needs to be improved and how they will do this. Team members sign these papers, put them in the folders for the instructor to review and use for group processing activities. Reflection on how the groups are working helps to improve the functioning of the groups. Without this reflection, dysfunctional groups tend to remain that way throughout the term and students become angry and bitter about group work. To have honest processing, however, the trust level must be high in the groups. Trust activities are an important aspect of building effective group functioning.

During class sessions, base groups can be used for both informal and formal cooperative-group work.

Informal Group Interactions. When lecturing or making a longer presentation, instructors break "teacher talk" into shorter periods of time (for adults about 10-15 minute time blocks). At the end of that "talk" time, students are asked to turn to their base groups or to one member of their base group and answer a ques-

tion that the instructor has posed based on the information just presented. This process transforms the students into active rather than passive learners. Students are randomly selected from different groups to present a response based on the interaction with their partners. Sometimes they give written responses which are then placed in the folders. During an hour session, this may be done three or four times.

Formal Group Work. Students complete a formally-structured group project in their base groups on an area of concern or issue in the field. We use base groups when heterogeneity is important or changing groups is not critical to the project. At other times we use other team configurations based on grade level or subject area when base groups would not be as effective. The decision to use base groups or to form different groups for a project is dependent on the outcome desired. For example, a case study analysis can be done by forming groups using one person from three different base groups. Or, a Jigsaw of course material could be structured with the base group being the teaching/learning group with individuals studying and planning how to teach their section with members of other base groups who have responsibility for the same section of the materials.

At the end of class sessions, base groups can be used for closure. Some of these tasks might be similar to those used at the beginning or during the class session.

Closing Tasks. At the end of the session, base-group members should check to see that each member understands the assignment(s) and if anyone will need support. This checking might take the form of a meeting or just talking with each other on the telephone between sessions. Group members might set goals about what they will read or have completed before the next session. In addition, members might discuss what they learned during the session. They might even check their notes to be sure they have all of the important information. Further, members might discuss how they can apply what they learned during the session in a real-life situation. Group members might rate themselves as to how well they worked together during the day. And, of course, there should be a celebration of the hard work and learning which took place. Someone in each group is responsible for being sure all papers are

in the base-group folder and that the folder is returned to the instructor prior to leaving class.

Research Support

The research support for using cooperative base groups is extensive.

Social Support. Social psychology tells us that "receiving social support and being held accountable for appropriate behavior by peers who care about you and have a long-term commitment to your success and well-being is an important aspect of progressing through college" (Johnson & Johnson, 1989).

Achievement and Productivity. Cooperative efforts result in high achievement and greater productivity than competitive or individualistic efforts (Johnson & Johnson, 1997).

Concern for Self and Others. Conger (1988) found that without a balance between concern for self and concern for others, concern for self led to a banality of life and, even worse, to self-destructiveness, rootlessness, loneliness, and alienation. Individuals are empowered, are given hope and purpose, and experience meaning when they contribute to the well-being of others within an interdependent effort.

Sense of Belonging. When students feel they are supported and known by other students, they tend to feel less alienated and more positive about remaining in college. This kind of support has been shown to combat dropping out of school (Johnson & Johnson, 1989).

Conclusion

Cooperative-learning base groups are at the heart of all our courses. We have collected data and comments from students concerning their feelings about being in base groups. Not only do students benefit through both personal and academic support, we as instructors benefit.

Student Comments: Some students have reported that:

"Base groups helped me to develop a connection with other students. It forced me to expand my friendships,"

"As a new student to college, it was a reassuring way to get adjusted to classes,"

"I had people to count on when I missed class,"

"The tasks we did at the beginning of each class as a base group got us on task and kept me on schedule for readings and assignments,"

"Having feedback from other students and forming answers made the material clearer," and

"I felt more prepared for large group discussions."

Authors' Experiences. After using base groups over several years in teaching both undergraduate and graduate courses, we have found that:

*We can both view and be part of the social interaction,

*We hear and can address student concerns quickly and housekeeping chores can be taken care of expeditiously,

*Absent students can get remedial assistance from their base-group members,

*Ready-made groups are set up for activities, and

*Base groups provide constant, appropriate modeling of collaborative efforts in the classroom.

