



Assessment Report:

Assessment of 18.02 Tutorials

18.02, Multivariable Calculus, Fall 2005

Conducted by:

Tom Clay & Associates

Conducted for and in Cooperation with:

The MIT Teaching & Learning Laboratory

Submitted On:

February 20, 2006

Contents

Background	1
About the Class and the Tutorials.....	1
The Purpose of the Assessment	1
Methods and Sample.....	1
Findings	3
Summary of Findings.....	3
Detailed Findings.....	3
Recommendations	18
Summary of Recommendations	18
Detailed Recommendations	19
Appendix A:	34
Appendix B:	39
Appendix C:	43

Background

About the Class and the Tutorials

This document reports the results of an assessment of the use of small-group tutorials in the fall 2005 offering of 18.02, *Multivariable Calculus*. The second of two classes designed to fulfill MIT's general institute requirement (GIR) in calculus, 18.02 covers vector and multi-variable calculus and is attended mainly by first-year undergraduates. With more than 300 students, 18.02 is the largest class to participate so far in a series of small group experiments funded by the Cambridge-MIT Initiative (CMI). Most 18.02 students attended two tutorials in place of two traditional recitations. In most cases the tutorials were led by the students' regular recitation leaders (TAs) and typically included three or four students (and in some cases five, to accommodate scheduling challenges). The experiment was led by Professor Haynes Miller in close coordination with the class's lecturer, Professor Gigliola Staffilani.

The Purpose of the Assessment

The assessment's purpose was three-fold:

- **To test hypotheses formulated by Professor Miller about specific impacts.** Specifically, he hoped that the tutorials would (1) help the students to learn the material better, not just directly but also indirectly, by improving communication between the students and the TAs/faculty, helping the TAs and faculty better understand the students and their needs, in turn improving their teaching, and (2) generate a personal connection between the students and their tutorial leaders that would improve the students' attitude toward the class generally and toward their recitations specifically, thereby improving attendance at recitations.
- **To investigate the impacts of the tutorials in a more open-ended way,** using a "sociological" approach to explore the students' and TAs' perceptions about whether and how the tutorials made a difference, and what impacts, if any, they had on their attitudes, on the quality of the teaching and ultimately on the students' learning.
- **To generate recommendations** about how to conduct tutorials in the Math Department in the future.

Methods and Sample

The assessment consisted of classroom observations, student interviews, TA interviews, staff interviews, faculty interviews and a brief email survey of the TAs. The majority of the data collection took place between 18.02's third exam (November 10) and December 1.

During this period, about 10% (31) students were interviewed. A stratified random sample ensured that each TA's students would be proportionately represented. It was generated by (1) dividing the class into groups by recitation leader, (2) randomizing the order of the rosters from each of the resulting groups by assigning random numbers to students' names and sorting

them by those numbers, and then (3) interviewing a proportionate number of students from each section. Forty-two invitations were issued to generate 31 acceptances, for an overall recruitment rate of 74%. Students interviewed represented a range of levels of success in the class; while most were passing the class, one was failing and one had dropped. Formal interviews with Professors Miller and Staffilani, all nine TAs, and the class administrator were also conducted. Interviews lasted between one and 1.5 hours and were semi-structured, i.e., based on but free to deviate from interview guides (see [Appendix 1](#) and [2](#) for Student and TA interview guides), as the flow and dynamics of each interview dictated. Consistent with guidelines from the MIT Committee on the Use of Humans as Experimental Subjects (COUHES), all interviews were conducted on a volunteer basis. Student interviewees were given two Loews movie tickets as an incentive to participate.

The numbers of interviews and classroom observations are summarized in [Tables 1](#) and [2](#) below:

Table 1:
Number of Interviews Conducted

Interviewees	Number
Professor Interviews	3
TA Interviews	12
Class Administrator Interview	1
Student Interviews	31
Total Interviews	47

Table 2:
Number of Classroom Observations Conducted

Observations	Number
Lecture Observations	2
Recitation Observations	2
Tutorial Observations	2
Total Observations	6

Note: Professor Staffilani and three TAs were interviewed twice.

The project design was primarily qualitative. As such, the project did not deliver hard (i.e., quantitative) data that addressed the direct impacts of the tutorials on variables such as students' learning or recitation attendance. Rather, it focused on the various players' experience of the class and the tutorials and their *perceptions* of their impacts, as well as their opinions about how the tutorials could be improved. (To ascertain the direct effect of tutorials on recitation attendance, for example, would require an analysis of students' attendance before and after tutorials. Methods like this were not part of this project. As Professor Miller has explained, the culture of Course 18 generally and 18.02 specifically dictate that attendance records not be kept.)

Findings

Summary of Findings

Finding 1: While there were some commonalities among the TAs' approaches to leading tutorials, there were also substantial differences. (p. 3)

Finding 2: While most students reported regular attendance at lectures and recitations, the majority do not take advantage of other "official" sources of help. They tend, instead, to seek out help from "unofficial" sources. (p. 5)

Finding 3: Most students were very positive regarding the tutorials, liking the comfort of the small group environment, which made it easy to participate and ask questions, and the "individual attention." They cited a variety of likes, as well as some dislikes. (p. 6)

Finding 4: Virtually all students reported that they learned from the tutorials, and a variety of other impacts were reported. The *overall* impact of the tutorials was generally considered to have been limited, however, which is not surprising, given the small number of tutorials offered to each student during the semester. (p. 7)

Finding 5: A number of students and TAs offered specific suggestions on how to increase the tutorials' impacts. Many of these dealt with the mix of students in the tutorials, and with the tutorials' timing and frequency. (p. 10)

Finding 6: Most of the TAs enjoyed leading the tutorials and found the experience rewarding. There were, however, aspects of the job that, if unchanged, would discourage them from playing the same role again. (p. 16)

Detailed Findings

Finding 1:

While there were some commonalities among the TAs' approaches to leading tutorials, there were also substantial differences.

Among the broad commonalities across the various TAs' tutorials were that they all tried to:

- Keep their groups small (with three as the target number and the actual number typically not exceeding four)
- Provide individual attention where needed, and "force" students to pay attention by not letting them "hide"
- Get to know the students and to make themselves accessible to the students

- Create comfort on the students' part, making it as easy as possible to participate and ask questions
- Provide opportunities to cover things that could not easily be covered in lecture or recitation formats

However, consistent with what I have come to understand is an open-ended, experimental “math culture,” the TAs were given very little direction on how to conduct this first round of tutorials. This was an intentional strategy designed to ensure that a healthy range of approaches would be tried and tested. On the one hand, we do have examples of and feedback on a variety of approaches. On the other hand, the amount of feedback on each approach is limited, as the sample sets become very small. (In other words, this assessment does not examine a single approach, but rather many approaches, limiting the opportunities to draw solid conclusions about the effectiveness of any of them.)

The dimensions on which approaches differed include the following:

- **The tutorials' objectives** – These varied from helping the students understand the homework on one end of the spectrum to helping them discover the beauty of math on the other. A range of other objectives were cited, e.g., helping the students to understand how to approach problems, helping them perform well on the exams and helping them understand the concepts underlying the material. (For relevant results from the TA survey, see p. 43.)
- **Methods for guiding students through problems** – The “thinking process” that the TAs used differed from TA to TA. While the processes they used tended to be similar, they did not all have the same components, and where they did have components in common, different TAs emphasized different components.
- **Target audience** – Many of the TAs did not have clear ideas about whether the tutorials should target some students over others and, if so, whom and why. But when asked, they gave a variety of answers, including that they should focus on helping (1) struggling students to “get it,” (2) all students to reach a minimum level of competence, (3) all students to do their best and (4) the best students/those with the most potential to master the material and inspire them to reach beyond it. (For relevant results from the TA survey, see p. 45.)
- **Classroom logistics** – Approaches included having the students work together at their seats, having a student present at the blackboard, having the students work on their own in parallel and having everyone listen to the TA as s/he explained the material. (For relevant results from the TA survey, see p. 48.)
- **Degree of student control** – While some TAs gave the students a significant degree of control over the agenda, others directed the agenda to much greater degrees, e.g., dictating the use of specific problems that they believed would benefit the widest range of students.
- **Methods for group selection and tutorial scheduling** – The mechanisms used for selecting groups varied considerably, resulting in variations in students' freedom to dictate group composition (e.g., to form groups with friends). Similarly, the methods of scheduling

tutorials varied; here the most noteworthy effect was different distributions of tutorials over the semester. They varied from being widely distributed across the semester from start to finish on the one hand, to being heavily clustered in several different weeks, on the other.

Indeed, some TAs reported that their approaches varied over the course of the semester and even from day to day.

Finding 2:

While most students reported regular attendance at lectures and recitations, the majority do not take advantage of other “official” sources of help. They tend, instead, to seek out help from “unofficial” sources.

Most of the students interviewed place a much greater value on lectures and recitations than on “optional” sources of learning. Indeed, most reported that they attend both lectures and recitations regularly; while they miss them sometimes, it is usually as a result of conflicting priorities. (A criterion for interviewee selection was that students had attended both tutorials, the thought being that they would not be able to offer useful comments on the tutorials if they had not attended.) The majority of interviewees reported that they do not attend office hours; of those who do, most attend only when they have specific questions that they believe they cannot easily get an answer to elsewhere. A number of students who do not attend office hours commented that they would attend them only if they were really struggling, e.g., if they failed a test. Furthermore, it would also not occur to many of them to attend another TA’s office hours if a schedule conflict prevented them from attending their own TA’s. Only one or two students had used Math Department tutors, and most indicated they never would. There seemed to be a particular stigma attached to the “need” to use such tutors. (Interestingly, many of the students professed to being unaware of the existence of departmental tutors, despite their having been mentioned repeatedly in class, as well as on the first page of the 18.02 syllabus.)

“Unofficial” sources – i.e., peers or upper-class friends/acquaintances – were often cited as the preferred means of obtaining academic help. The stated advantage here is that, in contrast to “official” sources of help, these are flexible and convenient (i.e., available at any time, including 4:00 AM, and without a special trip to campus) and safe (i.e., they do not make the students asking for help feel as stupid). While some students appeared to select their sources of help strategically, it is not at all unusual for students to go to their peers for help, even if those peers understand the material no better than they themselves do. While “misery enjoys company,” there appears to be a perceived benefit in students, as one put it, “beating your head against the wall.” Although not particularly efficient, this approach may ultimately be effective for some students, but it is hard to imagine that it is the *most* effective approach.

Finding 3:

Most students were very positive regarding the tutorials, liking the comfort of the small group environment, which made it easy to participate and ask questions, and the “individual attention.” They cited a variety of likes, as well as some dislikes.

Most students were positive about the tutorials. As in earlier assessments of small group experiments, the students liked the small group environment, finding it comfortable and conducive to participating and asking questions. A number particularly liked receiving what they perceived to be individual attention. No one reported that attending was a waste of his or her time.

