Teaching Statement

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Teaching is an opportunity to share my appreciation of mathematics with my students, and convince them that they might enjoy it just as much as I do. My goals as an educator include the following:

- Enhance students' impression of mathematics as a whole;
- Emphasize a growth mindset – mathematical ability is not innate but develops with practice;
- Develop students' ability to communicate mathematics effectively;
- Facilitate independent learning and exploration.

The following are some teaching practices that support the above goals and others, with examples of how I have applied them in my teaching; these are on pages 1–3. Pages 4–11 consist of summaries of teaching evaluations.

Engaging students in active problem-solving. I believe that we internalize new concepts best while working on problems. In-class problem-solving was a central theme in my proofs course, which was partially flipped – on Mondays I expanded on the reading assignment from the previous weekend in a lecture, while in the remaining class periods, students worked on problems together in long-standing groups as I went around the room assisting. This was a particularly useful format in this course since much of the content (discrete mathematics) was well-known to the students and the main challenge was in constructing and evaluating logical arguments. Instead of passively watching me write down some proofs on the board, the students were active participants in the class and were able to get immediate feedback in the process of creating their own proofs. As they worked within their groups, the students learned to articulate their thoughts persuasively while also gaining experience in evaluating the correctness of arguments suggested by their peers. From the evaluations: "[Groupwork] allows me to communicate my ideas with classmates, which helps refine my understanding of the questions and also corrects some of my wrongness[...]."

In advanced courses, in most class periods I invite students to give a proof of a particular statement that I write on the board. After a minute or so for students to think on their own I ask the class for comments or ideas. Together we construct a proof with contributions from multiple students. In this process, one of my goals is to tease out what students are actually saying and work with them to translate their suggestions into mathematical language. Once an idea is proposed, we evaluate as a class whether it might be relevant to the statement we are aiming to prove, modeling what they might do when proving things independently. From the evaluations for my undergraduate topology course: "There was obvious effort to engage students in dialogue and construction of proofs which is tremendously helpful [. . .]." Throughout my teaching, I consistently emphasize the process by which we reach a solution more than the solution itself. Through the above activities, students learn that mathematics is not about immediately knowing the right answer, but rather an iterative and creative approach towards solving problems.

Promoting mathematical dialogue in multiple formats. My courses frequently aim to hone mathematical communication skills. Students in my honors algebra course independently explored a topic of their choice to give 20–minute final presentations to their classmates. Since none of my students had given a mathematics presentation before, I created low-stakes opportunities for them to practice and receive constructive feedback from multiple sources. Each student gave 2–3 short in-class presentations, evenly spaced throughout the semester and graded only on participation, where they received (anonymous) feedback from their peers and myself. Students evaluated one another using rubrics, which also provided a concrete framework within which to evaluate

their own performance. From the evaluations: "The unusual aspects of the class were very helpful for my learning and growing as an academic. For instance, I was able to practice my presenting and teaching ability in a comfortable environment and received helpful feedback on my abilities."

In my proofs course, the students wrote one-page essays on mathematical topics of their choice. In order to assist students with developing writing skills, their work throughout the semester was graded on both content and exposition. I worked with students to choose essay topics that were appropriate in scope as well as of interest to them; topics were due long before the paper itself. A first draft was due a few weeks before the final deadline and was returned promptly with comments. Additionally, they had the option of entering an essay contest where the (anonymous) essays were voted on by the entire class, and the three finalists received extra credit. The final winner received a trophy and an additional prize. Through this assignment, the students gained experience in expository writing to complement their training in technical proof-writing which was the main focus of the course. Students were able to explore the mathematics they are personally interested in, resulting in a vast variety of paper topics, including the music genome project (Pandora), the algorithm behind AlphaGo, platonism in mathematics, the mathematics of Bridge, and bracketology. Through evaluating the essay contest, students were naturally exposed to the diversity of fields where mathematics crops up, which would have been impossible through just lectures. From the evaluations: "Some of the essays come to my surprise because I would never thought they are considered subjects of math", "It allows me to sit down and spend time on a topic that i have long interested but never have the chance to take a step into due to many reasons."