As more careers use teamwork to meet goals, institutions of higher education have an obligation to change the paradigm of how we conduct courses. When students interact with each other, we see that they not only achieve at higher levels, they also care more about each other. Even though structuring and organizing base groups requires time and thought initially, the benefits more than pay back the time and effort for both instructors and students. Base groups have been a gold mine in our courses.

21 Structured Controversy/ Constructive Controversy

David W. Johnson, Roger T. Johnson and Karl A. Smith

Using academic conflicts for instructional purposes is one of the most dynamic and involving, yet least-used teaching strategies. Although creating a conflict is an accepted writer's tool for capturing an audience, teachers often suppress students' academic disagreements and consequently miss out on valuable opportunities to capture their own audiences and enhance learning.

Controversy exists when one student's ideas, information, conclusions, theories, and opinions are incompatible with those of another. Structured academic controversies are most often contrasted with concurrence seeking, debate, and individualistic learning. For instance, students can inhibit discussion to avoid any disagreement and compromise quickly to reach a consensus while they discuss the issue (concurrence-seeking). Or students can appoint a judge and then debate the different positions with the expectation that the judge will determine who presented the better position (debate). Finally, students can work independently with their own set of materials at their own pace (individualistic learning).

Structured Controversy in Environmental Education

Topics on which we have developed curriculum units include the following and many others: "What caused the dinosaurs extinction? Should the wolf be a protected species? Should coal be

16 The Use of Pairs in Cooperative Learning

Mel Silberman

Originally published in the Cooperative Learning and College Teaching newsletter, Fall, 1996.

Let's face it, when you place students in cooperative-learning groups, lots of things can go wrong. Among the possibilities are:

- *Confusion*: Students don't know what to do because they didn't follow the directions.
- *Off-task*: Students don't stick to the topic or worse yet, they talk about the weather.
- *Unequal Participation*: Some people dominate, some remain quiet.
- *One-way Communication*: Students don't listen and respond to each other.
- *No Division of Labor*: Some people don't pull their own weight or let the group down.
- *Perfunctory Examination of the Issues*: Students are done before you know it, breezing through the assignment in the fastest way possible.

Experienced practitioners of cooperative learning know how to minimize these problems but their occurrence is still too frequent. In groups, it takes time to work out the several issues that delay the onset of learning and productivity. As many know, these issues are often referred to as forming, storming, and norming, and time and patience are required to let them happen.

Pairs are not immune to these problems and issues, but their ability to work through them is usually more rapid and less painful. It's hard to *hide* in a pair. It's also hard to get *left out* in one.

146

The communication network is simpler and there are more chances to work out conflicts.

There is a practical side to the use of pairs, as well. Pair activity tends to be less time-consuming and requires less movement of furniture. (Even a lecture hall can easily accommodate pair-learning activities.) In addition, pairs can more easily negotiate times to meet outside of the classroom.

The major disadvantage of pairs is the lack of several perspectives that exist in larger groupings. Therefore, one of the important goals in designing cooperative learning in pairs is to heighten an active exchange of viewpoints, information, and skills.

Ten Basic Activities in Pairs

I have developed a handy list of ten basic things you can ask students to do in pairs that begin the process of active learning:

1. **Discuss** a short written document together.
2. **Interview** each other concerning partners' reactions to an assigned reading, a lecture, a video, or any other educational activity.
3. **Critique** or edit one another's written work.
4. **Question** a partner about an assigned reading.
5. **Recap** a lecture or class session together.
6. **Develop** questions together to ask the instructor.
7. **Analyze** a case problem, experiment, or exercise together.
8. **Test** each other.
9. **Respond** to a question posed by the instructor.
10. **Compare** notes taken in class.

Of course, more complex assignments are also possible.

Five Structured Activities in Pairs

There are many ways to structure pair activity. Here are some of my favorites:

Active Knowledge Sharing

Overview: This a great way to draw students immediately into the subject matter of your course. You can also use it to assess the knowledge level of students, while at the same time, do some team building. It would work with any class and with any subject matter.

