Teaching Dossier

Balázs Elek

Contents

1 My Teaching Philosophy

From my experience teaching at both universities such as Cornell University, the University of Toronto and Virginia Commonwealth University and secondary schools such as Ithaca High school, I have drawn the following conclusions:

1. People learn more in active learning classes than in traditional lectures.
2. People learn best in an enviroment where they feel safe to make mistakes and ask questions.
3. Focusing on reasoning rather than answers leads to deeper conceptual understanding.

I want my students to develop real mathematical skills and the ability to construct, analyze and critique arguments. I believe the best way of achieving this is to guide students to their own discoveries.

1.1 Active learning

I started as a teaching assistant during the first years of my graduate school. I did not have any prior teaching experience nor any formal training. At the time, I thought that good teaching was just standing in front of students and presenting the material without making mistakes.

After teaching for a couple semesters, it became clear to me that this approach did not work for the majority of my students. I presented correct and careful solutions to standard problems during the tutorials, and I saw how the students who were nodding along could not solve very similar problems on the exams.

I wanted to become a more effective teacher and I started attending the Teaching Seminar at Cornell. One of the topics that we read papers on and discussed was active learning and I came to believe that people don't become experts by watching someone else perform a task. There is solid evidence that *active learning* is more effective than traditional lecture formats [FEM+14].

I have observed that giving students opportunity to express their ideas during class and in office hours allows them to gain independence and confidence in approaching and solving problems. Letting students explore also helps them develop a *growth mindset*.

In active learning environments, students learn more, but often they feel like they learn less [DMM+19]. For this reason, I like to take time to explain my methodology and emphasize the importance of why we go through certain steps rather than just finding the answer.

In my classes, most of the time is spent on students working on problems. I break down questions into small parts so that students can get started and make gradual progress. Students then share their ideas with their peers in small groups or a whole class discussion. I constantly communicate with the class to make sure that everyone is focused on the current task and is following the discussion.

1.2 Creating a safe learning environment

During my career, I have been able to maintain an atmosphere where students feel safe making mistakes and asking questions. The following comments from my recent course evaluations mean a lot to me:

- *"...I've never asked questions during the classes before this class. I normally just waited until office hour and asked. However, he changed my attitude during the class and made me ask questions during class without any fear of feeling stupid and got to participate more. ..."*

- *"I also really liked how patient and kind you were while explaining and answering questions. It made for a very supportive learning environment. Most math professors fall short of what is required not because of a lack of knowledge of their subject material, or because of an inability to articulate an explanation, but because the manner in which they respond to students is impatient. Making people feel stupid is hardly conducive for their learning. It was remarkable that you never once became impatient..."*

- *"...He is really invested in ensuring that his students can understand the material. He is willing to meet with you outside of class regardless of how simple your question and regardless of your performance of the course. However, more importantly, he really and truly cares about the well-being of his students and does not see us as machines who began his class with the same level of knowledge. Professor Balazs understands that his students are human and that the things that are happening around them and at the colleges and dorms/homes can truly affect them. ..."*

There is a large amount of research suggesting that *productive failure* and *productive struggle* can lead to more effective and deeper learning ([KB12] [Met17]).

There is often a perception that mathematics is overcompetitive and unwelcoming, where people are made to feel stupid for not being quick or lacking some knowledge. I have found that many students, especially those from underrepresented groups, have already internalized aspects of this culture and do not feel that they belong in mathematics classes. As a result, they lack the confidence to participate and ask questions in class. I make an effort to build a more collaborative and supportive environment.

I emphasize the importance of listening to the explanations and opinions of others, and I set an example for this by not cutting students off, and incorporating their ideas whenever possible. I consistently acknowledge the difficulty of the concepts we are considering and I avoid using words like "trivial" or "clear". I emphasize the role of making mistakes in the learning process, and I try to remove the social cost of being wrong by occasionally soliciting "wrong solutions" from students.

I have also found that an anonymous online discussion board like Piazza or Ed discussions can be an effective tool to let those students participate who would otherwise not do so in person.

1.3 Focusing on reasoning

I believe that the skill to construct and analyze arguments is more important than computing quickly and proficiently. Many students identify mathematics with manipulation of symbols, and focus on the rules and techniques of computation. In first-year Calculus classes, incoming students are often proficient at computing difficult derivatives, but lack the conceptual understanding of what their computations mean.

In a class I taught recently, after working on a problem and discussing a solution, a student came forward with a question that was: *"I understand this solution, I tried to do it differently and got the wrong answer. But I don't understand why my solution is wrong."*. I was extremely happy to walk the whole class through this solution, and to discover the mistake together.