Changing student impressions and attitudes. One of my goals in each course is to positively influence my students' perception of mathematics. This is particularly relevant in introductory courses where many students believe mathematics to consist entirely of rote learning of arbitrary rules. In such a course, I frame our work as problem-solving – a creative enterprise rather than a mechanical one. I describe the history and reasoning behind why mathematical terms are defined as they are, emphasizing that mathematics is not immutable but rather built, refined, and corrected over time. In any course, I strive to give the students a sense of how the topic fits into the overall fabric of mathematics. The second half of my proofs course consisted of a broad overview of the major fields of mathematics – there were units on set theory and logic, number theory, algebra, analysis, and topology. In each case, except topology, students had assignments on the basic topics, and I concluded the unit with a sketch of what comes next, a sense of what current research might consist of, and which course to take to learn more. In the more specialized course on topology, I ended the semester with a series of guest lectures by topology graduate students discussing their research, to give students a glimpse of graduate school in mathematics. For extra credit, students in most of my courses may attend mathematics talks such as the department colloquium or participate in other mathematical activities such as visiting the Museum of Mathematics or a Putnam practice session. This is a chance for students to engage with mathematics beyond the classroom, and sometimes get a taste of contemporary mathematics.

I believe that if an instructor is excited about a subject, students will become invested in learning it themselves; as a result, I let my enthusiasm for mathematics show. From evaluations in a calculus course: "I [. . .] consistently felt in class that my views of math as a subject evolved"; "She clearly loves math, and this shows in the form of her math jokes and excitement when teaching. Her interest in it is infectious"; "Math is also not my favorite subject but she made it seem interesting to me."

Tailoring courses to students. Students are significantly more engaged in a course if they believe it is relevant to their own interests. In order to calibrate each course to its students, I begin each semester with a short survey where students describe their background in mathematics

and their reasons for enrolling in the course, both of which can vary greatly. The information I receive informs my choices throughout the semester. For example, in a calculus course with several engineering majors I will give varied examples of real-world applications. For an audience with many biology majors, I would draw examples from population dynamics, disease propagation, etc. In more advanced courses, my students have chosen their own topics for papers and presentations, enabling them to explore a field that interests them on their own terms, in preparation for independent pursuits in the future. A third of my topology course was devoted to topics that students chose by vote. As a result, we discussed fixed point theorems and their applications to economics and game theory, dynamical systems and chaos, knot theory, etc. This process affirms that each student's interests matter, fostering a sense of inclusion and belonging in the class.

Supporting diverse backgrounds and skill sets. The key to engaging students is to strengthen their sense of belonging. The greatest hurdle for many students in a math classroom is a preconceived notion that they are not a 'math person', often due to not matching the race or gender of a 'typical mathematician'. To counter this thinking, I consistently focus on a growth mindset: the principle that mathematical ability is built over time rather than some sort of genetic gift. By tailoring courses to students' mathematical background and feedback, I aim to assure each student that they are a valuable member of the class and bolster their sense of agency. Exploring problems in small groups eases the pressure of speaking out in class while students also realize that their peers are struggling with the material just as much as they are, building a sense of community. Using multi-faceted assessments such as papers and presentations gives an opportunity for students to excel in the activities most suited to their particular skill sets. Throughout my teaching, my objective is to convince each student that they have the capacity to excel in mathematics.

Creating opportunities for student feedback and reflection. A course is successful to the extent that the students get something out of it, which we may determine from student feedback. In addition to the standard evaluations at the end of the semester, I periodically solicit midterm feedback, where students can themselves benefit from a response to their concerns. The feedback format specifically encourages students to not only consider the logistics of the course, but to reflect on their own learning process and level of engagement. The day after receiving midterm reflections, I discuss them in class – addressing concerns and discussing how I intend to respond to them. Through this process, my goal is to maintain a continuing dialogue with my students where they are comfortable in expressing their needs and to reinforce their sense of agency. From evaluations for a calculus course: "Although this class has very difficult material, the Aru's ability to listen to our feedback throughout the semester made it very easy to handle and even enjoyable."