Procedure:

1. Provide a list of questions pertaining to the subject matter you would be teaching. You could include some or all of the following categories:

- words to define (e.g., "What does ambivalent mean?")
- multiple choice questions concerning facts or concepts (e.g., "A psychological test is valid if it: a) measures an attribute consistently over time; b) measures what it purports to measure.")
- people to identify (e.g., "Who is George Washington Carver?")
- questions concerning actions one could take in certain situations (e.g., "How do you register to vote?")
- incomplete sentences (e.g., "A _____ identifies the basic categories of tasks you can perform with a computer program.")

2. Create pairs and ask them to answer the questions as well as they can.

3. Then, invite them to mill around the room, finding other pairs who can answer questions they cannot. Encourage students to help each other.

4. Reconvene the full class and review the answers. Fill in answers unknown to any of the students. Use the information as a way to introduce topics of importance in the class.

Learning Starts With a Question

Overview: The process of learning something new is more effective if the learner is in an active, searching mode rather than a passive, receptive one. One way to create this mode of active learn-

ing is to stimulate students to delve into or inquire into subject matter on their own without prior explanation from the teacher. This simple strategy stimulates question asking, one key to learning.

Procedure:

1. Distribute an instructional handout of your own choosing. [You may use a page in a textbook instead of a handout.] Key to your choice of material is the need to stimulate questions on the part of the readers. A handout that provides broad information but lacks details or explanatory backup is ideal. An interesting chart or diagram that illustrates some knowledge is a good choice. A text that's open to interpretation is another good choice. The goal is to evoke curiosity.

2. Ask students to study the handout with partners. Request that pairs make as much sense of the handout as possible and identify what they do not understand by marking up the document with questions next to information they do not understand. Encourage students to insert as many question marks as they wish. If time permits, form pairs into quartets and allow time for pairs to help other pairs.

A physics teacher, for example, might distribute a diagram illustrating how potential energy converts to kinetic energy by showing a circus diver leaping from a 50-foot pole. Students work with partners to review the illustration and determine questions (i.e., "When exactly does the potential energy become kinetic energy?" "What is the basic difference between kinetic and potential energy?").

3. Reconvene the class and field questions that students have. In essence, you are teaching through your answers to student questions rather than through a preset lesson. Or, if you wish, listen to the questions all together and then teach a preset lesson, making special efforts to respond to the questions students posed.

The Power of Two

Overview: This activity is used to promote cooperative learning and reinforce the importance and benefits of synergy, that is, that two heads are indeed better than one.

Procedure:

1. Give students one or more questions that require reflection and thinking.

Here are some examples:

- How do our bodies digest food?
- What is knowledge?
- What is "due process?"
- How is the human brain like a computer?
- Why do bad things sometimes happen to good people?

2. Ask students to answer the questions individually.

3. After all students have completed their answers, arrange them into pairs to share their answers.

4. Ask the pairs to create a new answer to each question, improving on individual responses.

5. When all pairs have written new answers, compare the answers of each pair to the others in the class.

Jigsaw Learning In Pairs

Overview: Jigsaw learning is a widely-practiced technique in which each student learns something which, when combined with the material learned by others, forms a coherent body of knowledge or skill. While Jigsaw learning can be utilized with different-size groups, pairs are an ideal choice.

Procedure:

1. Choose learning material that can be broken into parts. A segment can be as short as one sentence or as long as several pages. (If the material is lengthy, ask students to read their assignments before class.)

Examples include:

- A multi-point handout
- Parts of a science experiment
- A text that has different sections or sub-headings
- A list of definitions
- A group of magazine-length articles or other kinds of short reading material

2. Divide the learning material into two segments. Assign each

member of the pair one of the two segments and ask him or her to read and learn the material assigned.

3. After the study period, reconvene the pair.

4. Ask the partners to teach each other what they have learned. Or give the pair a set of questions or a task to do that requires the separate knowledge of each partner.

5. Reconvene the full class for review to ensure accurate understanding.

Pair Review

Overview: This strategy gently challenges students to recall in pairs what was learned in each of the topics or units of the class. It is an excellent way to help students revisit the content you have covered.

Procedure:

1. At the end of a class, present students with a list of the topics you have covered. Explain that you want to find out what they remember about the topics and what they have forgotten. Keep the atmosphere informal so that they do not feel threatened by the activity.