Likes:

There were a variety of things that students liked about the tutorials. Most can be categorized as relating to personal benefits, the teaching method/small group environment or outcomes, as the following sample shows:

- **Personal benefits:**
 - More personal, easier to be heard
 - Got to know the TA
 - Interaction with the other students
- **Teaching method/small group environment:**
 - Could continuously ask questions and get instant feedback
 - Quick pace
 - “Adds fun”
 - Had to pay attention – couldn’t hide
 - “The teacher wasn’t trying to grill us”
- **Outcomes:**
 - Good for clarifying problems
 - Learned a process for thinking through problems
 - Helped visualize problems
 - Learned things unrelated to the course
 - “I got my pset done in half the time (but on the next pset I was back to working on it 6-8 hours).”
 - 50 points (i.e., toward overall grade)

Dislikes:

While the dislikes were fewer overall, some were voiced. They related either to the teaching method/small group environment, design issues or implementation issues, as the following sample shows:

- *Teaching method/small group environment:*
 - Being put on the spot/doing problems in front of peers and getting stuck
 - If we were unprepared, we were limited in what we could discuss
- *Design issues:*
 - Tutorials were too few and fell too early in the semester
 - The timing was bad – not near to an exam
- *Implementation issues:*
 - Didn't really understand what the tutorials were for ... were they for doing the pssets?
 - Too much variation in the composition of the groups (i.e., too heterogeneous vis-à-vis competence with the material)
 - Some complaints about individual TAs

Finding 4:

Virtually all students reported that they learned from the tutorials, and a variety of other impacts were reported. The *overall* impact of the tutorials was generally considered to have been limited, however, which is not surprising, given the small number of tutorials offered to each student during the semester.

Impacts on Learning:

Although the impacts seemed to have varied by tutor, as well as from tutorial to tutorial for each tutor, virtually every student reported having learned from the tutorials. Specific impacts included:

- Learned the concepts better
- Understood individual problems better
- Made the lectures specifically and the class generally make more sense
- Improved understanding about what the problems were asking, how to interpret them and how to visualize them
- Translated formulas into concepts and relationships

This list of impacts seems to indicate that the tutorials – at least for some students – were successful in exploring concepts. The following two quotations from students support that idea, implying not only that the different components of the class do different things, but that they work together effectively, with the tutorials cementing understanding in ways that other components do not:

- “Recitations are about problems. Tutorials are about concepts.”
- “Lecture shows you how you arrive at it. Recitation shows you how to apply it. The tutorial goes back over the questions, ties what you learn in lecture and recitation together, uses harder examples, and makes sure you get the connections. So I understand things in the tutorial much better than things not in the tutorial.”

Other Impacts:

Other impacts reported by students relate to their attitudes/comfort levels in the class, personal relationships and their behaviors vis-à-vis accessing and using other components of the class. The following are examples:

- **Attitudes/comfort levels**

- Confidence, and a lower frustration level: "I understand it's not beyond my mental capacity. ... It made me realize I wasn't the only one having trouble with the practice exam."
- "It made me more comfortable talking in recitations."
- "I was more comfortable working at the blackboard in front of others. It expanded my 'social comfort zone'."
- "I actually thought about being a math major." (This comment came from a student who was struggling in the class.)

- **Use of other parts of the class**

- "I discovered office hours. I wouldn't have gone if I hadn't gotten to know the TA."
- "I went to more recitations because of it."

- **Personal relationships**

- "I got to know the TA. ... I was more likely to go to him with questions."
- "The recitation leader knows my name – I'm not just a student, I'm a person – which is especially important at MIT, where students keep their mouths shut."
- "I bonded with the teacher [i.e., Professor Staffilani, who also led the tutorial]. ... It motivates me ... at least for the week following the tutorial, but then it faded."

The TAs echoed the students' comments on personal relationships. One TA reported that the tutorials changed her relationship with her students, noting that "it puts a face on a person." She added that she was surprised at the extent to which she had misconceptions about the students and their understanding of the material. "The students who I thought didn't know their stuff turned out to be much more on the ball than I thought ... and vice versa," she observed, adding, "I was able to evaluate them more accurately, because I understand, not just assume."

Several TAs also believe that the tutorials made them better teachers. One of the newer TAs explained, "Because of the experiment, I questioned everything I was doing." The immediate and ongoing feedback he received during the tutorials, he said, using a medical analogy, was "like measuring the temperature inside the patient instead of only looking at the patient." He continued: "I constantly adjusted my style. I started out being very theoretical, but I realized I had to make it much more concrete. I started to understand more what the students understand and don't understand, and what they need." Those realizations, he said, affected not only how he led the tutorials, but how he taught his recitations. One of the more

experienced TAs expressed a similar effect. In his words, the tutorials “exercised my abilities to teach well. I constantly worked on finding different ways of explaining things. I tried to come up with good explanations and the simplest path.”

Professor Miller's Research Questions:

At the start of this study, Professor Miller posed several specific questions about possible impacts of the tutorials. Those questions, and the answers that the interviews suggest, are outlined below:

Q: How well does grading students' on participation stimulate their learning compared to other methods, such as grading homework?

A: The students with whom I discussed this question seemed unable to quantify such differences. Rather, they seemed only able to discuss the effects of grading on their attitudes and behaviors in more general terms. For example, a number of students indicated that attaching points to any activity changes their attitude toward that activity, causing them to take it more seriously, even if the number of points is small (i.e., the activity is positioned differently in their minds, even if they know the points associated with it are inconsequential to their grades). Several of them declared that the points associated with attending the tutorials were the only reason they attended, and that they would otherwise not have even considered going, even though they never expected at any point that the points would impact their grades.

It was also a widely held opinion among the interviewees that attaching points to tutorial attendance made it feel more like an obligation than an opportunity. When I asked how the tutorials could be presented as more as an opportunity and less as an obligation, most students had no idea how it could be done. Several suggested that the points be offered as “extra credit,” which is not how it is currently perceived. Interestingly, when I asked how they saw that working and how it would differ from how the points are currently offered, they generally concluded that giving extra credit would make little or no practical difference, since they are graded on a curve, but that calling it “extra credit” could result in a significant difference in how it would be perceived. On the other hand, several students advised me not to try to make it seem less obligatory if I wanted attendance to remain high, since any suggestion that the students did not have to go would be met with drops in attendance rates.

A few students were more analytical in their approach to gauging the degree to which the tutorials were an obligation vs. an opportunity. In their view, the extent to which it appeared obligatory depended on how much they needed the value that the tutorials offered. In other words, if they understood the material covered in the tutorials, then they viewed attendance as an obligation. If they did not, then they viewed it as an opportunity.

Q: Are there qualitative differences between the learning that takes place in tutorials and in other settings?

A: Yes. See the comments under *Impacts on learning* above (starting on p. 7), which refer to learning concepts and making connections among them in the tutorials.

Q: Does the supervision improve the students' recitation experience?

A: Most of the students who addressed this perceived no impact on their recitation experience. One or two cited impacts on the recitation experience that were in turn a result of their familiarity/comfort with their TAs. (That most students did not perceive this effect does not mean it did not happen for more of the students. In my experience, this would be the sort of subtle effect that many students would not recognize.)

Q: Does the supervision improve the problem set learning experience?

A: No student, when asked, attributed any impact on their problem set learning experience. There were several comments, however, saying that the tutorials helped the students with the problems sets that followed their tutorials, or that they were able to complete those problem sets in less time. (Note, for example, the quotation on p. 6, in which a student credited the tutorial with his ability to complete the tutorial in half the normal time, but pointed out that the effect was short-lived.)

Finding 5:

A number of students and TAs offered specific suggestions on how to increase the tutorials' impacts. Many of these dealt with the mix of students in the tutorials, and with the tutorials' timing and frequency.

Student "Mix":

There was a widespread perception among both students and TAs that the effectiveness of the tutorials was reduced – often dramatically – when students with different levels of understanding of the material were mixed in the same tutorial. (The terminology often used was “students with different levels of ability,” but I believe that to be inaccurate.) Such mixing resulted in the students with lower levels of understanding being uncomfortable and intimidated in the presence of those with the higher levels, and feeling that they slowed down the tutorials.

One student drew a bell curve similar to the one in **Figure 1** below and explained that the X axis (horizontal) represented the students' level of understanding of the 18.02 material and the Y (vertical) axis represented the number of students. He went on to comment that the distribution of students by understanding of the material would probably cause most to fall in the middle. He went on to point out that any obvious differences between the levels of understanding of students in a tutorial would lead those who felt at a disadvantage to feel awkward and perhaps intimidated. The worst mixes, he continued, would likely be those that included students from the left “tail” of the graph with students from the right “tail.” Absolute precision in grouping students by level would not be critical, according to that student, but the key would be to ensure that the “gap” among students in any given group was not too large.

Figure 1:
Student's "Level of Understanding" Distribution Curve



The effect of this awkwardness was that the students who felt intimidated often withheld their participation and did not enjoy being in the tutorials. In fact, some of the TAs commented that the most heterogeneously mixed groups were their worst; one described such tutorials as “a complete disaster.” Both students and TAs suggested methods for assigning tutorial groups that they felt would improve this situation, including the following:

- **Allow friends to sign up for tutorials together** – The thought here is that friends are likely to be comfortable together even where their levels of understanding are different. I heard comments like, “I’m not afraid to look like an [expletive deleted] in front of my friends. Hey, they’re my friends.” In fact, some of the TAs did allow this practice.
- **Assign homogeneous groups based on demonstrated competence with the material** – This was the approach endorsed by the vast majority of the students and all of the TAs. The advantage would be that, by grouping together students with similar needs, it would increase comfort levels and thereby lead to a better learning environment. The disadvantage, as a number of interviewees pointed out, is the potential that a stigma would be associated with being in a “slow group.” This stigma could be averted to a great extent if the reasons for grouping students together were not made known. Asked how to assign the groupings, students offered the following three ideas:
 - *Group according to results on a “placement test”* – According to this idea, the students would be given a diagnostic test at the beginning of the semester and placed on groups with students who had similar scores. The chief disadvantage to this is that it makes it far harder to make the criteria for assigning groups transparent to the students.
 - *Group according to results of Exam #1* – Since the students will all take Exam #1 fairly early in the semester anyway, this suggestion does not imply extra work and makes it easier to make the criteria for assigning groups transparent to the students. However, as one TA pointed out, performance on Exam #1 does not effectively predict performance in the class. A follow-up suggestion, based on this observation, was that initial group assignments be presented as temporary, and that the option be left to change them where appropriate.

- *Allow the students to assign their own levels* – Reaction to this idea was mixed. Some interviewees liked the idea, while others thought it was terrible. Interestingly, several students and TAs reacted very negatively to it at first, but the more they thought about it, the more they liked it. A number pointed out that this could be a scheduling nightmare if done manually, but several TAs pointed out that the proposed online scheduling tool could simplify it considerably. The idea would be that the students would express a preference for the speed/level of their tutorial, and the online scheduling tool would use that preference as one of the criteria in creating groups.

The advantages of “self-leveling” include:

- Stigmatizing would be minimized since (1) no one except for the TA would need to know for sure what “level” a group was, and (2) the leveling would not be something “done to the student” (i.e., no one would be judging him/her), but would instead be his/her own choice.
- According to some interviewees, placements are likely to be accurate because of the potential for embarrassment if students are in “over their heads.”
- The ultimate effect, according to one TA, is that students would end up sorting themselves by attitude; her idea was that the grouping method would militate against aggressive students being in groups with insecure students, which she saw as more important than sorting by level of understanding.