The above is an incomplete but growing list; while I have omitted describing some of my current practices for lack of space, I am also constantly adding to my pedagogical toolbox. As a postdoc at Brandeis University, I regularly participate in workshops organized by our Center for Teaching and Learning, including a Faculty Learning Community on the scholarship of teaching and learning. Earlier, at Rice University, in addition to participating in such programs, I was the graduate student representative on an advisory committee to our newly founded Center for Teaching Excellence.

As an undergraduate at a liberal arts school I saw firsthand the positive and profound impact that dedicated educators can have on students. I personally started college as a biochemistry major convinced that math was merely a tool for other fields, just like many of the students in introductory courses that I have now taught. I was fortunate to have fantastic teachers who spent countless hours talking to me about mathematics for no good reason beyond their sincere love for the subject; I continue to strive to follow their example.

Summary of Teaching Evaluations

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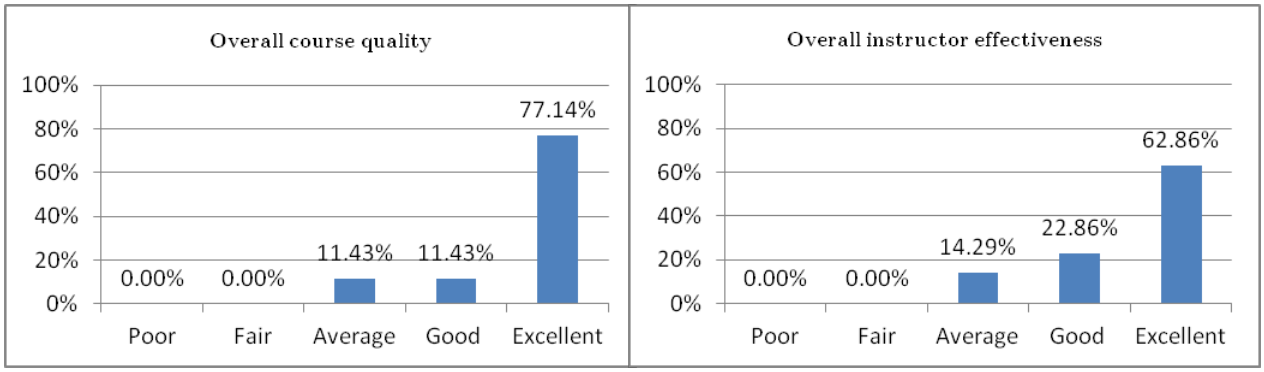
MATH 23b: Introduction to proofs, Spring 2016 (Brandeis University)

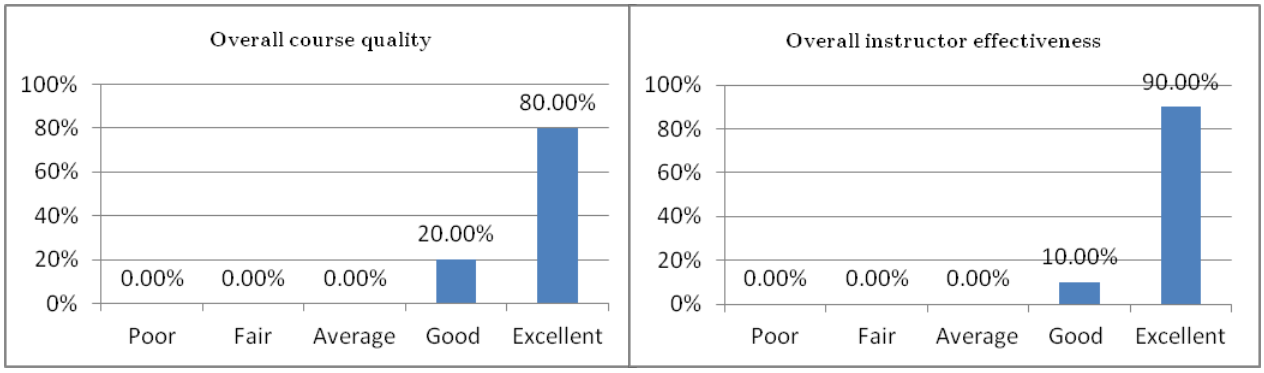


Responses: 35; Enrolled: 39.