2. Form pairs and ask partners to recall what each topic was about and as many things as they can remember about it. Ask questions such as:

- What does this topic refer to?
- Why is it important?
- Who can give me an example of what we learned about this topic?
- What value does this topic have for you?
- What were some of the learning activities we experienced with each topic?

If little is recalled, handle their forgetting humorously or place the blame on yourself for not making the topic "unforgettable."

3. Continue in chronological order until you have touched upon all the course material (or as much of it as you have time and student interest).

4. As you proceed through the content, make any final remarks you wish.

Improved Learning in a Large-Enrollment Physics Class

Louis Deslauriers *et al.*

Science **332**, 862 (2011);
DOI: 10.1126/science.1201783

Improved Learning in a Large-Enrollment Physics Class

Louis Deslauriers,[1,2] Ellen Schelew,[2] Carl Wieman*†‡

We compared the amounts of learning achieved using two different instructional approaches under controlled conditions. We measured the learning of a specific set of topics and objectives when taught by 3 hours of traditional lecture given by an experienced highly rated instructor and 3 hours of instruction given by a trained but inexperienced instructor using instruction based on research in cognitive psychology and physics education. The comparison was made between two large sections ($N = 267$ and $N = 271$) of an introductory undergraduate physics course. We found increased student attendance, higher engagement, and more than twice the learning in the section taught using research-based instruction.

The traditional lecture approach remains the prevailing method for teaching science at the postsecondary level, although there are a growing number of studies indicating that other instructional approaches are more effective (1–8). A typical study in the domain of physics demonstrates how student learning is improved from one year to the next when an instructor changes his or her approach, as measured by standard concept-based tests such as the Force Concept Inventory (9) or the instructor's own exams. In our studies of two full sessions of an advanced quantum mechanics class taught either by traditional or by interactive learning style, students in the interactive section showed improved learning, but both sections, interactive and traditional, showed similar retention of learning 6 to 18 months later (10). Here, we compare learning produced by two contrasting instructional methods in a large-enrollment science course. The control group was lectured by a motivated faculty member with high student evaluations and many years of experience teaching this course. The experimental group was taught by a postdoctoral fellow using instruction based on research on learning. The same selected learning objectives were covered by both instructors in a 1-week period.

The instructional design for the experimental section was based on the concept of "deliberate practice" (11) for the development of expertise.

The deliberate practice concept encompasses the educational ideas of constructivism and formative assessment. In our case, the deliberate practice takes the form of a series of challenging questions and tasks that require the students to practice physicist-like reasoning and problem solving during class time while provided with frequent feedback.

The design goal was to have the students spend all their time in class engaged in deliberate practice at "thinking scientifically" in the form of making and testing predictions and arguments about the relevant topics, solving problems, and critiquing their own reasoning and that of others. All of the activities are designed to fit together to support this goal, including moving the simple transfer of factual knowledge outside of class as much as possible and creating tasks and feedback that motivate students to become fully engaged. As the students work through these tasks, they receive feedback from fellow students (12) and from the instructor. We incorporate multiple "best instructional practices," but we believe the educational benefit does not come primarily

from any particular practice but rather from the integration into the overall deliberate practice framework.

This study was carried out in the second term of the first-year physics sequence taken by all undergraduate engineering students at the University of British Columbia. This calculus-based course covers various standard topics in electricity and magnetism. The course enrollment was 850 students, who were divided among three sections. Each section had 3 hours of lecture per week. The lectures were held in a large theater-style lecture hall with fixed chairs behind benches grouping up to five students. The students also had weekly homework assignments, instructional laboratories, and tutorials and recitations where they solved problems; this work was graded. There were two midterm exams and a final exam. All course components were common across all three sections, except for the lectures, which were prepared and given independently by three different instructors.

During week 12, we studied two sections whose instructors agreed to participate. For the 11 weeks preceding the study, both sections were taught in a similar manner by two instructors (A and B), both with above average student teaching evaluations and many years experience teaching this course and many others. Both instructors lectured using PowerPoint slides to present content and example problems and also showed demonstrations. Meanwhile, the students took notes. "Clicker" (or "personal response system") questions (average 1.5 per class, range 0 to 5) were used for summative evaluation (which was characterized by individual testing without discussion or follow-up other than a summary of the correct answers). Students were given participation credit for submitting answers.