The following disadvantages were also cited:

- Accurate leveling depends on the students having a realistic view of their own understanding; we have no data to indicate that this will be the case.
- Some students might also place themselves too high or too low despite knowing that they do not belong at their chosen levels.
- The need to self-level could add more complexity to the scheduling tool than was originally planned for.

Not all interviewees agreed that homogeneous grouping is called for. In fact, several students favored assigning students in heterogeneous groups on the theory that the students with a greater understanding of the material would be able to teach those with a lower level of understanding. Comparisons were drawn with TEAL classes in physics, where heterogeneous groups are formed for just that reason. Several other students rebutted that reasoning, pointing out differences between TEAL and 18.02 and arguing that (1) the purpose and nature of the material in the two settings is different and (2) the presence of the tutor eliminates the need for the stronger students to “teach” the weaker ones.

Other relevant arguments/observations from interviews include the following:

- The need to place students in “leveled” groups at all – either homogeneous or heterogeneous – depends on the degree of collaboration encouraged or expected. If the tutorials do not involve collaboration, according to this argument, such “leveling” is a moot point.

- Groups of students with a higher level of understanding of the material can be bigger than other groups – i.e., six or seven students – because they require less individual attention.

Timing of Tutorials:

One student, when asked how the tutorials should be timed over the course of the semester, drew the graph shown below in **Figure 2**.

Figure 2:
Proposed Timing of the Tutorials



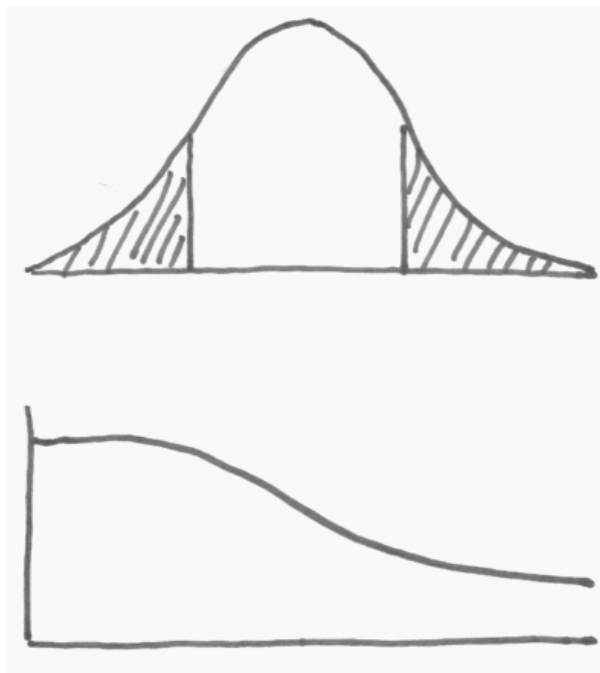
The trend line represents his learning in 18.02 over the course of the semester (i.e., the amount of learning he does at any given time, not cumulatively), with the five spikes representing the periods leading up to the four quizzes and the final exam. According to his explanation, he “cruises” most of the time, learning what he needs in order to avoid being “lost” in the class. Then, when a quiz approaches, he moves from a passive learning approach to an active one, “shifting into a new gear.” After drawing the line and giving that explanation, he inserted the circles and said, “This is where I want the tutorials, since this [referring to the “spikes”] is when I’m most receptive to learning. He added that the worst time to have a tutorial would be on a Friday afternoon during a “flat” period, since he would be shutting down for the weekend and would have no interest in being there. (**Note:** Since each class has its own pattern, while cruising in one class, a student could be “jamming” in another.)

I asked a large number of students and TAs about this model, and most said it rang true. Several TAs also pointed out that clustering the tutorials instead of spreading them out evenly across the semester would lighten their preparation load (i.e., since they could prepare for a larger number of tutorials fewer times). The idea of clustering the tutorials in the week before the exam was popular among students and some of the TAs, but other TAs were skeptical, saying that clustering the tutorials before exams would turn them into exam preparation sessions. Other TAs took a contrasting position, arguing that the TAs could control the tenor of the tutorial sessions, while taking advantage of the students’ receptivity to learning at that time. (For relevant results from the TA survey, see p. 47.)

Number of Tutorials:

There was widespread agreement that students would benefit from more than two tutorials over the semester. When asked how that could be accomplished, given the limitations in funding and TAs' time, a suggestion emerged according to which available resources would be concentrated where they would have the greatest impact. This line of thinking developed when a TA, in response to being shown the bell curve represented in **Figure 1**, added a second, corresponding graph below that he called a "learning opportunity curve." His drawing is represented below in **Figure 3**:

Figure 3:
Learning Opportunity Curve



The TA explained that, in his view, the further left a student stands in the bell curve, the greater the opportunity s/he has for learning from the tutorials (assuming that the tutorials are limited to 18.02 material). The logic is that the students on the right side of the curve have less to gain, since they already understand the material.

The next step in the argument, suggested by a student, was that, by offering more tutorials to the students on whom tutorials would have the greatest impact (i.e., those further to the left in the bell curve), and withholding tutorials from those on whom they would have less of an impact (those in the right), 18.02 could maximize the effects of its available resources. I discussed this idea with a large number of students and most of the TAs, and most agreed with its logic, even if not necessarily with its advisability.

Caveat: Regardless of the soundness of the logic of this argument, whether it should be pursued depends on the objectives of the tutorials. If, for example, the tutorials are aimed at better equipping students who have the most potential to make a significant on their eventual fields, then it does not make sense to pursue it.

When I asked students and TAs how this might work practically, a student and a TA independently suggested that students who score above a certain level on one or more exams “pass out” of the next tutorial (i.e., earn the right not to have to attend the next tutorial), and that they thereby receive their “points” as a reward for their exam performance rather than as a result of their attendance/participation in the tutorial. Then, the TA resources that would have gone toward delivering those tutorials could be redeployed to providing additional tutorials for the remaining students. (In other words, if the top 50% of the students received credit without attending a tutorial, then the remaining students could have twice as many – i.e., four instead of two – tutorial sessions. If the top third of students received credit without attending a tutorial, then the remaining students could have 50% more – i.e., three – sessions.)

A problem pointed out by a TA was that this would position the tutorials as a punishment, and having to attend as a stigma. Another TA suggested the following solution: “You could have only a minority pass out. How can two-thirds or three-quarters of the class be stigmatized by attending?”

Other Observations:

Several other observations have implications for the tutorials’ effectiveness:

- **Common recitation and tutorial leaders** – In one case, where one TA had three recitation sections and another TA had only one, the latter TA led the tutorials for one of the former’s recitation sections. While this did not appear to present particular problems, indications are that it is best to have the same TA for both. This is based on the importance that a number of students reported of building a relationship with their recitation leader through the tutorials, and therefore having a higher comfort level with him or her. (This would be less of a factor if tutorials met much more frequently, but with only two meetings over the semester, the students would barely have a chance to get comfortable with the new TA before the tutorials would end.)
- **Number of students in a tutorial** – Several TAs observed that it is harder to keep the discussion moving with four students than with three, and substantially harder still with five.
- **The nature of the physical space in which tutorials are held** – I observed two tutorials, both of which were in physical spaces that appeared not to be conducive to group participation and learning. One was in a Math Department lounge, where several other meetings were going on, there was substantial noise and a lot of students coming and going. I expect that two aspects of the space were especially problematic: (1) there were distractions that prevented the students from concentrating on the material and (2) the

presence of so many other students, most of whom appeared to be older and math majors, had the potential to intimate freshman and make it far less likely for them to ask what they might think would be perceived as “stupid questions.” The second tutorial was held in the TA’s office, which was so cramped that one student had to stand at all times.

In addition, TAs offered ideas that would either serve as alternatives for or complements to the tutorials. They were:

- **20-minute one-on-one tutorials** – The TA who made this suggestion scheduled such meetings with several struggling students, at their request, and found that it worked far better than she had expected. In her words, “It appeared to have more impact than I thought possible.”
- **Five-minute one-on-one meetings between each student and the professor** – The TA who suggested this believed that it would be as effective as the tutorials in getting the students comfortable with the instructor; the learning component, he felt, could be achieved via extra office hours. The idea was based on the practice of a professor who had required every student in his class to come to his office to meet him for five minutes. During that session, the professor took a photograph of each student so that he could use it to learn the student’s name.

Finding 6:

Most of the TAs enjoyed leading the tutorials and found the experience rewarding. There were, however, aspects of the job that, if unchanged, would discourage them from playing the same role again.

The changes to the tutorials that would be required involve (1) workload and (2) tutorial design and logistics.

Workload:

A number of the TAs pointed out that, despite being told that the addition of the tutorials would not add to their workload, they discovered during the semester that it did – in some cases significantly. These TAs estimated that their workload on 18.02 was anywhere between 1.2 and 2.0 times the normal TA load. One TA, asked to compare the costs of TAing with the benefits, explained it this way: “The way people usually think about this, the cost is mine and the benefit is the students’. But that isn’t the relevant cost-benefit analysis. It should be my cost vs. my benefit. The tutorials are fun, but I have to watch out for my own interests. The bottom line is that traditional recitations are less taxing and time-consuming.”

Several TAs pointed out that they were not compensated in any way for this extra time. I asked how they would expect to be compensated for this extra work/extra time. I was told that:

- While more money is not terribly meaningful to them, they “wouldn’t turn it down.”

- It would be nice to get a better choice of TA assignments in the future (i.e., a greater say in what classes they would be assigned to in future semesters).
- The scarcest and most valuable commodity for many of them – especially those who are working on research – is time. Accordingly, they would be looking for some sort of dispensation for the extra time spent on the class. One request was for credit for the extra time toward fulfilling their teaching commitment. A second suggestion was that the TAs who run tutorials be offered an opportunity, if interested, to fulfill a dual role during that semester that would have them be TAs *and* take on sufficient additional responsibilities – e.g., grading – to bring their total workload to double the normal TA workload. This would enable them to fulfill their entire obligation for the school year in one semester (e.g., perform a double load in the fall and have it also fulfill their obligation for the spring). In theory, this would not represent significant additional expense to the Math Department, since they would need to pay for a grader anyway.

Tutorial Design and Logistics:

The TAs cited a number of design and logistical issues which, if addressed, would reduce or rationalize their workload in some way, thus making it more attractive to lead tutorials in the future. Those issues include the following:

- Taking the logistics involved with grouping the students and scheduling the tutorials off of the TAs' plates
- Getting clarity on the tutorials' objectives and how they are supposed to be run
- Providing appropriate, interesting sample problems on a timely basis
- Having the students grouped homogeneously by level of understanding of the material
- Settling on a workable calendar (regarding the possible clustering of tutorials) that reduces their workload

Recommendations

Summary of Recommendations

The following are recommendations for the planning and implementation of future tutorials. They consist of one overall recommendation and a series of more specific suggestions, which are explained in greater detail in the following pages.

