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TEACHING LARGE MATH CLASSES: THREE INSTRUCTORS, ONE EXPERIENCE

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ABSTRACT. This article identifies challenges involved in teaching a mathematics class with 350 or more students. It discusses issues of preparation, organization, course administration, instruction, use of technology, and student management, while offering constructive help and useful techniques for teaching large mathematics classes. General reflections from three instructors on their large class teaching experiences are followed by a model of how large freshmen Calculus courses are conducted at Simon Fraser University in Burnaby, BC.

KEYWORDS. Large Classes, Mathematics, Teaching, Calculus, Online Assignments, Learning Management System.

REFLECTIONS ON LARGE CLASS TEACHING

In the current university environment, instructors are often called on to teach large classes, especially to incoming students. There have been some recent studies aimed at improving teaching and learning in a large class environment, but we have found no resources specific to teaching a large mathematics course (AUTC, 2001; Carbone, 1998; Gedalof, 2002; Gibbs, 1992; MacGregor, 2000; Stanley, 2002). This article thus aims to identify challenges, offer constructive help, and share useful techniques for teaching large classes, which we define to be classes with 350 or more students managed by a single instructor. The included suggestions are drawn from the experiences of three instructors who taught large entry-level mathematics courses at Simon Fraser University for more than two semesters. General reflections on our shared large-class teaching experiences are followed by a case study about how we conduct a freshmen Calculus course. While there are concerns specific to large mathematics classes, the issues of preparation, organization, course administration, instruction, use of technology, student management, and grading are common to large classes of other subject areas.

The magnitude of undertaking large class teaching presents many obstacles. How does an instructor maintain a level of human interaction with so many students? How might one address challenges of scheduling office hours, dealing with e-mail, assigning homework, and recording grades on a large scale? Under these conditions, how does an instructor effectively communicate the subject material? Not only must the instructor organize the course and communicate the material as in a smaller class, but it is also especially important in a large class

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to overcome difficulties of presentation and crowd control, while addressing freshman anxiety, providing feedback to students, and creating an atmosphere conducive to learning. Below, we describe challenges of administration, management, instruction, and interaction and outline techniques that we have used to meet those challenges in our collective experience teaching large mathematics classes.

A lecture hall filled with 350 or more entry-level undergraduates can be intimidating for both the students and the instructor. It becomes easy to ignore the importance of human interaction in this course format. These entry-level courses are content-heavy, fast-paced, and seem impersonal, which is often overwhelming for beginning university students (Erickson, 1991, pp. 29-45). Unfortunately, students who feel anonymous may not be motivated to attend class, much less seek help, ask questions in class, or communicate with other students and the instructor. Other types of students view the anonymity as an invitation to chat noisily even during lectures thereby showing disrespect for the instructor, fellow students and the course. On the other hand, the instructor looking out on a sea of dimly lit student faces can simply fail to see a timidly raised hand or to hear a cautiously ventured question. Sometimes, plunging onward with zeal to pass on knowledge can ruin opportunities for teaching and learning. Creating an atmosphere of learning where both the instructor and students take risks requires a certain level of comfort and experience in any course, but it is especially important in a large class to work towards an environment of individual learners rather than a mass of people. Person-to-person dialogue with students needs to be encouraged before, during, and after lectures to facilitate connections between the instructor and students, thus providing a platform for asking questions. We have found that electronic communication such as e-mail and discussion boards increases interaction with students. Soliciting student feedback mid-semester not only gives students an opportunity to comment on the course, but also gives the instructor an opportunity to value student input and suggestions.

An instructor teaching a first-year university course has seemingly contradictory tasks to balance. On the one hand, the instructor has a responsibility to teach foundational material and – in an aim to prepare students for future courses – to establish a level of rigor appropriate for university courses that is new to most freshmen. Such introductory courses often serve a gate-keeping function and issue early warnings to those students with inadequate academic abilities or working habits. On the other hand, the instructor plays an important role in welcoming, encouraging, and supporting students during one of the major transitions in their lives. Clearly communicating expectations for student work in the course, such as how much time they should plan to spend outside of class or how to study and prepare for class, can help smooth the adjustment to university life, (Davis, 1993). Often, it can be beneficial for both the instructor and the students of introductory courses to acquaint students with information about resources that offer guidance for the first year (Erickson, 1991).