While teaching a linear algebra class developed by Jason Siefken at the University of Toronto, I learned that asking students to find a mistake in an argument can be really beneficial for their learning. To encourage this sort of inquiry, I like to write problems that are phrased as fictional students discussing a question. There will be mistakes in their arguments, and the goal is to find and correct these mistakes. I found that this is an effective way of highlighting and dispelling common misconceptions.

2 Remarks about Online learning

I have substantial experience facilitating online learning. The COVID-19 pandemic hit while I was teaching a linear algebra class, and we had to switch to online instruction at very short notice. During the Summer of 2020, I taught the same linear algebra class, and helped to design the course to be fully online.

I believe that in our class, students were able to learn as well as they could have in person. We were able to keep the active learning format despite large (over 200 students) class sizes and the online instruction. We placed a lot of emphasis on student interactions. One example is that students were randomly assigned to groups and were given reading assignments every week where they had to annotate and discuss the book chapters. This led to more students reading and discussing the textbook before class than in the in-person format, even though this was always a formal requirement.

We communicated our expectations clearly and we were also able to maintain a consistent online presence outside class time to help students with various difficulties. Student feedback suggested that they really appreciated this effort, and they felt that their concerns were addressed promptly.

Unfortunately as many other courses, we had to deal with a large amount of academic integrity issues. Tests and examinations were fully online, and the temptation for students to use unautorized aids was large. We designed problems that were less prone to copying, monitored known cheating websites and asked them to take down the questions from our exams. Overall, our exams ended up going better than we initially expected.

3 Conclusion

I have had the opportunity to teach mathematics at many different levels and institutions, and while each course has required me to adapt to new students and circumstances, I make sure to remain approachable and open to students' prior experience and perception of mathemtatics. I take care to engage my students and encourage them to participate and understand the importance of the process of learning, not just for a particular math class, but in their personal development. I have made a point to learn new methods and course aids to include all students in my courses and I look forward to applying all that I have learned about teaching so far in my career to provide a rewarding and positive learning experience for my future students.

4 Teaching experience

4.1 Instructional experience

I have instructional experience in various Calculus and Linear algebra classes, Combinatorics and Complex Analysis at universities such as Cornell and the University of Toronto. During the Summer of 2019 I was the sole instructor for MAT344 Introduction to Combinatorics at the University of Toronto (the course website is here), where I had to oversee many of the administrative aspects that come with managing a large class. I also have substantial experience teaching online, in Summer 2020 I was an instructor for an active learning linear algebra class, held fully online. In Spring 2021, I was the only instructor for MATH1910 Calculus for Engineers at Cornell.

4.2 Course design experience

During my final years of graduate school (2017-2018), the Cornell Mathematics Department transitioned to an active learning approach to Calculus 1. I was an instructor for Calculus 1 during these terms, and I participated in many of the discussions surrounding this transformation. In Summer 2020, also participated in redesigning the standard Linear algebra class at the University of Toronto to be completely online, while maintaining the focus on active learning. In Spring 2021, I developed a large amount of material for the MATH1910 Calculus for Engineers class to make it an active learning oriented class.

4.3 Outreach

A highlight of my teaching experience at Cornell was a course I taught several times at Ithaca High School, known as the Senior Math Seminar. This is an outreach program run jointly by the school and Cornell where graduate students in the math department can design and teach a course on any topic of their choosing to an audience of interested seniors in the school. I chose to teach a course on finite reflection groups (notes for the course can be found here). Working independently on a course was a fantastic opportunity, since I could experience aspects of teaching that a graduate student is not necessarily exposed to, such as developing class plans and materials for an audience with unusual backgrounds, without necessarily having an existing appropriate text to draw from. As always, I put a lot of emphasis to making the lectures engaging and interactive. This made it possible for high school students to succesfully follow material that is not usually covered even in undergraduate math courses.

I also participated in smaller outreach projects organized at Cornell for children as young as 12 years old. One example topic we covered in a program organized at Cornell in partnership with the Johns Hopkins Center for Talented Youth was a very basic introduction to group theory and symmetries using line dancing and the mattress flipping problem. The unique feature of this day-long outrech event is that the parents of the children (ages 10-15) also participate in the activities, but in a different group. We received positive feedback about our module from both the parents and the children.

4.4 Mentoring experience

The Ithaca High School Senior Math Seminar also involves students doing a project with the goal of presenting their findings a few months later, and I mentored several groups each year

I was one of the instructors. This involved coming up with project ideas and meeting the students regularly.

In Spring 2020, I lead a reading course on quiver representations for a fourth-year undergraduate student at the University of Toronto.