Overall Recommendation: Using lessons learned in the 18.02 tutorials, introduce more structure into future tutorials and provide more direction for the tutors. (p. 19)

Recommendation 1: Facilitate agreement on a clear set of objectives that address how the tutorials will offer maximum value to the students, and clearly communicate it to all faculty, staff and students. (p. 20)

Recommendation 2: Establish a set of guidelines for the tutors that communicate recommended approaches to conducting the tutorials. These should address issues such as length, structure and various aspects of facilitation. (p. 21)

Recommendation 3: For future tutorials, move toward grouping students homogeneously according to their level of understanding of the material. In the upcoming 18.03 tutorials, do this by giving the students the option of forming their own groups or being placed in groups by the class's administrative staff. This will be the simplest and most practical grouping approach under the circumstances and should maximize the students' comfort in working together in the tutorial. (p. 24)

Recommendation 4: Cluster the tutorials in the week before each exam. (p. 25)

Recommendation 5: To ensure maximum impact by the TAs but minimum impact on their time, use careful expectations-setting, clear guidelines for preparing for tutorials, comprehensive administrative help and maximum compensation levels to (1) manage the TAs' part in the tutorials and (2) help them manage their own participation. (p. 26)

Recommendation 6: To set students' expectations, explain the tutorials clearly at the first class, during recitations and at their first tutorial. (p. 28)

Recommendation 7: Pay close attention to other logistical matters, such as instructions for students, policies on scheduling and rescheduling tutorials, awarding of points and the physical settings for the tutorials. Also examine ways to steer struggling students toward additional help. (p. 30)

Detailed Recommendations

The first round of tutorials yielded many positive results, as the findings show. It is also clear from the findings that the tutorials offer opportunities for greater impact. This section presents a series of recommendations intended to help realize those opportunities. These recommendations assume that a follow-up experiment will be conducted in Professor Miller's spring 2006 offering of 18.03, that all students will be expected to attend tutorials regardless of their level of mastery of the material, and that each student will have the opportunity to attend two tutorials.¹

Overall Recommendation:

Using lessons learned in the 18.02 tutorials, introduce more structure into future tutorials and provide more direction for the tutors.

18.02's "open-ended approach" was useful for this first round of tutorials in the Math Department, in that it showcased different methods and approaches that would otherwise not have been seen. But its downside was that what is sometimes seen as a lack of structure and direction meant that some of the TAs spent too much time preparing. Additional structure and direction are recommended to relieve pressure on the TAs by creating tutorials that take less of their time and energy to plan and execute.

A critical step in deciding the future of tutorials in the Math Department is for the faculty and staff members involved in the 18.02 tutorials to carefully consider the questions raised in this document and to arrive at a consensus about how best to proceed with tutorials in 18.03. This process is underway. It began with discussions among Professors Miller and Seering, Dr. Breslow and Tom Clay, continued via a brief email survey of the 18.02 TAs that elicited their opinions, is continued via these recommendations and will be an ongoing process informed by continued experimentation. In the short run, however, it should yield agreement on a strategy for the 18.03 tutorials that includes a set of TA guidelines. More flexible than rules, these guidelines should be accompanied by the following message: "For both philosophical and practical reasons, we have no desire to dictate exactly how you should lead your tutorials. You should find ways that work best for you, but please do so within the spirit of the guidelines and with the stated purpose of the tutorials in mind." (If, however, there *are* inviolable rules or limits beyond which it is unacceptable for a tutor to go, these should also come out of those discussions and need to be identified and clearly communicated.)

The following specific recommendations are intended to contribute to that process.

¹ These assumptions are based on discussion of the assessment with Professors Miller and Seering. The decision whether to offer tutorials to all students depends on the mission and objectives defined for the tutorials. As such, I believe that there is no right or wrong decision on it, and will not address it in these recommendations.

Recommendation 1:

Facilitate agreement on a clear set of objectives that address how the tutorials will offer maximum value to the students, and clearly communicate it to all faculty, staff and students.

The following discussion of objectives is recommended for discussion and consideration. It distinguishes two forms of objectives: (1) outcomes to be worked toward and (2) the TAs' "mission" or purpose, the purpose of which is to provide ongoing guidance to the faculty and TAs.²

Outcomes:

As a result of the tutorials, all students will have:

- Greater confidence in their ability to do the class work.
- A greater level of comfort dealing with the TA and other help resources.
- An improved understanding of concepts underlying the material discussed and an improved ability to approach problems in a way that optimizes their ability to solve them.
- An overall greater competence level in dealing with the material discussed.³

In particular, students who are struggling with the material should have:

- Greater awareness of the help options available to them and the advantages they offer, a greater level of comfort in using them and a greater likelihood of taking advantage of them.

TAs' Mission:

In conducting the tutorials, the TAs' mission is to:

- Address what the students see as their own learning needs by facilitating discussion, exploration and explanation of the students' questions, and by providing them with opportunities to verbalize their thinking process around those needs.
- Where the students do not have questions, anticipate their needs based on (1) what the TAs know about the individual students and about the group's level of understanding of the material and (2) information distributed to the TAs by the faculty, staff and TAs, including

² These outcomes were not defined with measurability in mind; i.e., they are not specifically intended to be measured quantitatively. An argument could be made that the class has traditionally pursued more measurable outcomes (e.g., can the students do the problems?), and that it is more subtle, less easily measured outcomes that are being pursued in the tutorials.

³ While improved performance in the class in terms of a grade is a desirable outcome, it may not be the most appropriate objective for our purposes. Past research projects at MIT and elsewhere have brought into question the importance of better grades as *the* indicator of improved understanding of the material.

written briefings on what the class has been covering and the challenges they have been encountering overall.

- Guide the students to as many useful insights as possible by helping them explore the strategies for understanding and approaching problems under discussion and the key concepts underlying their questions. (Relevant here is the statement by one student that “The recitations are about problems. The tutorials are about concepts.”)
- Deliver value to the students based on the group’s (and, where appropriate, the individual students’) level of understanding of the material. If they are struggling, this means helping them understand the basics; if they are competent, this means helping them toward mastery; if they have achieved mastery, this means helping them explore more advanced concepts according to their interests.
- Explain (especially to struggling students) what additional help options (e.g., office hours [not just of their recitations leaders, but of other TAs] and Math Department tutors) are available to them and the advantages that those options offer, and encourage them to use them. For struggling students who do not have a study group, encourage them to form or join a study group, and give coaching on how to go about it.

These are not rules that should be followed mechanically, but rather a statement of the TAs’ purpose that will inevitably require the application of judgment and wisdom. For example, the students might see a contradiction between the TA addressing their stated needs (e.g., “I just need you to show me how to do this problem so I can reproduce it on the test”) and helping them explore the key concepts underlying their questions. The TA’s job is to interpret the students’ request in light of everything s/he knows, and to give the students guidance that strives both to satisfy the student’s request and add the kind of value that will help the student’s overall understanding of the class material.

Once discussed, revised as needed and agreed to, these objectives should become part of the TA and student orientation/expectations-setting processes (also see **Recommendations 5** and **6** on pp. 26 and 28, respectively).

Recommendation 2:

Establish a set of guidelines for the tutors that communicate recommended approaches to conducting the tutorials. These should address issues such as length, structure and various aspects of facilitation.

Samples of what these guidelines could consist of are shown and discussed below.

- ***Guideline:* Devote about half of the tutorial to the students’ questions and the other half to exploring assigned exercises or problems.**

Discussion: The goal of the tutorial session is to get the students engaged with and focused on the class material. Based on the students’ requests, what the tutor knows about them in advance and his read on them at the time, the TA has the freedom to decide on the fly what

will best accomplish that. For example, if the students have a lot of good questions, the TA can decide to devote the whole tutorial to those questions. (It is always advisable, however, for the TA to keep the assigned exercises or problems in mind and be ready to refer to them if they are relevant to the points they are addressing and works better than the problem under discussion.) Or, if the students have no questions, few questions or questions that do not seem useful,⁴ s/he may want to move early to the assigned exercises or problems. The TAs need to keep in mind that the problems are a tool for engaging the students in the material, not the tutorials' *raison d'être*. As the discussion of the problems surfaces questions or misconceptions, they should feel free to explore relevant concepts, make up their own problems to address issues that arise, etc., in order to help the students better understand the material (see **Recommendation 1**, *TA's Mission*, p. 20.) This "adjusting on the fly" may be easier for more experienced TAs, but in any case should become easier for the less experienced ones as they run more and more tutorials. (For additional discussion of the pre-assigned problems, see **Recommendation 5**, *Administrative Help, Exercises/Problems*, starting on p. 27.)

- **Guideline: Give an introduction to/overview of the tutorials, and make sure that each student introduces him/herself before launching into the material.**

Discussion: Since most of the students will never have participated in a tutorial before, there will be a high level of uncertainty and they are likely to be in an evaluative (i.e., highly judgmental) mode in which first impressions are critical. A fast-paced but thorough, informative and supportive introduction will set the tone for their participation and therefore their learning, and help establish a personal connection between the TA and the students. (See **Recommendation 6**, *At the Start of Each Group's First Tutorial*, on p. 29, for specifics.) The recommendation that there be introductions at the start of the session (and that it be done again at the second session if the composition of the group has changed) applies only to groups that were defined by the administration staff, i.e., not self-formed (see **Recommendation 3**, p. 24). It is based on the findings that (1) students are more comfortable asking questions or otherwise revealing what they do not know in a tutorial in which they are familiar with the other students and (2) despite having been in the same recitation, the students often do not know each others' names and have never spoken to each other.

- **Guideline: Use the Socratic Method, meaning that you facilitate a discussion with the group, using questions to encourage the students to think about the issue at hand and to draw theories, explanations or answers out of them.**

Discussion: This method keeps students involved in the discussion. The TA's attitude toward the students is critical to its success. It is not about grilling the students, or judging

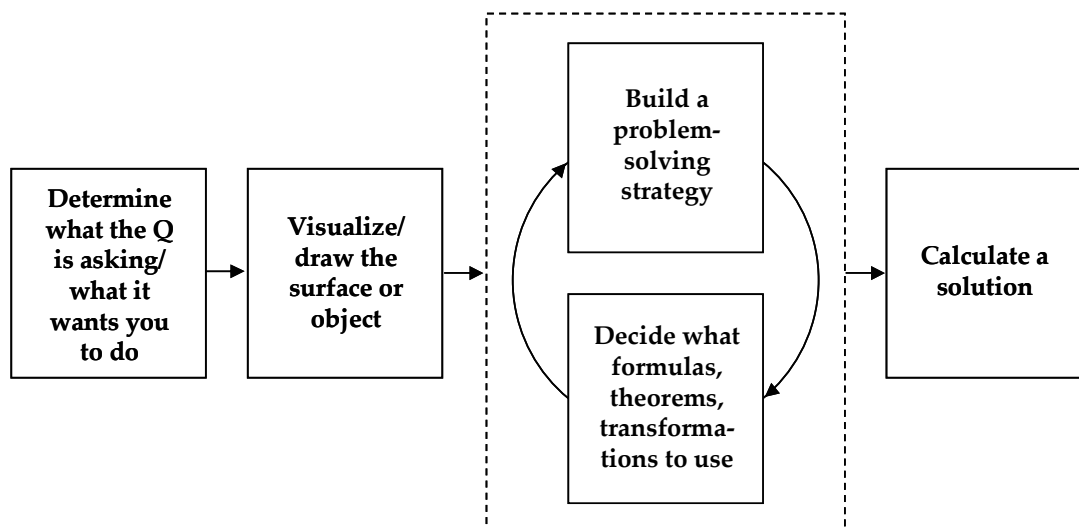
⁴ Students sometimes pose less-than-useful questions. This may happen, for example, when they believe that they must come up with a question – any question – because their participation grade depends on it, or if they expect to have to address their questions in front of the class and therefore do not want to pose questions they cannot answer.

them on what they do or do not know. Rather, it is about guiding the students to a better understanding. It does not mean that “telling” (as opposed to asking) is not allowed. There will certainly be times when telling is appropriate, but even then it is advisable to keep the students involved. Any inclination to lecture for concentrated periods should be avoided. Also, for this method to be most effective, the TA should be prepared to use silence effectively (i.e., be comfortable asking a question and waiting – for protracted periods of time, if necessary – for a response, since this throws the responsibility for responding onto the students. (Typically, when students know that they can wait out the TA, they will do so. But if it is clear that non-response is not an option, response times will decrease.)