Before the experiment, a variety of data were collected on the students in the two sections

[1]Carl Wieman Science Education Initiative, University of British Columbia, Vancouver, BC, Canada. [2]Department of Physics and Astronomy, University of British Columbia, Vancouver, BC, Canada.

*On leave from the University of British Columbia and the University of Colorado.
†To whom correspondence should be addressed. E-mail: gilbertwieman@gmail.com
‡This work does not necessarily represent the views of the Office of Science and Technology Policy or the United States government.

Table 1. Measures of student perceptions, behaviors, and knowledge.

	Control section	Experimental section
Number of students enrolled	267	271
Mean BEMA score (13) (week 11)	47 ± 1%	47 ± 1%
Mean CLASS score (14) (start of term) (agreement with physicist)	63 ± 1%	65 ± 1%
Mean midterm 1 score	59 ± 1%	59 ± 1%
Mean midterm 2 score	51 ± 1%	53 ± 1%
Attendance before experiment*	55 ± 3%	57 ± 2%
Attendance during experiment	53 ± 3%	75 ± 5%
Engagement before experiment*	45 ± 5%	45 ± 5%
Engagement during experiment	45 ± 5%	85 ± 5%

*Average value of multiple measurements carried out in a 2-week interval before the experiment. Engagement also varies over location in the classroom; numbers given are spatial and temporal averages.

(Table 1). Students took two midterm exams (identical across all sections). In week 11, students took the Brief Electricity and Magnetism Assessment (BEMA), which measures conceptual knowledge (*13*). At the start of the term, students took the Colorado Learning Attitudes about Science Survey (CLASS) (*14*), which measures a student's perceptions of physics. During weeks 10 and 11, we measured student attendance and engagement in both sections. Attendance was measured by counting the number of students present, and engagement was measured by four trained observers in each class using the protocol discussed in the supporting online material (SOM) (*15*). The results show that the two sections were indistinguishable (Table 1). This in itself is interesting, because the personalities of the two instructors are rather different, with instructor A (control section) being more animated and intense.

The experimental intervention took place during the 3 hours of lecture in the 12th week. Those classes covered the unit on electromagnetic waves. This unit included standard topics such as plane waves and energy of electromagnetic waves and photons. The control section was taught by instructor A using the same instructional approach as in the previous weeks, except they added instructions to read the relevant chapter in the textbook before class. The experimental section was taught by two instructors who had not previously taught these students. The instructors were the first author of this paper, L.D., assisted by the second author, E.S. Instructor A and L.D. had agreed to make this a learning competition. L.D. and instructor A agreed beforehand what topics and learning objectives would be covered. A multiple-choice test (see SOM) was developed by L.D. and instructor A that they and instructor B agreed was a good measure of the learning objectives and physics content. The test was prepared at the end of week 12. Most of the test questions were clicker questions previously used at another university, often slightly modified. Both sections were told that they would receive a bonus of 3% of the course grade for the combination of participating in clicker questions, taking the test, and (only in the experimental section) turning in group task solutions, with the apportionment of credit across these tasks left unspecified.

In contrast to instructor A, the teaching experience of L.D. and E.S. had been limited to serving as teaching assistants. L.D. was a postdoctoral researcher working in the Carl Wieman (third author of this paper) Science Education Initiative (CWSEI) and had received training in physics education and learning research and methods of effective pedagogy while assisting with the teaching of six courses. E.S. had a typical physics graduate student background except for having taken a seminar course in physics education.

The instructional approach used in the experimental section included elements promoted by CWSEI and its partner initiative at the University of Colorado: preclass reading assignments, preclass reading quizzes, in-class clicker questions with student-student discussion (CQ), small-group active learning tasks (GT), and targeted in-class instructor feedback (IF). Before each of the three 50-min classes, students were assigned a three- or four-page reading, and they completed a short true-false online quiz on the reading. To avoid student resistance, at the beginning of the first class, several minutes were used to explain to students why the material was being taught this way and how research showed that this approach would increase their learning.