5 Sample teaching material

5.1 Sample lecture worksheet

This is an example worksheet for a Calculus class where students are introduced the formula for the arc length of a curve. My goal here was to lead students to gradually discover the formula. The idea of a polygonal approximation is introduced through a concrete example in part (b), and some of the difficulties of finding the length of the approximation are addressed in part (c). Once the students have seen some concrete computation, Exercise 2 leads them through a more abstract setting to the general formula.

MATH 1910 Lecture 16
Arc Length

Exercise 1. Consider the semicirle on Figure 1 Let's pretend that we don't know that the length

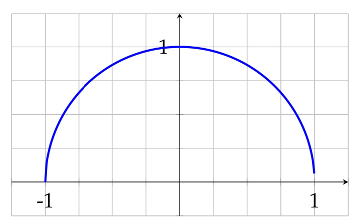

Figure 1: A semicircle

of this arc is π for this exercise.

(a) Write down a function $f(x)$ whose graph is exactly this semicircle.

(b) Let's approximate the length of this arc. Consider the approximation in Figure 2. Compute the length of the red curve.

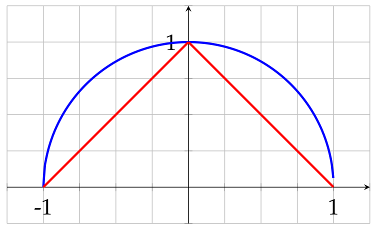

Figure 2: First approximation

(c) To improve the approximation, we increase the number of sample points. Compute the length of the red curve on Figure 3

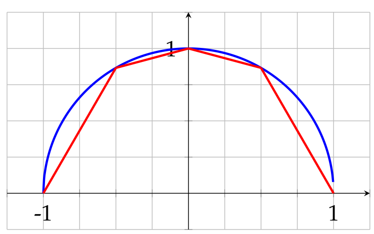

Figure 3: Second approximation

Exercise 2. Consider the approximating line segment on Figure 4. Assume that the blue curve is the graph of the function $f(x)$, and that the two blue circles are at $(x_i, f(x_i))$ and $(x_{i+1}, f(x_{i+1}))$, respectively. Let $\Delta x = x_{i+1} - x_i$ (the length of the green line segment on the figure).

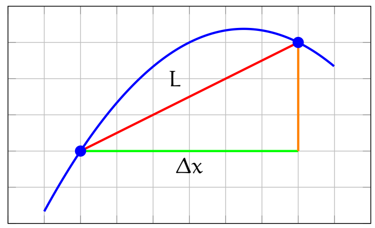

Figure 4: The length of a line segment

(a) How would you express the length of the orange segment?

(b) How can we express the length L of the red line segment?

(c) If f' exists and is continuous, then the Mean value theorem says that there is a value c_i in $[x_i, x_{i+1}]$ such that

$$f(x_{i+1}) - f(x_i) = f'(c_i)(x_{i+1} - x_i) = f'(c_i)\Delta x.$$

Substitute this into the formula for L, can you pull anything out from under the square root?

(d) Let s denote the arc length of $y = f(x)$ over $[a, b]$. Explain the two equalities below:

$$s = \lim_{n\to\infty} \sum_{i=1}^{n} \sqrt{1 + (f'(c_i))^2}\,\Delta x = \int_a^b \sqrt{1 + f'(x)^2}\,dx.$$

5.2 Sample homework question

This is a homework question for a Calculus for Engineers class in Spring 2021. The students were assigned regular WeBWorK assignments where they can develop computational proficiency, and I wanted to complement this with critique-style questions where students have to analyze a given argument and find the mistakes. This is supposed to simulate the in-class student discussions in an active learning classroom. My goal with this question is to highlight a common misunderstanding about manipulating equations involving indefinite integrals.

Problem 1. (8 points) Odysseus and Penelope are trying to compute the indefinite integral

$$\int \frac{1}{x\ln(x)}\,dx.$$

Having just learned integration by parts, they are keen to apply this method. They choose $u = \frac{1}{\ln(x)}$ and $dv = \frac{1}{x}dx$ and they proceed as follows:

(i) Penelope then computes $du = \frac{1}{(\ln(x))^2}\cdot\frac{1}{x}dx$, $v = \ln(x)$.