- Guideline:** When helping students think through individual problems, guide them through – and have them guide one another through – a thinking process that discourages them from rushing too quickly to a solution.

Discussion: The suggested process is depicted in **Figure 4** below.

Figure 4:
Thinking Process for Approaching Individual Problems



The third step in the dotted box represents an iterative process in which the student arrives at a method for solving the problem. It may be useful for Professors Miller and Staffilani to write general guidelines that recommend a percentage of time, on average, to spend on each step. Each TA, however, still needs to experiment to discover how they are most comfortable implementing the process, varying the order and weighting depending on the problem and the needs of the particular students.

- Guideline:** During discussion of problems, have individual students take turns going to the blackboard to work through the concepts or problems. This is best done with your guidance and peer involvement, so that arriving at an understanding of the concept or problem becomes a group accomplishment.

Discussion: This is recommended even for students who may be uncomfortable going to the board, since presenting in front of others is a skill every MIT student should acquire. Non-threatening facilitation by the TA that gets the entire group involved should ease these students' discomfort. If the tutor senses that calling the student to the blackboard would be a serious issue, however, s/he can use an alternative approach. Some 18.02 TAs used another approach and were happy with the results. They had the students sit around a table and focus on a piece of paper, which served essentially the same purpose as the blackboard but may have been less threatening. (For relevant results from the TA survey, see p. 48.) It was also suggested that, if there were more sessions over the semester, the discussion could focus on paper at the start, and transition to the blackboard when students had become comfortable with the tutorials and with each other.

TAs should also consider whether to avoid calling students to the board to work on questions that they themselves posed. This can be seen as a "punishment for a good deed" and may discourage them from posing questions in the future.

- ***Guideline:* Focus primarily on current material, but be prepared to relate it to past material or concepts.**

Discussion: Sample exercises and problems and other guidance distributed to the TAs will reinforce TAs' understanding of what material is current. The TA should be ready to discuss past material if the students request it, and especially if it becomes clear that misconceptions about past material impact the students' understanding of the current material. Future material should be introduced only if the students have mastered the past and current material. (For relevant results from the TA survey, see p. 49.)

Recommendation 3:

For future tutorials, move toward grouping students homogeneously according to their level of understanding of the material. In the upcoming 18.03 tutorials, do this by giving the students the option of forming their own groups or being placed in groups by the class's administrative staff. This will be the simplest and most practical grouping approach under the circumstances and should maximize the students' comfort in working together in the tutorial.

In recent discussions with Professor Seering, Dr. Breslow and Tom Clay, Professor Miller indicated an interest in combining assigned and self-formed groups in his use of tutorials in 18.03. This recommendation is an endorsement of that approach, as long as it is carried out according to the understanding reached in that conversation. My understanding of the situation is described below.

A sophisticated online tool for scheduling tutorials is under development, but is unlikely to have the capability in the short term to assign students to homogeneous groups based on their understanding of the material. The best alternative for 18.03 in the meantime will be to adopt the simplest approach, which does indeed appear to be (1) to tell the students that they will be

placed in tutorial groups of three by the class's administrative staff, but (2) to also give them the option of forming their own groups if they so choose. This will enable them to form groups with friends or acquaintances without causing those who choose not to form groups or do not have friends or acquaintances to form groups with to feel left out. Those who form their own groups will "register" their groups (via the online scheduling tool if it has that capability at that time) by a certain deadline, after which the students not in self-formed groups can be placed into groups based on their scores on the first test. Students will be told that the resulting assignments are for the first tutorial only, leaving open the possibility of changing the composition of groups as the faculty and staff members get a clearer picture of students' levels of understanding of the class material. The students should not be told that they are being grouped according to their level of understanding of the material.

This plan will help ensure that the students will be comfortable in their groups since students report that (1) they tend to be comfortable with their friends regardless of the mix of levels of understanding and (2) when put into groups with strangers, they are likely to be most comfortable when they placed with students whose understanding of the material is similar to their own. Other options for grouping students homogeneously can be considered for future experiments, particularly when the online scheduling tool offers full functionality.

Recommendation 4:

Cluster the tutorials in the week before each exam.

Clustering tutorials before the exams is recommended because the results of the assessment imply that (1) it will reduce the TAs' workload (by requiring them to prepare just four times instead of each week), (2) the TAs are likely to become more effective at facilitating the material as they cover it multiple times and (3) the students will be more receptive to learning the material before exams. To take full advantage of the students' receptivity to learning the material, the tutorials should ideally be scheduled in the week before each exam. (No tutorials are likely to be held before the first exam, however, since (1) there was a perception among TAs that there was less meaningful material to cover that early in the semester and (2) the grouping process for the first set of tutorials will be based on the results of the first exam. For this reason, four is a good minimum number of exams, plus a final exam. Furthermore, the ideal day on which to schedule exams, where possible, is Friday, since it gives the maximum time in the week of the exam to hold tutorials.)

If individual TAs' schedules preclude their holding all of their tutorials in weeks directly preceding exams, they should be encouraged to schedule the tutorials in the two weeks prior to the exams. If even that is unworkable, they may schedule them at their convenience, but this will result in hardships for the administrative staff, since they prepare sample problems and briefings for the tutorials, and these will need to be resolved. (Taking a hard line on scheduling before the exams in 18.03 will be difficult, since the TAs will not have known about these impacts on their schedules when they took their TA jobs. To the extent possible, it may be desirable for the TAs for future classes to commit up front to such a schedule, which would allow more consistent clustering in the week prior to the exams.) In any case, these TAs should

also avoid scheduling tutorials after the week's last 18.03 class to ensure sufficient interest by the students.

Caveats:

- As noted in **Finding 5** (p. 15), the appropriateness of this recommendation depends on the objectives defined for the tutorials.
- Professors Miller and Seering should keep in mind that the recommended approach is the result of brainstorming and is not a proven strategy. We do know that it has potential downsides, e.g., that it could become more about test preparation and maximizing grades than about learning material, making it hard for the TAs to explore concepts.
- While the majority (six of 10) of TAs supported the idea of clustering tutorials before exams (see survey results and discussion starting on p. 47), (1) that opinion was by no means unanimous and (2) the support of a majority does not necessarily mean that it is a good idea.

Recommendation 5:

To ensure maximum impact by the TAs but minimum impact on their time, use careful expectations-setting, clear guidelines for preparing for tutorials, comprehensive administrative help and maximum compensation levels to (1) manage the TAs' part in the tutorials and (2) help them manage their own participation.

The TAs' participation in the process can be managed in the following ways:

- Expectations-setting via a TA orientation/training session and a tutorial handbook
- Guidelines for TAs' preparation for tutorials
- Administrative help, including scheduling, briefings and sample problems
- Finding any additional loopholes allowing for more compensation for extra time spent

Expectations-setting

Clear and accurate expectations-setting is critical to the success of new teaching methods. It is especially important here, where we know that the previous group of TAs grumbled about the demands the tutorials put on their time. In an orientation meeting/training session, the tutorial experiment should be clearly explained. This should include the objectives for the tutorials, how they will work, etc., as well as a briefing on what happened last time, what we learned from it, what we plan to do to address criticisms, and a request to the TAs for ongoing feedback and ideas for continuous improvement. As part of this, the TAs should hear that the tutorials will take extra time, but that (1) specific efforts will be made to support them and minimize the impacts on their time and (2) the previous TAs reported extra rewards in the form of personal satisfaction at being able to form relationships with the students and witnessing tangible impacts on their learning. Key information for the meeting should be included in a short *TA's Handbook to Leading Tutorials*, which should be distributed at or before the introductory meeting.

Preparation Guidelines

The TAs need to be told that managing the time they spend on the tutorials will require a balancing act on their part. On the one hand, doing a great job requires that they be prepared (i.e., aware of what is happening in class, who their students are and what their needs are, the level of any group they are about to meet with and the challenges the particular material are likely to present). On the other hand, they need to police themselves to make sure that they are not consumed by it. The good news is that two changes will ease workload concerns: (1) the clustering of tutorials (see **Recommendation 4**, p. 25) will decrease preparation time overall, since it will enable the TAs to prepare once for a number of sessions instead of preparing separately for many individual sessions and (2) additional administrative support (see *Administrative Help*, immediately below) will enable the TAs to prepare more efficiently.

Administrative Help

Running the tutorials should be made as “turnkey” for the TAs as possible, meaning that logistics should be taken off of their plate wherever possible and handled by one or more course administrators. The administrators’ role could include (1) tutorial scheduling, (2) writing and distributing or conducting pre-tutorial briefings for the TAs and (3) writing and distributing exercises and problems for use in the tutorials. (Additional responsibilities may also be identified.)

Scheduling – The planned online scheduling tool will be a significant boon once it is available. To the extent that it is not available, however, the administrator(s) should take on as much of the scheduling load as possible, including confirmation/reminder emails and the inevitable correspondence about rescheduling. The ideal – albeit one that will be difficult to achieve – will be for the TA to simply show up and lead the tutorial.

Briefings or Briefing Meetings – These two options could help the TAs prepare efficiently, but they need to be evaluated in light of the administrator’s experience to date. Well-organized, easily-accessible written briefings would contain succinct statements about what has been covered in class and where the students may need help, overviews of the exercises and problems for the upcoming tutorials, and any other information from the faculty and staff that would help the TAs to prepare. They would have the advantage of brevity. Briefing meetings, in which the administrator assembled the TAs to walk them through similar preparations, would have the advantage of bringing the TAs together to share experiences and discuss the coming tutorials. The disadvantages of such meetings would be that they would take more time and could be difficult to schedule. Whichever briefing option proves more practical, the keys to its success will be timeliness, thorough thinking and clarity/organization.