Selected comments

- Aru construct the course in a creative way. We do not only do problem sets, but also have group works and math-related essays. She encourages us to learn and practice the knowledge in different ways.
- She is open to every student and she respects every thoughts. She really spent a lot of time answering questions since there are multiple ways to prove something [. . .].
- by write this paper and read the papers by other students in our class, I see how math can relate to other fields such as physics, economics and computer science.
- The essay contest was a nice addition, and it was fun to participate and read other people's essays!
- Although this course is a writing intensive course, I don't feel tiresome or boring because everything we wrote is meaningful and useful and it was a lot of fun.
- Through the group works, we get connected to our classmates, and we have deeper understanding by through communication.
- She [. . .] encourages us to go to math exhibition and talks, etc. Thus I not only have a deeper understanding about proof, but also loves math more.
- I love how she brought her field of study, topology, into class and used it as an example of what proofs can be used for.
- I especially appreciated how accommodating she was; she frequently took student feedback on the course and modified the course accordingly to benefit the whole class.

MATH 104a: Introduction to topology, Fall 2015 (Brandeis University)

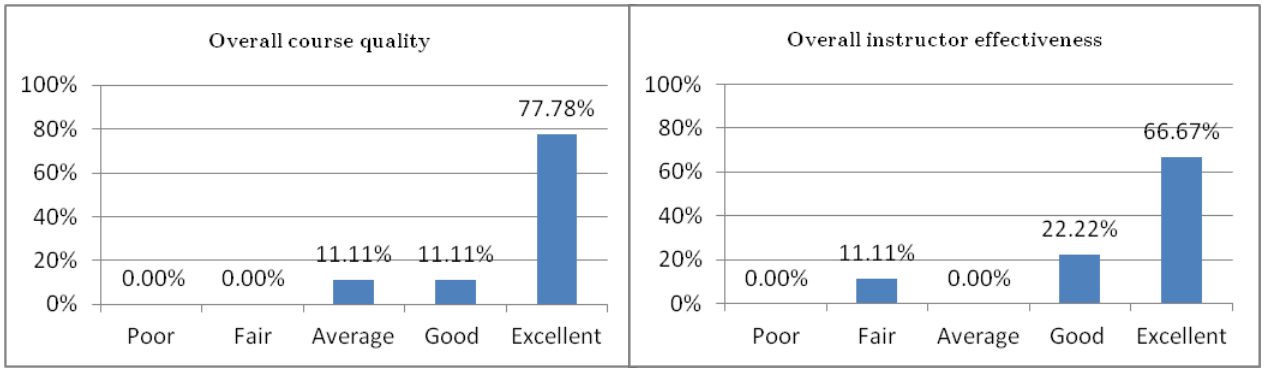


Responses: 10; Enrolled: 10.

Selected comments

- Aru is by far the best professor that I have had at Brandeis. [. . .] the course was simultaneously my most challenging course and also the most interesting. I truly looked forward to attending lectures and wrestling with the problem sets every week.
- There was a coherence and flow to every topic [. . .]. There was clearly thought and effort put into how lectures and textbook readings would complement one another.
- There was obvious effort to engage students in dialogue and construction of proofs which is tremendously helpful, and unfortunately not often implemented in math classes.
- I deeply appreciated the distinction between problem sets– which could be tremendously challenging and where problems might take several days to complete – and the exam, which was an opportunity to show an understanding of the concepts [. . .].
- The special topics were very exciting and gave a lot of good perspective on how broad a topic topology really is.
- Aru clearly cares deeply about student engagement with the material and is always willing to provide additional support. I have never felt silly for asking even the most basic questions – something that most professors do not manage.
- Assignments, some required others optional, encourage students to think beyond the simple requirements to succeed in the course, be it by researching an interesting topic or attending a seminar or writing a blog post.
- Her ability to effectively teach is helpful for students who may not be enthusiastic about the material at the onset, and her encouragement of extracurricular learning is incredibly helpful for those who are.