(ii) Odysseus then writes out the result of the integration by parts formula

$$\int \frac{1}{x\ln(x)}\,dx = \frac{\ln(x)}{\ln(x)} + \int \frac{\ln(x)}{(\ln(x))^2 x}\,dx$$

(iii) Penelope simplifies the righ-hand side to obtain

$$\int \frac{1}{x\ln(x)}\,dx = 1 + \int \frac{1}{\ln(x)x}\,dx$$

(iv) Odysseus then says the following:

We must have made a mistake. We got back the integral that we started with, so we can cancel $\int \frac{1}{x\ln(x)}\,dx$ *from both sides and then we get*

$$0 = 1.$$

(v) Penelope thinks that they must have made a sign mistake somewhere, it happens all the time with integration by parts, so the answer then is probably

$$\int \frac{1}{x\ln(x)}\,dx = 1 - \int \frac{1}{\ln(x)x}\,dx$$

and this would lead to

$$2\int \frac{1}{x\ln(x)}\,dx = 1,$$

therefore

$$\int \frac{1}{x\ln(x)}\,dx = \frac{1}{2},$$

(a) (4 points) Find all the mistakes in Odysseus and Penelope's argument. Make sure to explain in complete sentences any of the conceptual mistakes they made. In particular, what is wrong with the last equation they have? (**Hint:** it isn't just one sign mistake)

(b) (2 points) Find $\int \frac{1}{x\ln(x)}\,dx$. Check that you got the correct answer by differentiating. (**Hint:** you might want to try substitution instead of integration by parts.)

5.3 More sample questions

These are more homework quesitons from the Spring 2021 Calculus for Engineers class. During the final few weeks of the course, students are introduced the formal definition of a limit of a sequence. My goal with these questions was to highlight the importance of interpreting and using definitions very carefully. I designed the modifications to correspond to concepts that the students have encountered before: "the sequence is eventually constant" and "the sequence is bounded", and many of them successfully answered part (c) of these questions.

Problem 1. (6 points) Consider the following modification of the definition of a limit.

Definition 1. *We say that the **lumit** of a sequence* $\{a_n\}$ *is* L *and write*

$$\operatorname*{lum}_{n\to\infty} a_n = L$$

if there exists an $N > 0$ *such that for all* $\varepsilon > 0$,

$$|L - a_n| < \varepsilon$$

for all $n > N$.

For each of the following parts, give a proof or a concrete counterexample.

(a) (2 points) Assume that $\lim_{n\to\infty} a_n = L$. Is $\operatorname{lum}_{n\to\infty} a_n = L$?

(b) (2 points) Assume that $\operatorname{lum}_{n\to\infty} a_n = L$. Is $\lim_{n\to\infty} a_n = L$?

(c) (2 points) An informal way to describe a sequence $\{a_n\}$ with $\lim_{n\to\infty} = L$ is to say:

As n *increases, the values of* a_n *get arbitrarily close to* L.

How would you informally describe a sequence with $\operatorname{lum}_{n\to\infty} a_n = L$?

Problem 2. (6 points) Consider the following modification of the definition of a limit.

Definition 2. *We say that the* ***lamit*** *of a sequence* $\{a_n\}$ *is* L *and write*

$$\operatorname*{lam}_{n\to\infty} a_n = L$$

if there exists an $\varepsilon > 0$ *such that there exists* $N > 0$ *such that*

$$|L - a_n| < \varepsilon$$

for all $n > N$.

For each of the following parts, give a proof or a concrete counterexample.

(a) (2 points) Assume that $\lim_{n\to\infty} a_n = L$. Is $\operatorname{lam}_{n\to\infty} a_n = L$?

(b) (2 points) Assume that $\operatorname{lam}_{n\to\infty} a_n = L$. Is $\lim_{n\to\infty} a_n = L$?

(c) (2 points) An informal way to describe a sequence $\{a_n\}$ with $\lim_{n\to\infty} = L$ is to say:

As n *increases, the values of* a_n *get arbitrarily close to* L.

How would you informally describe a sequence with $\operatorname{lam}_{n\to\infty} a_n = L$?

5.4 Sample outreach material

The lecture notes are from the outreach course on Reflection groups at the Ithaca High School. The audience consists of highly motivated high school students of ages 16-18, but they do not have any background university-level mathematics. I tried to write in a language that they understand, and we did two hands-on examples thoroughly before we got to the definitions. In class, students would walk up to the smartboard and work out the reflections with color.

Exercise 3.7. *Identify the cross-polytopes in Figures 5, 6, and 8.*

Exercise 3.8. *What happens if you dualize the n-simplex?*

Exercise 3.9. *What happens if you dualize the dodecahedron? The icosahedron?*

Exercise 3.10. *Show that dual polytopes have identical symmetry groups.*

So far we have seen three infinite families of regular polytopes: the n-simplices, the n-cubes and their duals, the n-cross-polytopes. But how about the other guys? The dodecahedron, icosahedron, 24-cell, 120-cell and 600-cell? It turns out that it is dimension 4 where their story ends. They have absolutely no analogues in higher dimensions, moreover, from dimensions 5 onwards, the only regular polytopes are the n-simplices, the n-cubes and the n-cross-polytopes. The reason behind this fascinating result is the lack of exceptional finite reflection groups that would serve as these polyotope's symmetry groups.