There is no unique solution to the problem of managing a large class, since individual instructors vary and different institutions uphold different requirements and maintain a variety of expectations. It is our opinion, however, that managing a large group of students requires advanced organization and detailed planning. Students in a well set up course are better able to focus on their learning rather than dealing with logistical issues of where to hand in or pick up assignments, where to turn for help, and so on. Before the course begins, the instructor should distribute the course material over the given time period, set midterm and final exam dates, select questions for homework assignments and assign their due dates, select old exams for students to study from, choose office hours – typically three per week, settle on a grading scheme, and define course and lecture policies.

The use of contemporary technology greatly simplifies the huge task of managing a large class. We have found course web pages invaluable for administrating and communicating with large classes. A standard way of maintaining a course web page is through one of many existing learning management systems (LMS). A typical LMS contains a grade book, chat rooms, and a discussion board. A course web page thus allows for communication between the instructor and the students, as well among the students themselves. With e-mail and an LMS, each student in the class is easily reachable by the instructor. From the discussion board the instructor can take the pulse of the class. What confused students? Were certain examples helpful or unclear? What additional examples might help? Often, common concerns arise in a chat room and these can then be addressed by the instructor in the lecture setting. A typical LMS also has a bulletin board where the instructor can post various course materials – such as the course outline, lecture notes, assignment solutions, and old exams – for the students. Other examples of possible use of technology in teaching a course are online quizzes and online surveys. Online quizzes and assignments could be used both as tutorial and assessment tools, while surveys allow the instructor to receive timely feedback on the course.

One specific benefit of a web page is the ability to communicate a lecture policy early and so set the tone for the course. In this policy the instructor outlines rules of conduct expected during a lecture: no talking when the instructor speaks, raising a hand and calling the instructor's name when a question arises, turning off of all electronic communication devices owned by students, and so on. This policy not only helps set the tone of the lectures, but it also and helps with classroom management in a large class.

Although structure is necessary for a smooth semester of large class teaching, it is important to build in some flexibility as well. Common student problems like illness, procrastination, cheating, and family deaths will naturally arise more frequently than in a smaller class. The instructor should anticipate exceptions and have a policy at hand to deal with these matters in a manner fair to all students. For example, the grading scheme is a policy that applies for all students, but this does not mean that an instructor cannot make an exception when a situation warrants it.

Managing a class of several hundred students is certainly a demanding job, but it cannot consume all of the instructor's attention. In fact, the infrastructure for course administration should be running smoothly so that the instructor can primarily focus on delivering the subject material. Likewise, the instructor cannot focus too much on being a disciplinarian because the presentation and delivery of the subject material requires preparation and organization. Careful time management is thus another essential component of large class instruction. Often this requires adjustments from smaller class teaching. For example, reducing the material presented in the classroom from two applications to one allows more time for questions from a large body of students. Skipping steps in proofs or calculations is another option to create more time; however, the instructor should only opt for this method of teaching when just a rough proof outline is sufficient or the instructor has established that the students are able to follow the sketchy proof. Sometimes, explaining a single example twice, slowly and in detail, is more effective than covering a handful of different applications.

These are helpful methods for maximizing time, but we have found that the most effective way to use time efficiently in a large class is simply to prepare typed lecture notes for students in advance. These notes list motivations, definitions and theorems that will be presented in the lecture. They also include unsolved examples and applications that will be worked out in class. Providing these notes in electronic format a few days ahead of time allows students to print them out and to come to the lecture prepared. Students who are not hunched over, frantically working to copy down detailed mathematics can better concentrate on the presentation. The details are in the notes, so more class time can be spent communicating the bigger picture, clearing up confusion, and motivating students to work outside of class. Instead of talking to a room full of bent heads, the instructor can explain definitions and theorems to students that have been given the opportunity to pay attention. Furthermore, the instructor can demonstrate how to read examples and applications effectively and allow time for more questions.