A typical schedule for a class was the following: CQ1, 2 min; IF, 4 min; CQ2, 2 min; IF, 4 min; CQ2 (continued), 3 min; IF, 5 min; Revote CQ2, 1 min; CQ3, 3 min; IF, 6 min; GT1, 6 min; IF with a demonstration, 6 min; GT1 (continued), 4 min; and IF, 3 min. The time duration for a question or activity includes the amount of time the students spent discussing the problem and asking numerous questions. There was no formal lecturing; however, guidance and explanations were provided by the instructor throughout the class. The instructor responded to student-generated questions, to results from the clicker responses, and to what the instructor heard by listening in on the student-student discussions. Students' questions commonly expanded upon and extended the material covered by the clicker questions or small-group tasks. The material shown on the slides used in class is given in the SOM, along with some commentary about the design elements and preparation time required.

At the beginning of each class, the students were asked to form groups of two. After a clicker question was shown to the class, the students discussed the question within their groups (which often expanded to three or more students) and submitted their answer using clickers. When the voting was complete, the instructor showed the results and gave feedback. The small-group tasks were questions that required a written response. Students worked in the same groups but submitted individual answers at the end of each class for participation credit. Instructor A observed each of these classes before teaching his own class and chose to use most of the clicker questions developed for the experimental class. However, Instructor A used these only for summative evaluation, as described above.

L.D. and E.S. together designed the clicker questions and small-group tasks. L.D. and E.S.

had not taught this class before and were not familiar with the students. Before the first class, they solicited two volunteers enrolled in the course to pilot-test the materials. The volunteers were asked to think aloud as they reasoned through the planned questions and tasks. Results from this testing were used to modify the clicker questions and tasks to reduce misinterpretations and adjust the level of difficulty. This process was repeated before the second class with one volunteer.

During the week of the experiment, engagement and attendance remained unchanged in the control section. In the experimental section, student engagement nearly doubled and attendance increased by 20% (Table 1). The reason for the attendance increase is not known. We hypothesize that of the many students who attended only part of a normal class, more of them were captured by the happenings in the experimental section and decided to stay and to return for the subsequent classes.

The test was administered in both sections in the first class after the completion of the 3-hour unit. The control section had covered the material related to all 12 of the questions on the test. The experimental section covered only 11 of the 12 questions in the allotted time. Two days before the test was given, the students in both sections were reminded of the test and given links to the postings of all the material used in the experimental section: the preclass reading assignments and quizzes; the clicker questions; and the group tasks, along with answers to all of these. The students were encouraged by e-mail and in class to try their best on the test and were told that it would be good practice for the final exam, but their performance on the test did not affect their course grade. Few students in either section finished in less than 15 min, with the average being about 20 min.

The test results are shown in Fig. 1. For the experimental section, 211 students attended class to take the test, whereas 171 did so in the control section. The average scores were 41 ± 1% in the control section and 74 ± 1% in the experimental section. Random guessing would produce a score of 23%, so the students in the experimental section did more than twice as well on this test as those in the control section.

The test score distributions are not normal (Fig. 1). A ceiling effect is apparent in the experi-

Fig. 1. Histogram of student scores for the two sections.
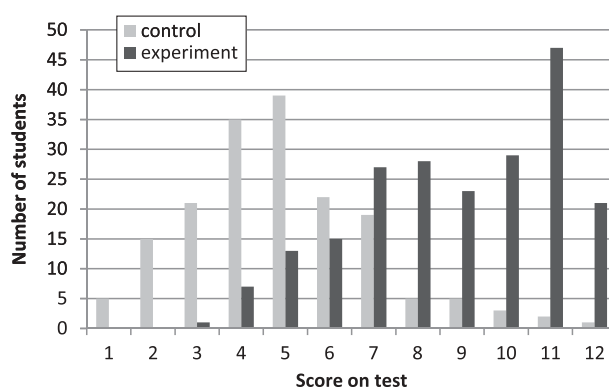
mental section. The two distributions have little overlap, demonstrating that the differences in learning between the two sections exist for essentially the entire student population. The standard deviation calculated for both sections was about 13%, giving an effect size for the difference between the two sections of 2.5 standard deviations. As reviewed in (*4*), other science and engineering classroom studies report effect sizes less than 1.0. An effect size of 2, obtained with trained personal tutors, is claimed to be the largest observed for any educational intervention (*16*).