4 Root systems

We have remarked previously that the reason for the lack of regular polytopes in higher dimensions was the lack of suitable symmetry groups. We are now going to classify finite reflection groups. The way we are going to do this is to find a nice combinatorial gadget that we can associate to a reflection group, and classify those.

4.1 A_2 and B_2

We have defined reflectiong groups to be groups generated by reflections in Euclidean space. However, looking at the examples in Section 2.4, it seems that all the stuff in $\mathbb{R}^n$ is not really necessary to describe our reflection group W. For instance, if we know s sends a vector $\mathbf{v}$ to $-\mathbf{v}$, then s sends every vector on the line through the origin and $\mathbf{v}$ to their negatives. It would be nice if we could think about what W does without concerning ourselves with all of $\mathbb{R}^n$. In particular, it would be great if we could find a *finite* set of vectors in $\mathbb{R}^n$, which are preserved by W, and are sufficient to describe its behavior.

Let's see what we can do with the symmetry group of the regular triangle (a.k.a. S_3, but later we'll call it A_2).

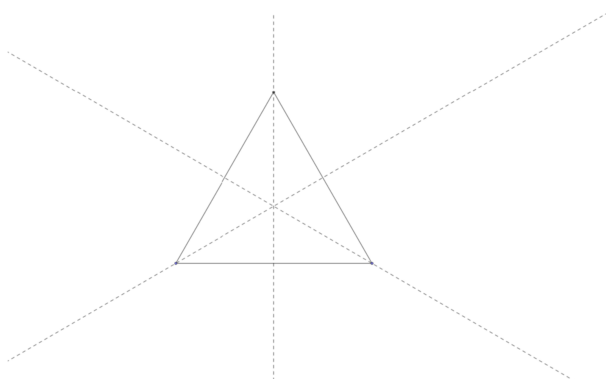

Figure 14: Symmetry lines of the regular triangle

Since any element of S_3 will preserve the triangle, it will also preserve these lines. However, we would like to keep track of the reflections sending certain vectors to their negatives, so let's pick two vectors of equal length that are perpendicular to each line

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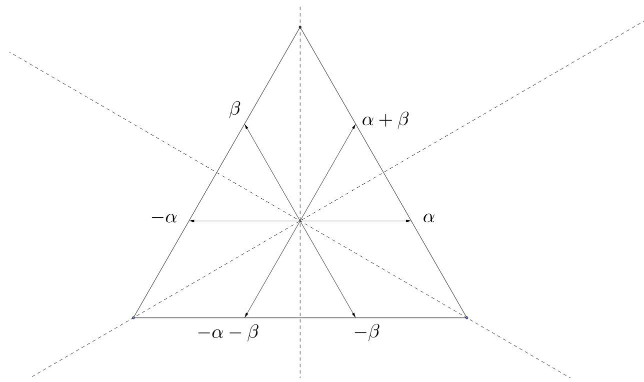


Figure 15: The root system of A_2

Now notice that any reflection along the symmetry lines will permute the set $\{\alpha, \beta, \alpha+\beta, -\alpha, -\beta, -\alpha-\beta\}$. So we have managed to turn this geometric action of a reflection group into combinatorics. We can write down in a table what happens to the roots if we apply elements of A_2 to them.

	α	β	$\alpha+\beta$	$-\alpha$	$-\beta$	$-\alpha-\beta$
e	α	β	$\alpha+\beta$	$-\alpha$	$-\beta$	$-\alpha-\beta$
s_α	$-\alpha$	$\alpha+\beta$	β	α	$-\beta-\alpha$	$-\beta$
s_β	$\alpha+\beta$	$-\beta$	α	$-\alpha-\beta$	β	$-\alpha$
$s_\alpha s_\beta$	β	$-\alpha-\beta$	$-\alpha$	$-\beta$	$\alpha+\beta$	α
$s_\beta s_\alpha$	$-\alpha-\beta$	α	$-\beta$	$\alpha+\beta$	$-\alpha$	β
$s_\alpha s_\beta s_\alpha$	$-\beta$	$-\alpha$	$-\alpha-\beta$	β	α	$\alpha+\beta$