It is very likely, that an instructor new to a content-heavy course will not get through as many examples and applications as were planned. It is therefore especially important to motivate students to learn more on the subject matter outside of the lecture hall. Online quizzes on present lecture material that are due before the next lecture are an effective method in keeping students on the task of learning the material outside the lecture. If the quizzes are also designed around definitions and theorems, then it encourages students to engage in reading the textbook on a deeper level as well. Furthermore, this method provides opportunities for students to see more examples and applications when an instructor is unable to give that many in a content-heavy course.

The delivery of a lesson deserves a few more remarks. In our experience, a large class is far less tolerant of small, common human errors such as making a calculation mistake, getting stuck in an explanation, loosing a train of thought, or forgetting a formula. We believe that an

instructor of a large class is much like an actor on a stage and in that role must also rehearse. It is important to proofread one's slides and to go through the lecture mentally, noting where time can get created and where it cannot. New terms and concepts must be clearly and slowly introduced, not just orally but also visually. Just like an actor, an instructor needs to have a vast repertoire of effective lecture methods on hand. Students can benefit from being kept on their toes and surprised every once in a while. "[Students] would welcome being able to make use of the many different perspectives, knowledge-bases, interests and approaches present in their community of learners, when they are learning mathematics" (Burton, 2004, p. 179). For example, slicing fruit to demonstrate the disk and shell method is an unexpected approach. Getting students involved in demonstrations can be effective, too. Another idea is to bring in graphics or animation projections that further aid visual understanding of a concept. Furthermore, maintaining high energy and communicating your enthusiasm for the subject throughout the lecture helps to retain student attention. You should use the vast space of the large lecture hall to maximum advantage. Moving around the auditorium not only helps to hold students' attention, but it also helps to reduce chatter, which saves precious class time otherwise spent to get the lecture hall in order.

On the technical side, delivering a lecture in an auditorium with 350 or more seats generally requires the use of a microphone, a couple of overhead projectors, and/or a computer and data projector. This technology is simply needed to make communicating a lecture more effective. Yet, as in a performance, technical difficulties can be problematic in teaching. Crackling microphones, bad felt pens, unavailable internet connections, or malfunctioning projectors can cause major disruptions during the lecture. Not only that, but the instructor can quickly loose student attention and respect through a technological break down. It is best to recognize these risks, to plan ahead, to arrive early to test all devices, and, finally, to be flexible enough to deliver differently than planned, if necessary. Many institutions provide audio and visual support for lecture halls. It is helpful to find out how to contact an AV person during a lecture before the semester begins and to keep this information on hand for all lectures.

Lastly, we address the issue of assessment and evaluation of students, which must also be well planned for large classes. Paper and online assignments should be seen as formative assessment. They are designed for students to practice certain concepts and skills, to become familiar with notation and terminology and to provide continual feedback on their learning. Our large courses are supported by workshops manned by the instructor and teaching assistants, which are essentially drop-in math help centres that provide on-going help with assignments, understanding concepts, or any other course related issues that arise. Midterm and final examinations are summative assessments that summarize the level of skills and mastery of concepts a student has attained at specific times during the semester. We have found that review sessions prior to any examination are invaluable in "integrating, summarizing, synthesizing, and otherwise pulling together disparate pieces of information [which] are sophisticated learning

skills that merit attention and development" (Weimer, 2002, p. 134). Especially first-year students are concerned with the letter grades they will be obtaining in their courses. We have found that there are very few student complaints when assessment and evaluation are dealt with up-front and based on criteria that are clearly communicated to the students such as setting a grading scheme at the beginning of the course and providing timely feedback on assignments.

Despite the challenges outlined above, teaching a large class offers unique rewards. In particular, a large class offers the instructor incredible potential for creating excitement among students. When a lecture or demonstration goes well, it generates a charge of positive energy that excites the students and instructor alike. A collective aha moment with a mass of students is a powerful reminder of what university learning can be. We all agree that large class teaching can be enjoyable, despite the additional hurdles to overcome. We include below a model of our Calculus courses. The explanation of the way they are conducted includes specific suggestions from our teaching experience that will hopefully help others make the most of their large class teaching experience.