This work may obtain larger effect sizes than in this previous work because of the design and implementation that maximized productive engagement. The clicker questions and group tasks were designed not only to require explicit expert reasoning but also to be sufficiently interesting and personally relevant to motivate students to fully engage. Another factor could be that previous work primarily used end-of-term tests, and the results on those tests reflect all the learning that students do inside and outside of class, for example, the learning that takes place while doing homework and studying for exams. In our intervention, the immediate low-stakes test more directly measured the learning achieved from preclass reading and class itself, in the absence of subsequent study.

We are often asked about the possible contributions of the Hawthorne effect, where any change in conditions is said to result in improved performance. As discussed in citations in the SOM, the original Hawthorne plant data actually show no such effect, nor do experiments in educational settings (*17*).

A concern frequently voiced by faculty as they consider adopting active learning approaches is that students might oppose the change (*18*). A week after the completion of the experiment and exam, we gave students in the experimental section an online survey (see SOM); 150 students completed the survey.

For the survey statement "I really enjoyed the interactive teaching technique during the three lectures on E&M waves," 90% of the respondents agreed (47% strongly agreed, 43% agreed) and only 1% disagreed. For the statement "I feel I would have learned more if the whole physics 153 course would have been taught in this highly interactive style." 77% agreed and only 7% disagreed. Thus, this form of instruction was well received by students.

In conclusion, we show that use of deliberate practice teaching strategies can improve both learning and engagement in a large introductory physics course as compared with what was obtained with the lecture method. Our study compares similar students, and teachers with the same learning objectives and the same instructional time and tests. This result is likely to generalize to a variety of postsecondary courses.

References and Notes

1. R. J. Beichner *et al.*, in *Research-Based Reform of University Physics*, E. F. Redish, P. J. Cooney, Eds. (American Association of Physics Teachers, College Park, MD, 2007).
2. C. H. Crouch, E. Mazur, *Am. J. Phys.* **69**, 970 (2001).
3. J. E. Froyd, "White paper on promising practices in undergraduate STEM education" [Commissioned paper for the Evidence on Promising Practices in Undergraduate Science, Technology, Engineering, and Mathematics (STEM) Education Project, The National Academies Board on Science Education, 2008]. www7.nationalacademies.org/bose/Froyd_Promising_Practices_CommissionedPaper.pdf
4. J. E. Froyd, "Evidence for the efficacy of student-active learning pedagogies" (Project Kaleidoscope, 2007). www.pkal.org/documents/BibliographyofSALPedagogies.cfm
5. R. R. Hake, *Am. J. Phys.* **66**, 64 (1998).
6. J. K. Knight, W. B. Wood, *Cell Biol. Educ.* **4**, 298 (2005).
7. M. Prince, *J. Eng. Educ.* **93**, 223 (2004).
8. L. Springer, M. E. Stanne, S. S. Donavan, *Rev. Educ. Res.* **69**, 21 (1999).
9. D. Hestenes, M. Wells, G. Swackhamer, *Phys. Teach.* **30**, 141 (1992).
10. L. Deslauriers, C. Wieman, *Phys. Rev. ST Phys. Educ. Res.* **7**, 010101 (2011).
11. K. A. Ericsson, R. Krampe, C. Tesch-Romer, *Psychol. Rev.* **100**, 363 (1993).
12. M. K. Smith *et al.*, *Science* **323**, 122 (2009).
13. L. Ding, R. Chabay, B. Sherwood, R. Beichner, *Phys. Rev. ST Phys. Educ. Res.* **2**, 010105 (2006).
14. W. K. Adams *et al.*, *Phys. Rev. ST Phys. Educ. Res.* **2**, 010101 (2006).
15. Materials and methods are available as supporting material on *Science* Online.
16. B. Bloom, *Educ. Res.* **13**, 4 (1984).
17. R. H. Bauernfeind, C. J. Olson, *Phi Delta Kappan* **55**, 271 (1973).
18. G. K. Allen, J. F. Wedman, L. C. Folk, *Innovative High. Educ.* **26**, 103 (2001).

Supporting Online Material