Table 1: The action of A_2 on its root system

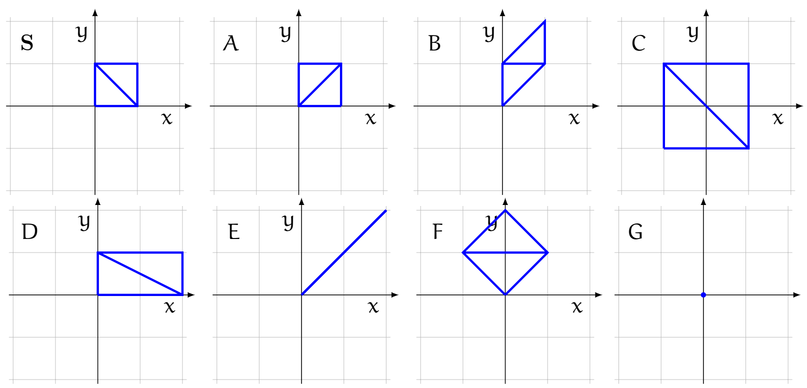
Exercise 4.1. *If someone covers the first column of Table 1, how would you try to identify which rows correspond to reflections and which to rotations?*

Let's try to replicate this for the symmetry group of the square (which later will be known as B_2).

5.5 An exam question

This is a question I wrote for the final exam of the Summer 2020 class MAT223 Linear Algebra at the University of Toronto, which was held fully online, and we had significant trouble with cheating websites such as Chegg during the term. My goal with this question was twofold: to reduce or prevent cheating, and to focus on the conceptual understanding and reasoning rather than computation. I have received positive feedback from teaching experts concerning this question, and students also enjoyed solving it.

Out of pure interest a student uploads some of the pictures from our Quiz 2 to Chegg:



(note: some of the labels have changed from Quiz 2) and asked: Here S is a picture of a set and A − G are images of the set under some transformation. For each of these transformations, find all possible eigenvalues and eigenvectors. Since Chegg pays their workers per answer, they are incentivized to answer as many questions as they can during a given time.

The exploited Chegg worker had the following quick thoughts about each picture before having to move on to solve another student's Calculus exam for them while wondering about how much profit Chegg will be making in this exam period:

(A) This looks like a rotation, so it shouldn't have real eigenvalues. Or maybe it's a reflection? I'll just say something like "rotations must have complex eigenvalues, so they can't have real ones". *This sounds very knowledgeable, and if the student is asking this question on Chegg they won't check what I say anyway.*

(B) This is a tilting, so nothing is being stretched here, no eigenvalues. *Just like the tilt that the instructors will feel when they see this question appear on Chegg.*

(C) Finally an easy one, clearly everything is scaled up by a factor of two, so everything is an eigenvector with eigenvalue 2.

(D) Any vector on the x-axis is an eigenvector with eigenvalue 2. *This means a stretch by a factor of two, just like the speed of the course whose final exam this is an actual question on.*

(E) This is a projection, so it's not invertible and therefore it can't have eigenvalues. *Just like you can't learn effectively by copying solutions someone else wrote.*

(F) We can see that the diagonal line in the original square has been scaled up by a factor of $\sqrt{2}$, so any vector on it is an eigenvector with eigenvalue $\sqrt{2}$.

(G) This transformation sends everything to zero. *Just like what happens to students' knowledge when they ask exam questions on Chegg.* Since only nonzero vectors can be eigenvectors, this does not have eigenvectors at all.

Point out **all** the mistakes in the Chegg worker's arguments using **at most two** sentences each (2 points for each picture). **Ignore** everything that is in italicized font.

6 Teaching evaluations

Research shows that student evaluations of learning are correlated with factors such as gender, race and appearance, but not strongly correlated with actual learning. Therefore, I mostly focus on the student comments and their evaluations of the other aspects of course, such as approachability and organizational aspects of the course.

I tend to get comments that students feel that I am a patient and approachable, and that they feel comfortable asking questions and generally participating in my classes. Students also feel that they get a lot out of my office hours.

One area that I would like to improve in is establishing student buy-in for active learning. Generally speaking students are very comfortable with traditional lecture formats and they often feel that any form of struggle during class is unproductive. I have some activities that I use to convince students that active learning is the best way for them to learn, but I sometimes feel like I should be doing more.

6.1 Complete evaluation history

Below is a selected list of my recent student evaluations, full evaluations are available upon request

13. If you have any comments about the instructor, please include them here.

13234. Best math instructor I have had thus far.

12180. Balazs Elek is the best instructor I've had at Cornell so far, by far as well. He does a great job of engaging with the class during lecture, even with the zoom / COVID situation, by asking questions and confirming that nobody is overly confused with the material at hand. His office hours are extremely helpful as well; I went to his office hours almost every time they were held. From homework help to practice exam questions, Balazs' office hours provide the best support. Three adjectives to describe Balazs: enthusiastic, helpful, empathetic. After my fall semester math class being such a disaster and my high school math classes being lackluster, Balazs made me love and appreciate math again.