A WORKING MODEL

The Courses: Simon Fraser University (SFU) offers three introductory Calculus courses serving students who declare business or economics, biological sciences, or engineering, computer science or mathematics as their major. Each course is offered every semester at this tri-semester university with three 50-minute lectures per week for 13 weeks. There are slight differences in these courses, but they share large course structure and characteristics, so we have combined below our approaches in these three courses to the high priority issues of time management and course administration, as well as the issue of creating a positive learning atmosphere. We will discuss in well-defined sections the various components that define our large class, including the use of technology, which we have found effective in enhancing teaching and learning in a class of 350 or more students.

The prerequisite for all three courses is BC Principles of Mathematics 12 (or equivalent) with a grade of at least B, or a university pre-calculus course with a grade of at least C-.

Students: The mathematical abilities of students range considerably despite the prerequisite. Some are very confident and capable problem-solvers, while others are very weak algebraically. Weak algebra skills can be a particular hindrance in a calculus course. It is thus helpful to warn the class of potential difficulties, to provide a review sheet or reference book the first day of class, and to let students know where they can go for help.

Learning Management System: The main learning management system at SFU is WebCT, which greatly simplifies organization for a large class. It also puts the onus on each individual student to get informed about the course material and to make sure their marks are

correctly recorded. On average, over two sample semesters, each student visited the WebCT container about 465 times per semester. The WebCT container for Math 157 is used for posting all information about the course and the Applied Calculus Workshop, including:

- course outline and lecture schedule
- workshop schedule
- lecture notes
- announcements from instructor and workshop coordinator
- assignment problems with due dates
- assignment solutions
- review material
- sample exams and solutions to exams
- relevant links: old exams, online assignments, reference websites, etc.
- students' grades

The Help Centre: At SFU, the calculus courses are serviced by two drop-in help centres called the Applied Calculus Workshop (ACW) and Calculus Workshop (CW). The ACW and CW are coordinated by two faculty members – called coordinators – of the Department of Mathematics and staffed by teaching assistants (TAs) who are undergraduate mathematics majors or graduate students in mathematics. The coordinators handle all scheduling, record keeping, and TA supervising in addition to spending a few hours per week advising students in the workshop. Each course instructor usually schedules two office hours per week in the workshop as well. The workshops are open every weekday for most of the day. At any time there are at least two teaching assistants in the workshop to answer student questions and provide individual help. The workshops also serve as the homework clearing house. Students submit their homework to the workshop and also pick it up there after it is marked.

The paid workload of a teaching assistant is broken down into preparation time and duties. The duties are to be available in the workshop to advise students, to mark and record assignments, to invigilate, mark and record midterm and final exams. The coordinator will assign these duties to ensure that there is a good mix of experienced and new TAs represented in all tasks.

Lectures:

• Preparation: Arriving at the lecture hall at least five minutes early sets a good example for students and also allows time to put up the first transparency, to focus the overheads, to adjust the lights in the theatre, to get the laptop hooked up, to attach the microphone, and to socialize with the students. It is helpful to discuss technology with the audio-visual support staff. We have also found it informative to talk with a professional actor about microphone usage and stage presence.

• Organization: The instructor should strive to always be well prepared and organized. Transparencies should be proofread in detail along with written notes related to the lecture. It is also very helpful to perform a quick rehearsal before the lecture to get into the right frame of mind.

• Time management: The instructors strictly follow the clock in the theatre and always start and end the lecture at the scheduled time regardless of the numbers of students walking in late or leaving early.