Exercises/Problems – This includes not just writing the problems, but also (ideally) testing them and distributing them to the students and TAs and, over time, compiling a library of problems that have been tested by use and revised accordingly. This effort can build on what Michael Nagle learned from his efforts in 18.02, but new problems will need to be written for 18.03. It will be desirable to have multiple problems for each tutorial (to accommodate the need for

different levels of difficulty and to address a range of concepts). At first glance, this may seem prohibitive because it appears to imply an increased workload. However, that increase should be offset because the clustering of tutorials will mean that problems will not have to be produced weekly. The administrator(s) will nevertheless probably need to respond to requests during tutorial weeks to revise existing problems or create new ones on the fly in order to address students' unanticipated needs.

In creating the exercises and problems, the administrator(s) should also be aware that the TAs' reaction to the 18.02 problems was mixed – that some were very pleased with them, while others found them less useful. Those that liked them found them appropriate for the purpose and appreciated not having to generate their own problems. Among those who found them lacking was a TA who saw the need for “more interesting, fun and creative problems” that would inspire more enthusiasm and excitement in the TAs and the students. Another TA hoped for “problems that were longer and slightly more imaginative than what could be asked of the students on the problem sets or done in recitation.” When she prepared problems herself, she explained, she “tried to come up with something that would tie together different topics done recently in the class in a way that illustrates how they are all related, to help the students make sense of how everything fits together. ... [She] aimed for something interesting and ... challenging, with a conclusion that the students could reach with only a few mild hints ... and it would make them feel like they had just come up with something really cool.”

Maximum Compensation

If possible, creative solutions should be looked for that would enable the TAs either to receive extra pay for their tutorial duties or to have the time they spend be acknowledged in some other meaningful way. Since they are currently receiving the maximum compensation allowable for TAs, perhaps their tutorial duties could be re-defined as beyond the scope of the their TA responsibilities, and they could be compensated some additional amount – even if it is primarily symbolic. Other options suggested by the 18.02 TAs could be considered as the starting point of further brainstorming. For example, one TA suggested that they be given the option of taking on a double load during the tutorial semester (e.g., by also doing grading for the class), thereby fulfilling their teaching obligation in one semester instead of two. (In theory, this should not significantly add to the overall spending for the class, since the grading portion of the job would need to be done anyway.)

Recommendation 6:

To set students' expectations, explain the tutorials clearly at the first class, during recitations and at their first tutorial.

Professor Miller should set clear and accurate expectations for the tutorials verbally in the first class and hand out a sheet explaining the tutorials. Any student joining the class later should receive the same sheet by email. The TAs should remind the students of this information in recitations as the first tutorials are approaching, and then set expectations again at the start of the first tutorial for each group. (While setting expectations on multiple occasions may seem

excessive, interviews for previous research projects have shown that they can be very helpful, since many students forget messages like these from week to week or pay attention to them only when they have immediate relevance.)

At the First Class

Professor Miller's explanation of the tutorials should present them as an opportunity and should include the following:

- The tutorials' purpose/objectives
- Their experimental nature and the signing of consent forms
- A request to cooperate fully if asked to help with the assessment
- The likely timing of the sessions during the semester and their duration
- How tutorial sessions will be conducted and by whom
- How groups will be formed
- The tutorials' impact on their grades and how they will be evaluated
- What is expected of the students vis-à-vis preparation and participation
- Policy on rescheduling missed tutorials
- Other ground rules, as applicable

The written introduction should include the same subjects. Professor Miller will also need to reintroduce the tutorials when the first set draws nearer, since the groups will need to be established at that time.

In Recitation

As the first tutorial draws near, each TA may want to remind the students about the tutorials during a recitation. Here it is likely that they will want to limit the reminder to a high-level description, followed up with the answering of any questions the students have at that time.

At the Start of Each Group's First Tutorial

The TAs will have a chance to address students' expectations again when they welcome each group to its first tutorial. This should be fast-paced but not rushed (i.e., it should take four or five minutes) and the message should reflect the TAs' own perspective on the tutorials. The following are suggestions for what it might include:

- An overview of how the session will work and why
- An review of key points in the TAs' official mission (see **Recommendation 1**, *TAs' Mission*, p. 20)
- A brief explanation of how grading of student participation will work
- An explanation of the TA's personal mission in the tutorials – something like “The tutorials are designed to give you more and better access to me so that I can help you with what challenges you in this class ... but they are not intended to limit that access to the tutorial hours. Based on what we do here, I hope you'll use me more – in office hours, by email, etc.

I want to get to know each of you as a person – not just as a name or face – and find ways to help you in this class.”

- A statement about the TA’s expectations for the students – something like “This is *your* time to learn and address the things that are challenging you in the class. That’s not to say that you will have complete control, since there will be things I’ll want to make sure are covered, but we are all in this together. I request your complete participation and a commitment to help each other learn as much as possible. Do you accept my request?” (Although the last part – the request – may seem unusual, I have found that asking students specifically if they will agree to an action, and then having them say that they will, can effect an attitudinal shift away from that of a passive observer toward one of a committed participant.)
- A chance for students to ask questions.

It could be argued that spending time explaining the tutorials at the start of each group’s first session is inefficient, i.e., that it would be efficiently done during recitation, when many tutorial groups are assembled together. The recommendation that this be done in the tutorial itself is based on a belief that this brief discussion – particularly the parts in which the TAs outline their personal mission and their expectations for the students – will be critical to establishing a connection between the TAs and their students.

Recommendation 7:

Pay close attention to other logistical matters, such as instructions for students, policies on scheduling and rescheduling tutorials, awarding of points and the physical settings for the tutorials. Also examine ways to steer struggling students toward additional help.

Other logistical points that need to be addressed are:

- Instructions for students on how to prepare for tutorials
- Policy on scheduling tutorials with student’s own recitation leaders
- Policy for rescheduling missed tutorials
- Policy of awarding points for participation
- The physical setting for tutorials
- The possibility of tutorials triggering offers of additional help for struggling students

Instructions for the Students

Students should be instructed to come to the tutorial:

- With their own questions about the material from the class, past or present. These may be about the lecture, pset problems, exam or exam-prep questions, concepts that they would like to understand better, or any other aspect of the class material.
- Prepared to discuss one or more exercise(s) or problem(s) that will have been sent to them in advance. Specifically, they will have received an email three to seven days in advance of their tutorial, confirming the time and place and conveying the exercise(s) or problem(s). It will ask them to look over the exercise(s) or problem(s), try to solve them, be ready to

discuss them (particularly the aspects that they found most challenging) and possibly to work through them at the blackboard.

TAs should be aware that, if they ask the students to work on problems in advance, they should try to address those problems at some point during the tutorial, since not using them will decrease the probability that the students will prepare for the next tutorial. (For relevant results from the TA survey, see p. 46.)

Matching Students with their Own Recitation Leaders

Where possible, students should have the same TA for both their recitations and tutorials, since their familiarity with their recitation leader is likely to make them more comfortable in tutorials and to facilitate the relationship-building process. (As noted earlier, this would be less of a factor if tutorials met much more frequently, but with only two meetings over the semester, the students would barely have a chance to get comfortable with the new TA before the tutorials would end.) An exception, as noted under *Rescheduling Policy* immediately below, should be the rescheduling of missed tutorials.

Rescheduling Policy

I recommend that scheduling guidelines be adopted that state that:

- No more than three students will be scheduled for any tutorial group.
- If a student is a no-show for a tutorial, that tutorial will not be rescheduled.
- If a student informs the class administrator in advance that s/he cannot attend a scheduled tutorial and requests a rescheduling, the administrator will do his/her best to accommodate the request based on the availability of spaces. To make rescheduling easier, the administrator will have the option of rescheduling these students into tutorials with TAs other than their own tutorial leaders.
- No tutorial will exceed four attendees, even after students are added to accommodate requests for rescheduling.

These policies should be made clear to all parties in advance.

Awarding Points

I recommend that the students continue to be awarded points for their participation on the same basis that they were awarded in 18.02. While it does make the tutorials seem obligatory, that is generally not resented, and it appears to be the best way of ensuring high participation rates.

Physical Setting

Where possible, tutorials should be scheduled in suitable rooms. Although it is clear that access to space is a constant challenge at MIT, efforts should be made to ensure that tutorials are held

in spaces that are private, quiet and large enough to accommodate comfortably the number of students expected.

Additional Help

In a recent discussion with Professors Seering and Miller, the subject of “unofficial sources of help” (e.g., study groups and seeking the help of dormitory- or fraternity-mates, as opposed to official sources such as recitations, office hours and departmental tutors) arose. Among the subjects discussed were the following observations (addressed in greater detail in **Finding 2** above):

- Many students go to office hours only if they are struggling and feel that they cannot get answers to their questions from other sources.
- Most students had not considered and would not consider using departmental tutors, many claiming to have been unaware of their existence.
- The majority of students seek help through “unofficial sources” – most commonly peers – for the sake of convenience.

Also discussed was the difficulty some students – particularly those who do not have established social networks – have in accessing unofficial sources of help. This may be the case for students from one department who take classes in another department where the students have already formed tight-knit networks, but in introductory classes it usually seems to be a function simply of shyness.

Two questions arose from that discussion:

- Are there ways that the tutorials can encourage students to use official help sources?
- Are there ways to help students to access official or unofficial sources of help if they are not already doing so, or to help them to use sources of help more effectively? For example, can the Institute make qualified upperclassmen available after hours or facilitate the formation of study groups?

While solutions probably extend well beyond 18.03, the tutorial process does afford opportunities to consider these questions and possibly experiment with answers. The *TAs’ Mission* section of **Recommendation 1** (p. 21) suggests that the TAs use the tutorials toward this end. The ideal would be for a larger initiative to be established and ways found to link the tutorials to that initiative. Until such time, however, additional ways to use the tutorials to facilitate access to other help sources should be considered. For example, one possibility would be for specific events in 18.03 (e.g., a failing or borderline exam grade or an alert from a tutor) to trigger an invitation to that student to attend office hours or to access the Math Department’s tutors. The invitation to office hours could include the schedule for the TA’s office hours, as well as the schedules of other TAs’ office hours and encouragement to attend those if they are more convenient.

A “referral service” to connect students who have no study group could also be considered. Here, if a TA talks to a student who is struggling and discovers that s/he has no study group, the TA could send an alert to the administrative staff, who could offer to link them to other students who have no study group or potentially to existing study groups. (Because of the combination of the following two factors, the creation of *new* study groups may be preferable: (1) what is holding the student back may simply be hesitation at making a first move; if that is done for them, they might be quite open to connecting with other students, and (2) existing groups may be more intimidating to a shy student because its members already know each other, making the new member feel like an outsider.)

Appendix A: Student Interview Guide

Interview Guide Student Interviews for 18.02, Fall 2005

- Introduce self
 - Purpose
 - Time pressures?
 - Don't be shy ... say what you think ... it's about learning and improving
 - Anonymous
 - Comfortable?
 - Questions?
-

About you ...

Freshman?

How like MIT?

How well prep'd were you coming in?

Probable major?

How did you like 18.02? Why?

Go to lectures? recitations? office hours? (per Haynes, who wants to reach students who don't go to recitations)

How **compares** to other classes?

How do you **like the 18.02 material**? How does that impact how you approach learning it?

How much do the tutorials relate the material to other stuff you're learning (e.g., electricity/magnetism, fluid mechanics, etc.) vs. being pure mathematics? If not, what do you make of that? How should it be?