13147. Very helpful. I dont really think I do well but he still inspires me to try to understand and not give up. Breaks down difficult concepts to aid my understanding

18255. Sometimes the instructor got lost on the explanations which made it a little bit harder to understand the subject.

30045. Professor Balazs was wonderful, caring, and an overall very helpful and considerate instructor. He taught the material that would be tested on the exams and was very helpful during office hours. I will surely miss his instruction.

18207. The professor had a different style of teaching than most of the instructors that I have seen at this college so far. He is really invested in ensuring that his students can understand the material. He is willing to meet with you outside of class regardless of how simple your question and regardless of your performance of the course. However, more importantly, he really and truly cares about the well-being of his students and does not see us as machines who began his class with the same level of knowledge. Professor Balazs understands that his students are human and that the things that are happening around them and at the colleges and dorms/homes can truly affect them. Not only is he willing to listen to his students, but he is more than willing to be accommodating, and I am so very thankful for him. I am thankful for his considerate heart and his continuous support and guide with various study techniques and tips.

5208. He was very approachable and considerate of our difficult circumstances this semester. I have never felt overwhelmed by this class though it is still challenging as math classes should be.

14. Please comment on any other aspect of this course, including the lecture, textbook(s), homework, exams, course content, etc. Would you recommend this course to a friend?

(No comments about the instructor in this box, please.)

13234. I would recommend this course to a friend.

12180. I would definitely recommend this course to a friend. The exams are a little bit harder than they should be, but not to the point where they're super unfair or anything.

18255. The material that the professor prepared for the class were very high quality. They were very well prepared and definitely allowed me to better comprehend each subject.

5208. I would definitely recommend this course to a friend if they needed it. Based on this class I would suggest that people take the engineering math courses over other math classes. I took MATH 1110 last semester and did not feel like I could get the help or attention I needed. The staff seemed to be more concerned with not making our grades too high than our actual learning experience.

Course Name: Linear Algebra I MAT223H1-F-LEC0201
Division: ARTSC
Session: F
Session Codes: F = First/Fall, S = Second/Winter

Instructor: Balazs Elek
Section: LEC0201

Report Generation Date: July 8, 2020

Raters	Students
Responded	32
Invited	125

Section 1: Course Evaluation Overview

Part A. Core Institutional Items

Scale: 1 - Not At All 2 - Somewhat 3 - Moderately 4 - Mostly 5 - A Great Deal

Question	Summary	
	Mean	Median
I found the course intellectually stimulating.	4.1	4.0
The course provided me with a deeper understanding of the subject matter.	4.2	4.0
The instructor (Balazs Elek) created an atmosphere that was conducive to my learning.	4.4	5.0
Course projects, assignments, tests, and/or exams improved my understanding of the course material.	4.1	4.0
Course projects, assignments, tests and/or exams provided opportunity for me to demonstrate an understanding of the course material.	3.7	4.0
Institutional Composite Mean	4.1	-

Scale: 1 - Poor 2 - Fair 3 - Good 4 - Very Good 5 - Excellent

Question	Summary	
	Mean	Median
Overall, the quality of my learning experience in this course was:	3.8	4.0

7. Please comment on the overall quality of the instruction in this course.

Comments
For an online course, the quality of lectures were very good and aided in my understanding of the concepts by forcing me to apply knowledge that I learned prior to the class. However, I found many of the extra videos tedious and hard to get through, especially the ones that were 30–50 minutes in length.
I am so impressed with the way this course was delivered in an online format and actually feel that I got a better education as a result of the course being online. Professor Balaz did a great job at interacting with the students online and answering questions in a respectful and clear way. I really enjoyed the structure of lecture!
I enjoy this online course. The quality of the notes isn't as good nor organized. This is mainly down to the software we're using. I don't particularly enjoy Zoom but then again there isn't a better app at the moment.
Professor Belaz explained steps to solve questions well. He uses technical tools to show 3D space to us and uses that to help us understand the concepts better, which is really useful and helpful!
good
instruction was not great, there was not much instruction at all, all class time was used for group discussions instead of instruction from the professor, the instructions that were given in class were technical and computational that were very different from the explanation questions given on the tests and did not help to prepare us for the tests in any way, it was very unfair for the all the questions on all the tests to be explanation questions!
Very good quality.
The course is well structured and the objectives are very clear.
The overall quality of the instruction in this course was excellent and accomodating to the way we learn. For example, when we had questions, I had many opportunities to ask those questions during lectures.
Pretty good, but tests and quizzes are bit hard
While I was skeptical of the perusall assignments at the start of the course, the assignments were very helpful in actually learning the material of the course, not only because one could ask questions but in order to make thoughtful and useful comments, one really had understand the material fully and be able to think back and connect it previous problems. So the assignments encouraged the sort of deeper learning which I found helpful. I liked that while class time was all questions, all the questions helped discover links between the concepts. Overall, the quality and style of teaching was very conducive to learning. Also the course was well organized, which is always nice. And, when there was a change in schedule, they were very open about it and was not made harder on the student.
great
Prof. Elek excels at explaining concepts in a lucid manner. He is also extremely kind when he has to repeat something, or explain something again, as was often the case. He always stayed after class time to answer questions, and he never became impatient with anybody, although there were many extremely inane inquiries posed by people who had come to class without having understood the reading. He facilitated an excellent atmosphere in which to learn. I also appreciated that he had the good sense to give us a twenty–minute break in between, because a three hour class is more than most people can take.
The instruction is alright. But the tests and the exams are too difficult.
Tests/exam questions wordings are hard to understand
Well–around and accurate
The instruction was really good. The instructor and the TAs explained the material well.
Great Instructor! Assumed no base knowledge and taught everything from ground root levels!
Average
I like the instruction but I felt that we could have gone a bit faster on certain topics that i felt most people understood and only a few didn't
he accepted the advice from students to enhance the quality of lecture like give the answer of polls that was good, but the quality of his course needs to be improved, he can't explain a question that well and didn't go deep of the definition I believe the time of the lecture is a part of the reason but the way he explains a question should be more clear, instead of assuming most of us know the how to solve some kind of problems.