• Student management: One big challenge in teaching a large class is to make students aware that, regardless of its size, a large class is still a class with the instructor in charge. Any sign of the instructor's insecurity will be met with students' negative reactions resulting in loss of control and the ability to teach the class effectively. It is helpful for the students to spend a few minutes of the very first lecture articulating policies for the course, which include rules of conduct (regarding cell phones, talking in class, tardiness, etc) and address unacceptable behaviour. Occasionally, the instructor has to be tough and reinforce the rules. If a cell phone rings in the middle of a lecture, that issue must be addressed and the cell phone owner should be talked to directly. If a group of people is talking during a lecture they should be reminded that they are students in the class and that they do not have the right to disturb the rest of their colleagues.

• Student participation: Students should be encouraged to participate in the lecture by asking questions and responding to the instructor's questions. Keeping students involved and interested can help them stay quiet and focused. Introducing humour or group work or demonstrations helps to provide breaks during the lecture and gives students time to process material. Humour should certainly never belittle the students and should not be personal unless self-directed at the instructor. It is useful to give students one or two minutes to work on a particular aspect of an example – setting the problem up, drawing an accompanying diagram, working through some algebra, applying the newly learned technique, etc – or the whole solution of a problem and then to discuss it as a group. This actively engages the class in learning and gives the instructor opportunity to circulate in the lecture hall, being available for questions and making contact with students. In our experience, teaching a large class requires far more energy and enthusiasm than a small class.

Notes: The instructor posts notes in PDF format online so they are available to students prior to the lecture. These notes contain an outline of the lecture which includes new definitions, new theorems, and examples along with blank space for students to add explanations, observations, details, and solutions worked out in class. Many students come to class prepared with a printout of these notes, which allows them to follow the transmitted information more readily. The instructor works through transparencies of the notes during the lecture. This method decreases mistakes made by the instructor during the lecture and thus avoids some confusion. It is our impression that this system encourages students' participation during lectures and enhances the learning of the material. Students are quite appreciative of this approach. Two students describe their experience in the following way. "For the lecture, it is a good idea to ask students to fill up the space or copy down the solutions. This is much better than only talking, since math is an issue of practicing;" and "I want to thank you for the lecture notes! They are awesome and allow me to follow you more easily, as I'm not always busy copying down your writing. They are very nice to study with."

Textbook: Reading a printed math text thoroughly is a useful intellectual exercise in understanding the language of mathematics and how material is presented. Since the most important part of teaching a freshmen class is to help students reach the next level of academic maturity, this exercise could have a long lasting positive experience and we encourage all instructors to offer this form of teaching to their students. In addition, while we all agree that the main lecture material is based on the suggested textbook; we have some differing opinions regarding a further role of the textbook. We offer both views here.

One approach is to have a tight link between the notes and the textbook. Most definitions, properties, and examples are taken straight from the textbook. An exact reference to the textbook accompanies each of those citations. With this approach the instructor wants to justify the expense of a textbook and to encourage students to read it and use it as a common reference. The instructor can direct students to a particular example or problem, and students can quote the textbook to support their chain of thoughts. Following the textbook closely also allows the instructor to spend more time elaborating motivation for some of the big ideas that are often overlooked in a survey course. An obvious problem with staying close to the textbook is that students can get an impression that the instructor is taking an easy way out. This can be avoided by using puzzles and quotes to introduce new topics, by providing other examples regularly, by slightly changing examples from the textbook, and by using problems from old exams as examples during lectures.

Another approach is based on student opinion as expressed in surveys. Many strongly object if an instructor follows the book too closely. They want to see other examples and applications developed during a lecture so that they can use the examples and applications provided in the textbook as an additional resource for studying outside of class. Some students

also benefit from reading and hearing definitions and theorems expressed differently than they are in the textbook. Moreover, well-prepared students will surely read other calculus textbooks in an effort to understand the material better and in preparation for their exams. It is therefore beneficial to teach students how to read any calculus textbook and not just the suggested textbook. Furthermore, while a particular textbook is suggested for the course and most likely with very good reasons, it is still a student's individual decision whether to spend the money on it or not. Often an older edition suffices or a different, but similarly organized textbook. Lastly, a textbook is but one author's decision on how material is laid out. The instructor may, for example, find it more beneficial to do section 3.4 before section 2.2 in an effort to bring greater understanding to the concepts and a better flow to the material.