How conceptual vs. practical (e.g., examples)?

How do you like the **lecturer**? How does that impact how you approach the class/learning the material?

What other variables impacted how you approached the class (and how you approach other classes)?

What's your take on the **tutorials**? (open-ended, probe)

Ever done anything like the tutorials before?

Enjoy?

What did you **like** about the tutorials? What did you **dislike**?

Where falls on **opportunity-obligation** scale? (Graph it.)

Why?

What could they do to move it to the left?

What **benefits** did you get out of the small group recitations? Probe, e.g., ...

- Impacts on learning?
 - Learned to do the problems better?
 - Learned the concepts better?

Other impacts? Probe, e.g., ...

- Impacts on attitudes? (How/why?) ... e.g., liked individual attention, easy to ask Qs
- Social impacts? e.g., got to know teachers/TAs better, got to know students better
- Others?

How will it impact you in the long term? How would it impact you if it were standard operating procedure at MIT?

Who was your tutor?

Stated objectives of tutorials:

- **From course information:** "to provide an opportunity to work in a more private setting than the full recitation on specific difficulties you may be encountering with the subject matter, and push deeper into the subject than is normally possible in a full recitation."
- **Per Consent Form:** "We believe these practices have the potential to improve our students' understanding and use of basic knowledge."
- **Per Gigliola:** "Not just to do the steps, but to get it to click."

How well met?

What actually happened in your tutorials? (Same in both meetings?)

How would you describe the atmosphere? To what do you attribute it?

How much freedom did you have to set agenda? Take advantage? Interested in setting agenda? (Felt that it was your time? Or that it was the tutor's? ... Spontaneity?)

Who drove? (What think of idea of students driving, with TA unsticking as needed ... practical)

How was the tutor?

Seemed to know what doing at the start (certainty vs. uncertainty)? Well prepared? (if no, impact?) Got the hang of it?

Really listened? Tried to understand what y'all needed?

How much talking vs. listening? Asking vs. telling?

(Tutor: telling takes less time, so is more efficient; efficiency vs. effectiveness)

How excited/interested did they seem?

What makes a TA good/not good at this?

Dynamics?

General participation level? Your participation level? Why? Got more comfortable in next?

How many would have needed before got really comfortable?

How shy were the students in general? How about you? How should TAs deal with that?

Were TAs able to break the ice? How?

Did you introduce selves? Were you introduced? Did/Would that make a difference?

Developed rapport? Trust? Developed atmosphere of trust/comfort in session?

How much do you think the **TAs got out of the tutorials?** ... how compared with how much students got out of them?

(I've heard that profs/TAs can be clueless about students, what they do/don't know, how hard it can be for them, what they need, etc. ... think this helped address that?)

Opened lines of communication? Forced TAs to engage with you? Vice versa?

Who do you think benefits more, the TAs or the students?

Theory: The **effect on** the students **isn't a direct** one. It's indirect. The tutors get impacted, and the students get impacted by what the tutors learn and do better. True?

How accurately do you think the profs and TAs perceive how well you do or don't get the material from the psets and HWs? Do the tutorials give away what students don't know? Is that good or bad? Do the students freely reveal what they don't know in the tutorials?

Did you get put on the spot? Good or bad?

Did students help each other out in the tutorials?

Who would you rather know what you don't know, the TAs or the other students?

What did you learn from the tutorials?

Learn better, more or different in tutorials from in other settings?

Conceptual vs. computational?

Alternative to a recitation that week; discussion based on recitation material; did you attend the recitation anyway? Why/why not?

Tutorial as alternative to recitation? Office hours?

Impacted need for office hours?

How does the tutorial impact your recitation experience? Comfort? Attitude? Likelihood of attending? What you get out of it?

How does the tutorial impact your pset experience? Attitude? What you get out of it? Grade?

Gigliola: doesn't see tutorials as standalone, but as something that should help/augment other parts of the class. Happened here?

What determines the success of the tutorials?

- Background, experience and preparation of the tutor?
- Background, goals and skill level of the students?
- Mix of students in tutorials? (What are the variables in this?)

We talked earlier about the benefits you got out of the 18.02 tutorials ... What were the costs?

Bottom line: Worth it? Best way to achieve benefits? Better ways?

How important was the material itself vs. the process and the opportunity to ask Qs, get to know TA, etc.?

Timing

Discussing previous week's problems vs. present or future weeks'

When in semester to have it?

When in week to have it?

Twice?

When in MIT career should have this?

1 hour appropriate?

Locked in to two pre-determined dates/times ... worked?

Sign-up procedure: How did you get assigned to groups? Worked? How would you do it?

What is importance of having continuity in composition of groups?

Knew other kids in tutorial? Effect?

Number of students: three good? Four? Two?

Range of students' abilities in tutorials

Any impact on how you study? Study habits?

Preparation ahead of time: Prep'd? How? Good idea to give specific problem?

Grading: How well does getting graded on participation stimulate learning? How about compared to other things they can do?

Impact of grading on attendance

Relationship between size of class and need for tutorials? (Huge class ... personal touch made difference in that?)

Elizabeth/Jason Group: Implications of having different leaders? Advantages/disadvantages? (at Cambridge, tutor is separate person, so you can really feel comfortable asking stuff)
Comparison specifically of these two tutors?

Gigliola's group: Effect of having prof as tutor?

Theory: learning mathematics isn't linear, it's about building foundations, then figuring out how they relate to one another. Sound reasonable? To what extent do the tutorials do that?

What have we not talked about that we should cover?

Thanks.

Give movie tix

Appendix B: TA Interview Guide

Interview Guide TA/Tutor Interviews for 18.02, Fall 2005

- Time constraints?
 - What I'm doing ... interviews with selected tutors first, then students and finally all tutors
 - Ground rules
 - Feel free to criticize ... it's about improvement
 - Anonymous
-

Small talk ...

About you ...

Undergrad/grad/faculty?

Went to MIT undergrad?

Like TA'ing? Why?

Ever done anything like these tutorials before?

How is it going?

- How compares to just doing recitations?
- Level of enjoyment
- Challenge
- Students' levels of preparedness
- Students' level of engagement/enthusiasm/openness
- How sharp they were
- Ability to reach/engage
- Interactions with students?
- Interactions among the students
- Facilities/logistics

What has surprised you?

- Material?
- How students reacted?
- Sense of what kids do, don't find hard?

What's working, not working?

Feel you were able to do it right, given the amount of time you had to spend?

What could be done to address what's not working?

Do tutorials as currently conceived **make sense**?

Graph how it has gone? (i.e., your enthusiasm curve)

Worth the effort? (why/why not?)

What would you change to make it worthwhile?

Your preference: the tutorial model vs the traditional model? Why? If traditional, is it a rewards problem?

What do you hope ...

- The students get out of this?
 - If cite conceptual understanding, then what is the relationship between understanding the concepts and being able to do the problems? What's the causal chain?
- You get out of this?

How realistic is all of that?

How/how much do you think the students were impacted?

- Short vs. long term?
- Students with different level of understanding of material (bell curve)?
 - If this is the mastery curve ... (bell curve)
 - What would the benefit and enjoyment curves be?
- Has it helped you help any at-risk students (either directly or indirectly)?
- Do you think you reached students who otherwise wouldn't have come to recitations?
- How open were they about what they did and didn't know? Level of trust built?

Has it affected you in any way? How?

- What have you learned about teaching/learning? Has it made you a better teacher? How?
- What have you learned about your students?
- Has it affected the dynamic between you and your students in any way? (How does that show up?)

How would you **describe** the **learning curve** for you as a tutor?

- How steep?
- What has affected it?
- Where did you draw your learning from?
- How did you apply it?

Who do you think **benefited more**? The students or the TAs?

- Theory: biggest impact on students was indirect ... from increase in quality of teaching

Were you **sufficiently prepared** coming in?

- How were you prepared?
- What do you wish someone had told you before you started?
- What advice would you give to a new tutor?
- What kind of training could be done to prepare tutors?

How much **prep** did you have to do?

- What did you do to prepare?
- Have time to look over students' exams and psets before tutorials?
- What could be done to make it smoother?

How do you run your tutorials?

- How compares with how you run recitations?
- How are the players positioned?
- Do you stand at the board?
- Did you have them present?
- What percentage of the talking do you do? Do you ask or tell more?
- To what extent do you follow a prepared agenda vs. having the students dictate it?
- How much silence was there?
- How much interaction among students?
- Did you concentrate more on conceptual material, or on how to do the problems?
 - For problems, where concentrated the most, and why?
 - What the Q is asking; what it wants you to do
 - Visualize/draw surface or object
 - What formulas, theorems, transformations to use
 - How to build a solution (i.e., problem-solving strategy)
 - Calculate the solution
 - For problems, more how to approach specific problems, or how to approach problems generally (i.e., tactical vs. strategic)?
- To what extent did you concentrate on past vs. current vs. future material?
- Did you have them prep a problem in advance? How did that go?
- How do you want the students to regard you? To what extent do you think that happens?

To what extent do you think the tutors share your practices/understanding?

- Do you think there should be standard approaches to running the tutorials? (not talking about styles ... assume that everyone would apply own style to standards approach.)
- Perceive any convergence of approaches among the tutors? Describe.

What makes for a good tutorial?

- What factors differentiate the good for the not-so-good?

Design:

- format (one hour twice per semester)
- effects of having different numbers of student in the groups – 2, 3 or 4

There has been talk of **grouping** tutorial of students **by levels of ability** or understanding ...

- What have you observed on mix and its effects?
- What are your thoughts on grouping intentionally?
- Methods of assigning groups based on level of understanding of material ...

- Heterogeneous?
- Homogeneous?
 - Assign based on results of exam 1
 - Self-assign by students based on speed/level of difficulty of groups (to be based primarily on the level of understanding of students)

Your effectiveness as a tutor?

- Meet stated objectives
- Interest the group in the material
- Reach individual students

Based on everything you've told me, are there **implications for tutor training**?

Disposition to being a tutor again? Why?

Test **other ideas**:

- Cluster tutorials (vs. spread them over semester); pros and cons?
 - Offer before tests?
 - Offer before tests early in semester, then encourage to use office hours to fill the need?
- Award points to students with certain exam scores and not have them go to tutorials; use extra capacity to offer more frequent tutorials (to concentrate on students who need tutorials the most)
- Eliminate division of labor vis-à-vis grading; fewer students per TA, TA does all grading in addition to running recitations and tutorials – to ensure in touch with students and their needs
- What are implications of giving points as extra credit?

What have we not talked about that we should cover?

Thanks.

Appendix C: Results of TA Survey

Questions for TA Input
18.02 Tutorial Experiment
Fall, 2005
Summary of Responses

Q1: To what extent do you agree that we should introduce such guidelines?

Strongly Disagree					Strongly Agree
1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	4 <input type="checkbox"/>	5 <input type="checkbox"/>	
		X,X	X,X,X,X	X,X,X,X	

Comments (optional):

I think if these "guidelines" are really friendly recommendations they should be very useful. Of course TA freedom should and will not be affected then.