MATH 151a: Topology I, Fall 2015 (graduate course, Brandeis University)

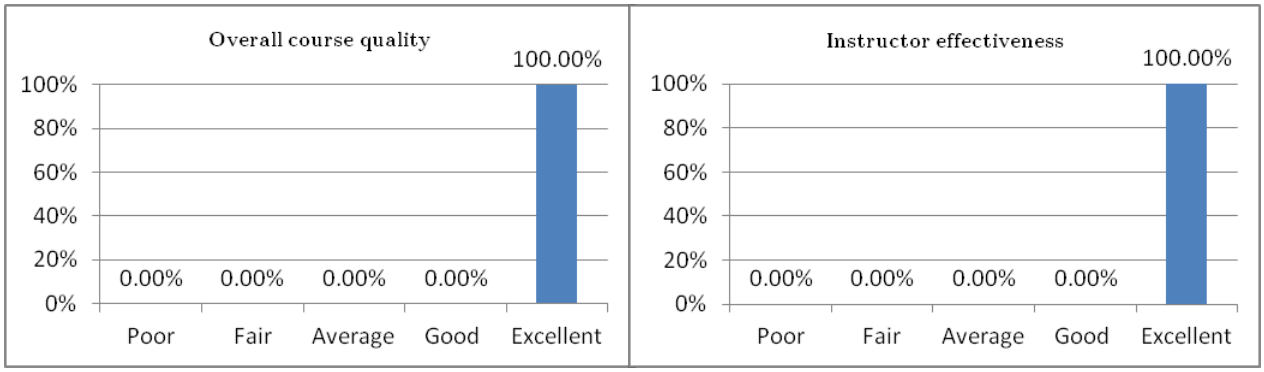


Responses: 9; Enrolled: 12.

Selected comments

- The professor is particularly good at illustrating both the "big picture" of this subject and yet also is very successful in presenting the important details in a satisfying and intuitive manner.
- Aru is excellent at telling a story in her lectures. She clearly states not only the content but also points out which parts are most important to focus on and motivate the material well.

MATH 100b: Introduction to algebra part II, Spring 2015 (Brandeis University)

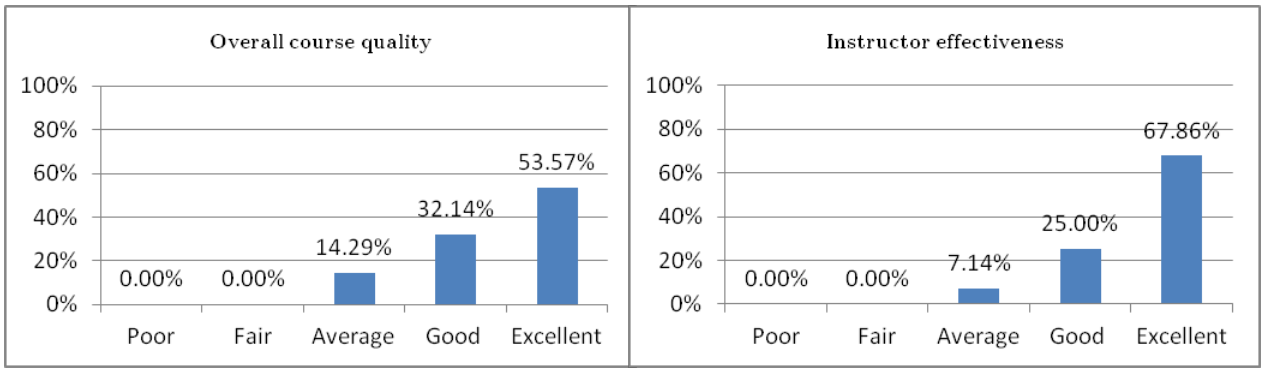


Responses: 6; Enrolled: 8.

Selected comments

- She [. . .] pushed her students to go above and beyond the typical standards of math classes by mandating self-directed study.
- I [. . .] enjoyed having a motivator for doing some self study at the end of the semester on a topic of interest to me.
- The unusual aspects of the class were very helpful for my learning and growing as an academic. For instance, I was able to practice my presenting and teaching ability in a comfortable environment and received helpful feedback on my abilities.
- It was good to practice giving lectures on math (as I hope to one day do so professionally) [. . .].
- I enjoyed the motivation to go to seminars and the chance to write about them.
- I [. . .] enjoyed the paper because it gives us liberty to apply or explore the algebraic nature of topics of interest.
- The research project at the end helped me explore an entire new area of math, as well as learn about new areas from other people. Thank you!