Assignments: Calculus courses at SFU currently utilize both online and standard paper assignments. Writing up solutions to weekly assignments of 15-20 problems gives students experience in preparation for midterm and final examinations, while online assignments offer an excellent assessment and tutorial tool that can be used to help students better manage their study time. Due to the large class size and the limited number of teaching assistants' hours, only one or two questions per paper assignment are marked thoroughly. This means that a student will only get feedback on about 7% of their written assignments. The assignment solutions were regularly posted on WebCT after the due date. This allowed the students to compare their presentations and solution methods with those given by the instructor or the textbook.

Online assignments were introduced at SFU in the fall 2004 in the calculus for social sciences course and are now being introduced to all calculus courses. After each lecture, an assignment of one to three related questions is posted online. This assignment is due 30 minutes before the next lecture and the questions are created so that they are similar to examples done in class with the idea to encourage students to regularly go over their notes and the textbook.

These online assignments used not only as an assessment tool, but also as a tutorial tool. They are created, posted, submitted, graded, and recorded using LON-CAPA, which is managed at SFU and has evolved into a full-featured LMS. LON-CAPA is an open-source freeware Learning Content Management System, which started in the College of Natural Science and Michigan State University (MSU) in 1992. The problems are parametrically generated, i.e. each student randomly gets one question from a pool of a few hundred different variations of the same problem. Students have at least eight attempts without penalty to correctly answer each problem or a part of the problem in the case of multipart questions. The large number of attempts was decided upon as a suggestion from Dr. Gerd Kortemeyer from MSU, in an effort to allow students to use these questions as a learning tool rather than quiz with the immediate feedback they get from the system. Most of the questions have built-in hints that would pop up in case of an incorrect answer to give students a chance to learn from their own mistakes.

A discussion board provided by LON-CAPA accompanies each problem, where students exchange their questions and ideas how to come up with the correct answer. Since each student had a different variation of the problem, it was impossible just to post a correct answer and give the problem away. The instructor did not need to intervene often regarding students questions since mostly their peers would respond to the posted questions.

A main concern before introducing multiple weekly online assignments was whether students would be overwhelmed by the frequency of assignments. However, the students adapted to the challenge very well. In fact, many students responded on a subsequent survey that the online assignments did indeed make them stay on top of the material. The average mark on online assignments during one semester was 71%, which approximates the average mark for written assignments. The main difference in marking between the types of assignments is that students are graded on every question in the online assignments, and only one or two in a written assignment.

Online assignments are a great solution to provide lots of feedback to large classes, where TA resources are scarce. Moreover, because of the parametrically generated problems, students are starting to work together to achieve understanding of the question, rather than simply answering/copying for textbook assigned questions. Many current textbooks include a package with for online assessment that includes parametrically generated problems from the textbook and can often be easily integrated with the LMS in use.

Discussion Board: Students are encouraged to use the WebCT discussion board. The instructor does not moderate the board, per se, but instead visits it intermittently. Very rarely does the instructor have to intervene and suspend a student's privilege due to abuse of the system. Overall, students really use this form of communication to get help from their peers with assignments and preparation for the exams. During one semester, the average number of discussion board visits per student was 108. This can provide cohesiveness and connect students in large classes. Postings on the discussion board are also an excellent source of information for the instructor on how students react to particular segments of the course and on their level of understanding.

Exams: There are two in-class midterm examinations and a final examination at the end of the term that is scheduled during the final exam period.

Before each exam, a checklist with a detailed list of topics that would be tested on the exam is posted on WebCT, matched with relevant sample questions. When a course is run for the first time, we suggest that a sample exam be constructed in the same format as the real exam and provided to the students. The main goal of the sample exam is to familiarize students with the format of the examination, thereby alleviating stress. Another goal is to underline the most important topics to be tested. We also hold an in-class review lecture before each exam, where questions from a sample exam can be addressed in addition to any outstanding issues students still have regarding concepts on the checklist.