I would think of them as suggestions rather than guidelines

I think that the "fishing" period we all had trying to figure out what will work with our kids was the hardest and, for the most part, the least useful to the students. I'm in favor of guidelines, at least where it's been decided what seems to work the best.

It wasn't that difficult to prepare, since we were sent problems each week. However, I spent the whole semester wondering if I was even doing the right thing for tutorials. It would be nice to have a more clear cut program laid out.

Q2: Recognizing that the tutorials cannot do everything well, please help us prioritize the following objectives by indicating how important each is for the tutorials:

Address whatever the students see as their needs

1 <input type="checkbox"/>		2 <input type="checkbox"/>		3 <input type="checkbox"/>		4 <input type="checkbox"/>		5 <input type="checkbox"/>
		X	X,X,X,X,X		X,X,X,X			

Address what we see as the students' likely needs

1 <input type="checkbox"/>		2 <input type="checkbox"/>		3 <input type="checkbox"/>		4 <input type="checkbox"/>		5 <input type="checkbox"/>
		X,X	X,X,X	X,X,X	X,X,X		X,X	

Help the students better understand how to approach problems

1 2 3 4 5

	X	X	X,X,X	X,X,X,X,X
--	---	---	-------	-----------

Help the students better understand underlying concepts

1 2 3 4 5

	X	X,X	X	X,X,X,X,X,X
--	---	-----	---	-------------

Inspire students to explore more advanced mathematical concepts

1 2 3 4 5

X,X	X,X	X,X,X	X	X,X
-----	-----	-------	---	-----

Other (specify):

1 2 3 4 5

				X,X
--	--	--	--	-----

Comments (optional):

For a TA teaching the course for the first time it is hard to see what the students really need (or for that matter what they think they need) help on before an exercise is put on the table. Their problems/needs are likely to come up to the surface as a reaction to a large range of exercises. Therefore it would be advantageous to have well-tested and enjoyable exercises (and which answer most of the criteria in the table) that have worked in previous semesters and that have benefited previous generations of TAs/students.

For those students who already understand the material very well, tutorials should be geared toward exploring more advanced concepts. It would be nice if students in this position could be grouped together in tutorials.

Also, I found that students' perceptions of their needs matched my perception of their likely needs most of the time.

The hard part, and the most important part, is learning (mathematical) problem-solving skills.

Spend a little time on things that use concepts from class in some way, but aren't the ordinary "homework" kind. Not necessarily a lot more advanced - just something different and interesting that they can be excited about, though it's may not be needed for class.

I feel that recitation is more appropriate for regular "how to approach problems", unless of course it's what the kids are confused about. As for the advanced concepts, I think it's very important with the students that are doing well in the class, and somewhat lower on the priority list for those that are having trouble with the more basic concepts.

It obviously depends on the level of the student.

Q3: Again, recognizing that the tutorials cannot do everything well, please help us prioritize the following objectives vis-à-vis a “target audience”:

Help *all* students to maximize their grades

1 2 3 4 5

X,X	X,X,X,X	X,X	X	
-----	---------	-----	---	--

Help *all* students reach a reasonable degree of competence with the material

1 2 3 4 5

		X	X,X,X,X	X,X,X,X,X
--	--	---	---------	-----------

Help *all* students to learn as much as possible

1 2 3 4 5

X,X	X,X	X	X,X	X,X
-----	-----	---	-----	-----

Help *struggling* students achieve as high a degree of competence with the material as possible

1 2 3 4 5

X	X	X,X	X	X,X,X,X
---	---	-----	---	---------

Help *the best* students to master the material and inspire them to reach beyond it

1 2 3 4 5

X	X,X	X,X,X	X,X	X
---	-----	-------	-----	---

Other (specify):

1 2 3 4 5

--	--	--	--	--

Comments (optional):

Sometimes the struggling students are not working hard enough. So wouldn't like to make them think that an hour of tutorial could release them from few hours of extra needed work!

Regarding the "struggling students" line above: I truly saw that struggling students will continue to struggle if they don't supplement tutorials by many hours of extra help available otherwise. Two hours a semester cannot be reasonably be expected to even partly help such students. On the other hand, two such hours can provide a useful and refreshing supplement for all students, and in the specific case of very strong students this refreshing experience can/may provide them (and the TA) with inspiration.

I think a student's grade should not be the issue in tutorials. Realistically, of course, students will take tutorials less seriously if they don't think a tutorial will help them improve their grade.

We don't need to worry about grades; the students will do that for us.

My experience: even the best students are swamped enough by about halfway through the semester that supplementary material is mostly wasted, and perceived as busywork. But anyone interested enough to show up for tutorial is interested enough to work on what they feel they don't get.

Uh, this is really a matter of what we want the tutorials for in the first place. Ideally I'd say they should help each student achieve as high a "degree of competence" as possible, whatever that may be for each of them.

I don't think it's so important to focus on helping the best students reach beyond the material, since two sessions a semester won't really do the trick. Also, even among the best students, very few understand the material well enough that they need to move beyond it to find a challenge.

Q4: Which of the following “preparation strategies” would you recommend? (If you select more than one choice, please explain under “Comments.”)

Students are not asked to prepare for the tutorials.

X

Students are asked to come with a specific question or a concept that they would like to understand better.

X,X,X,X,X,X

Students come to the tutorial ready to discuss a problem set or exam problem of their own choosing.

X

Students come to the tutorial having looked over a problem assigned specifically for the tutorial.

X,X,X,X

Students come to the tutorial having solved a problem assigned specifically for the tutorial.

X

Students come to the tutorial ready to present a problem assigned specifically for the tutorial.

X,X,X

Other (specify):

Comments (optional):

I selected all those since I would imagine something like this: an email is sent to the group of 3-4 students 3-7 days in advance asking them to look at the problem, try to solve it, and to be ready to discuss and possibly present their work (to the rest of the group).

Presenting a solution is an important skill for the students to develop. Such a requirement would make students put more thought into the problem than they would for a problem set question. (After all, many students got high homework scores without really understanding everything.) I don't think it's too much to ask students to bring another question they would like to understand better. That would make them assess their own level of comprehension before the tutorial.

This problem could be counted as part of the homework

The second (Students come to the tutorial having looked over a problem assigned specifically for the tutorial) generates more group cohesiveness and forces students to evaluate their level of understanding, while the first (Students are asked to come with a specific question or a concept that they would like to understand better) will ensure that individuals get their needs addressed.

If they receive the problem in advance, it becomes just another homework problem; they get plenty of those already.

I think that it would be useful to make students really look over the past problem set when they get it back, but having them bring one of the problems to tutorial may not be interesting for the others. I think a "concept" is better since it gives the TA some room to accommodate the rest of the students. Assigning a problem beforehand is hard to do responsibly since it should be something tailored to the students coming, but their most recent work is often not available sufficiently ahead of time. Also freshmen are *crazy* busy, and unless we compensate the extra work somehow, I don't think we should ask them to do more than they're doing already.

Anything that depends on the student to choose something to discuss is problematic. Many students won't prepare anything, and the TA doesn't know what to discuss until the minute the tutorial begins. I think looking over a problem is best because it doesn't ask too much of the student outside of class time. Having the student present often just means other students have to watch one student struggle.

I find the tutorials most productive when students "get stuck" in my presence - so I want them to be looking at something they couldn't necessarily do when they walked in the door.

Q5: Which of the following methods of distributing the tutorials over the semester would you recommend? (If you select more than one choice, please explain under "Comments.")

Evenly distributed over the semester.

X

Clustered at times most convenient to the TAs.

X,X

Clustered in the two weeks before exams.

X

Clustered in the one week before exams.

X,X,X,X

Other (specify):

X (clustered in the 4 weeks when the exams are due)

X (Evenly distributed but not in the week before an exam)

X (Different possibilities might work better for different TAs. There should not be imposed a single scheme though, I believe. In general though, as stems from my previous answers, I strongly believe the TAs should be advised not to schedule in the week before an exam/quiz.)

Comments (optional):

In the week before an exam students are mentally too focused on what they are going to find in the exam and they show little interest in understanding concepts.

It is a good idea to cluster the tutorials before the exams, but I think it would be too concentrated of a time commitment for the TA if the tutorials are all the week of the exam. Convenience for the TA is key-- the timing of my tutorials (which I scheduled very early on and distributed them evenly over the semester) became a major inconvenience. I'm not concerned about convenience for the students, who only attend two tutorials total.

I think a week before exams is when students really need to sit down, look over all the concepts for that part of the term, and try to make sense out of how it really fits together. That, I feel, is probably the biggest help the tutorials can be, as opposed to problem solving that's done in recitation and homework and office hours.

Students were VASTLY more interested in the week before the exam, and it was easier to discuss practice problems than problem set problems. I ended up scheduling all my tutorials in the week of an exam by the end.

Q6: Which of the following best describes how you think the tutorials (or the structured portion of the tutorials) would be most effectively conducted? (If you select more than one choice, please explain under “Comments.”)

- The students listen to the TA’s explanation of the material and answer the TAs’ questions when they are called on

X,X

- The students work collaboratively on problems, and then explain their results

X,X,X,X

- The students take turns working at the board without peer involvement, and explain the problem or other material to their peers

- The students take turns working at the board, walking through the problem or other material, with help from their peers

X,X,X,X,X

- The students work in parallel on problems, after which the TA will ask them to explain the results

X,X,X

- Other (specify):

Comments (optional):

and with help and guidance from the TA.

Collaboration and group discussion is most important. Preferably the TA would do as little explaining as possible, but sometimes this is necessary when the students don't fully understand a concept. I especially like giving students the chance to work at the board, but I think this doesn't work too well with larger tutorial groups.

Not every student likes to stand at the board

I'm more interested in what they can do individually; most people cooperate on the homework already.

I like having tutorials be low-stress, so no kids at the blackboard. I do like lots of student involvement; they hear me enough in class. What worked best for me was having the students collaborate, helping each other through the more difficult passages. I only occasionally steered things in some useful direction, or led them for a while when they got stuck or needed some new technique that would have been hard for them to just figure out.

I generally had students work out a problem in parallel, asking for help as they needed, and then had them take turns presenting the parts of the problem. Occasionally, I would step in myself and explain an especially tricky part. I found this worked pretty well, since many students who knew how to solve the problem on their own didn't really understand what they were doing, and it was good for everyone to try to explain why they did what they did.

Q7: Which of the following should the tutorials concentrate on? (If you select more than one choice, please explain under “Comments.”)

Past material

X,X,X

Current material

X,X,X,X,X,X,X,X,X

Future material

X

Other (specify):

Comments (optional):

I think the tutorial should explain current material, but put it into context with respect to the past material.

It's hard to cut up the course sometimes into different "materials". If one must do so, I think that past and current materials and their possible interactions should be emphasized.

Students don't want to hear about past material, even if they don't fully understand it.

Both students in my recitation that didn't pass the class didn't come to my second tutorial. All the others did.

Focus on current material, but stronger students may need enrichment or a preview of later topics to help hold their interest.

I guess that would be "current and past" for the "future exam"-relevant material. As for grades vs. attendance, all my kids came to tutorial both times so I can't really say.

Most student interest and participation.