MATH 15a: Applied linear algebra, Spring 2015 (Brandeis University)

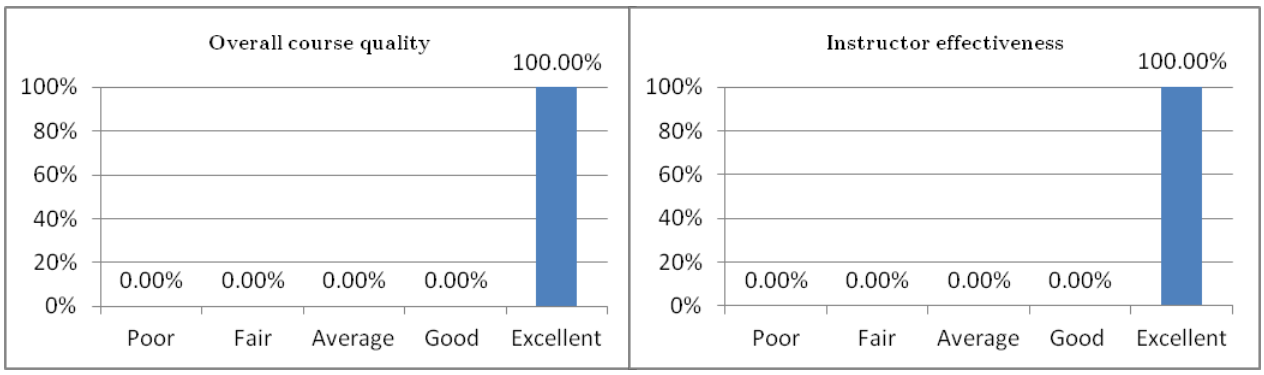


Responses: 28; Enrolled: 38.

Selected comments

- She also very patient when students have any questions for her. She respects every student's idea about the topic.
- She was consistently available for office hours and via e-mail, which made getting necessary help very easy and effective.
- I thought the course was very well-structured, and the professor was a very good teacher.
- She was clearly always organized and very knowledgeable about the subject matter.

MATH 151a: Topology I, Fall 2014 (graduate course, Brandeis University)

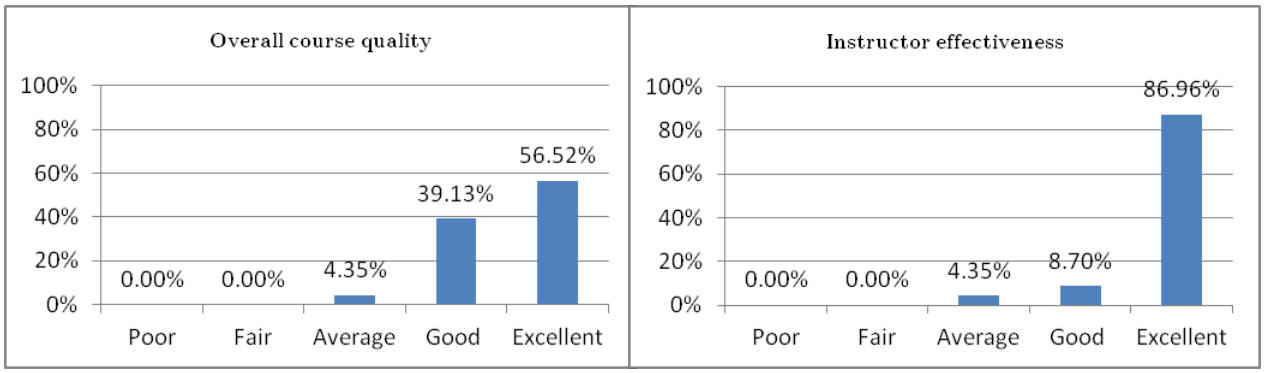


Responses: 3; Enrolled: 6.

Selected comments

- The lectures were [...] a good complement to the book, providing further explanation in sections that are difficult to follow, and glossing over details that are explained carefully in the text.
- The somewhat informal style of teaching helped to bring forward key ideas that would otherwise have been obscured by the convoluted proofs and complex formulations of their respective theorems.
- The exercises were well-chosen and required the student to understand the concepts at hand.