It is extremely important to plan the administration of an exam for a large class. Teaching assistants will be necessary to help with the distribution, invigilation, and collection of exams. Time between lectures is short and others will likely need to use the room before and after the exam. Students should be well-informed (in lectures and by e-mail) of exam procedures in advance. Calculus students at SFU are advised to arrive early. They then wait outside while the instructor and a team of typically four teaching assistants set up the lecture hall by putting an exam on every other chair. Often, two or three versions of the exam are distributed to help combat cheating on the exams.

Grading Scheme:

With both written and online assignments:

8%	written assignments
7%	online assignments
15 %	midterm 1
20%	midterm 2
50%	final exam

With only written assignments:

10 %	written assignments
20%	midterm 1
20%	midterm 2
50%	final exam

Survey: Three to four weeks into a thirteen-week semester an anonymous survey is conducted to collect feedback from the students regarding the course and their learning. We used to give surveys on paper until we discovered FAST - The Free Assessment Summary Tool developed at Mount Royal College, which allows for the creation of free anonymous online surveys. "Traditionally, teaching assessments are conducted at the end of a course – a practice precluding students from offering constructive feedback while they are still in the course. However, conducting instructor-designed and administered web-based course assessments opens a proactive dialogue with students about teaching, the course, and the entire learning process" (FAST, 2000) One instructor asked the single request "Please give me your comments and suggestions about our class Math 157 in the first four weeks of this semester." The survey was open for three days and about 1/3 of the class responded to it.

Another instructor asked the following, more detailed, questions. Questions 1 through 12 were answered on the Likert scale ranging from strongly disagree, somewhat disagree, not applicable, somewhat agree to strongly agree. Question 13 was an open response question.

Q1. There are enough examples given per lecture.

Q2. The level of examples ranges from easy to difficult.

Q3. Explanation of concepts is adequate.

Q4. Demonstration of solution process is adequate.

Q5. The lecture notes are well organized, well written and useful.

Q6. Prior to the midterm your confidence level for functions was high.

Q7. Prior to the midterm your confidence level for limits was high.

Q8. Prior to the midterm your confidence level for continuity was high.

Q9. Prior to the midterm your confidence level for derivatives was high.

Q10. The midterm review lecture was informative and useful.

Q11. The midterm 1 exam difficulty level was fair.

Q12. The types of questions assigned for homework helps you learn the material better.

Q13. Please comment on the lectures with 2-3 points.

This survey was open for two days and about 2/3 of the students responded. Two goals were realized. First, the instructors received useful information and suggestions on how to fine-tune the teaching. Second, and more important, the students were shown that their opinions mattered, and that even in a large class of freshmen the instructor was willing to listen (Davis, 1993). Each instructor summarized the survey and in a message to the class addressed the most common issues. One word of caution: We make it explicit that we expect answers that are not of a personal nature, and if they are, we ignore them. Most we find that students take the survey very seriously and provide helpful comments. Some contribute straightforward requests like "Can you not have your notes online in blue ink?" or "Please do not use the red overhead pen because it's hard to see it." Other students provide more sophisticated analyses: "I love the format of your lectures they are the right mix of slides and notes. You keep my attention and challenge me while providing the tools I need to meet those challenges"; "At first, I thought the materials were being taught too fast (maybe it was because that I hadn't adjusted to the environment yet). However, after a while, I liked it. I think it is quite fun to have such a big class and that people have different questions. Although some questions may seem stupid, it is actually okay to take time and learn and understand the process of getting to a certain step or answer"; or "Sometimes, the pace is a little bit fast. I would recommend doing a few more examples in lecture to reinforce what material has been taught. Also it would be great to maybe post two sample midterms." Such a survey is an additional way of addressing one of the biggest challenges in teaching large classes, which is to create a common bond among the students.

To transform a class from a group of several hundred individuals simply sitting in the same room into a group that is engaged together in learning is both difficult and rewarding. As we have outlined above, this requires careful planning, substantial organization, and advance preparation, as well as both creativity and flexibility on the part of the instructor. We hope the reflections and suggestions in this article will be helpful and thought-provoking for instructors engaged in teaching large classes of all kinds, from whom we invite further discussion on the topic.

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