MATH 102: Calculus II, Fall 2011 (Rice University)



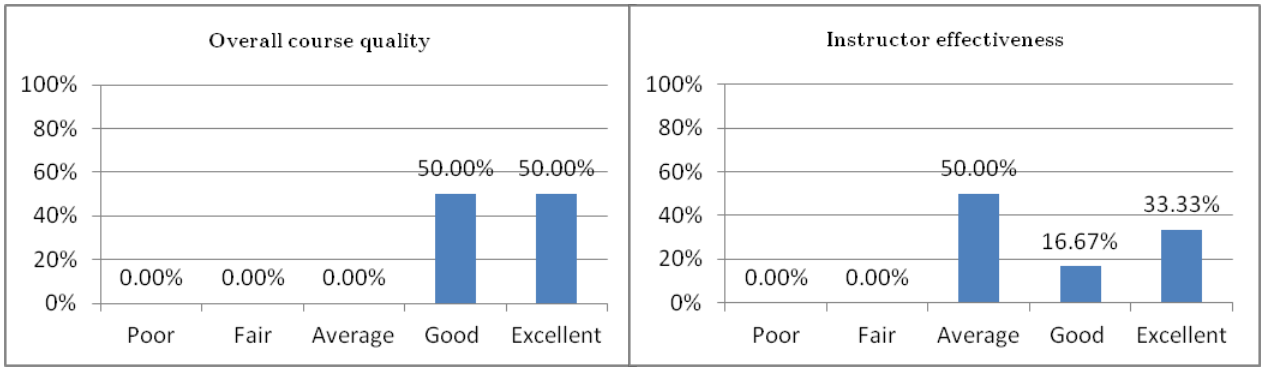
Responses: 23; Enrolled: 22[1].

Selected comments

- I [. . .] consistently felt in class that my views of math as a subject evolved. Every class period involved some further development of fundamental concepts (rather than monotonous practice, the new ideas were nicely blended with the practice).
- Aru is definitely the best teacher I have had at Rice. She explained the theories behind mathematical concepts and then went on to provide varied, useful examples. I wish other classes gave as many examples. For an engineering major, examples and applications of concepts are very important to me, and Aru definitely gave many of those.
- Aru was outstanding. I don't have any complaints whatsoever. When we had problems, she changed her style to accomodate the class. I'm sad I can't take another class with her =[
- Math is also not my favorite subject but she made it seem interesting to me. I do not have a single negative thing to say about Aru. She is one of the best professors I have had in my educational experience.
- Although this class has very difficult material, the Aru's ability to listen to our feedback throughout the semester made it very easy to handle and even enjoyable.
- Everyday, I would be shocked to see how the time had flown by. She is one of the most engaging instructors I have ever had.
- She clearly loves math, and this shows in the form of her math jokes and excitement when teaching. Her interest in it is infectious. Outstanding MATH 102 course with Aru.

[1]Rice freshmen are allowed to drop courses until the last day of the semester. I believe this is why the number of responses is greater than the number of students enrolled i.e. a student turned in evaluations and subsequently dropped the course.

MATH 102: Calculus II, Summer 2011 (Rice University)



Responses: 6; Enrolled: 7.

Selected comments

- Definitely do not change your approach to math and your enthusiasm. It really dictated the attitude of the class, which was a very fun atmosphere to learn in.
- I am very content with the class so far and I have truly started to enjoy doing math again, which is great!

For Rice University courses, responses to the prompts "Overall, I would rate the quality of the course as:" and "Effectiveness: Overall, I feel that the instructor's effectiveness as a teacher was:" have been displayed. Originally the students responded on the scale "1 (Outstanding), 2 (Good), 3 (Average), 2 (Fair), 1 (Poor)".

For Brandeis University courses, responses to the statements "The overall quality of this course was excellent" and "The instructor was effective as a lecturer and/or class leader" have been displayed. Originally the students responded on the scale "1 (Strongly disagree), 2 (Disagree), 3 (Neutral), 4 (Agree), 5 (Strongly Agree)".

Comments are reproduced as they were written including errors. Ellipses have been used to indicate when original comments were part of a longer sentence.

Complete teaching evaluations are available upon request; they are also available at people.brandeis.edu/∼aruray.