8. Please comment on any assistance that was available to support your learning in this course.

Comments
I did not participate in office hours but Prof Elek provided assistance by spending extra time after class to answer some of my questions which I found very helpful.
Piazza was always available to us and was very useful. As well because of the way we did textbook readings, we were able to ask questions about the readings and have other students answer. Additionally, Professor Balaz was always available for office hours (however I did not attend).
Office hours are absolutely amazing for this course. There are so many options to choose from and I benefited significantly from them. I suppose this virtual office hour works better than in person office hour given how convenience it is.
Pizza is definitely a good tool for learning. Instructors and TA generally reply to our questions very quickly.
good
office hours with professors and tas
Very helpful
Amazing TAs, breakout sections and annotations are helpful strategies.
I appreciated that there was help in the Math Help Center for the course.
There was a lot of extra worksheets and tutorial questions which was provided which was helpful. Piazza was there, and the professors responded quickly and helpfully. I knew there were office hours but I didn't go to them, but they were well advertised. The professor always stayed a bit after lectures which was helpful. Overall, while I didn't make full use of assistance in this course, I always knew that it was there and where to look.
office hour
N/A
Office hours, piazza
Office hours and talks required by students after the lectures
The office hours were really helpful.
There were plenty of office hours and quick responses on piazza

Part B. Divisional Items

Scale: 1 - Not At All 2 - Somewhat 3 - Moderately 4 - Mostly 5 - A Great Deal

Question	Summary	
	Mean	Median
FAS001 The instructor (Balazs Elek) generated enthusiasm for learning in the course.	4.6	5.0

Scale: 1 - Very Light 2 - Light 3 - Average 4 - Heavy 5 - Very Heavy

Question	Summary	
	Mean	Median
FAS002 Compared to other courses, the workload for this course was…	3.9	4.0

Scale: 1 - Not At All 2 - Somewhat 3 - Moderately 4 - Mostly 5 - Strongly

Question	Summary	
	Mean	Median
FAS003 I would recommend this course to other students.	3.9	4.0

Part C: Departmental Items

Scale: 1 - Not At All 2 - Somewhat 3 - Moderately 4 - Mostly 5 - A Great Deal

Question	Summary	
	Mean	Median
The course instructor (Balazs Elek) explained concepts clearly.	4.3	4.0

Scale: 1 - Not At All 2 - Somewhat 3 - Moderately 4 - Mostly 5 - A Great Deal

Question	Summary	
	Mean	Median
The course instructor (Balazs Elek) was approachable.	4.6	5.0

Scale: 1 - Not At All 2 - Somewhat 3 - Moderately 4 - Mostly 5 - A Great Deal

Question	Summary	
	Mean	Median
The course instructor (Balazs Elek) answered questions clearly.	4.3	5.0

Scale: 1 - Poor 2 - Fair 3 - Good 4 - Very Good 5 - Excellent

Question	Summary	
	Mean	Median
UNIT(OQI) Overall, the quality of instruction provided by (Balazs Elek) in this course was:	4.3	5.0

Course Name: Intro Combinatorics MAT344H1-F-LEC0201
Division: ARTSC
Session: F
Session Codes: F = First/Fall, S = Second/Winter

Instructor: Balazs Elek
Section: LEC0201
Report Generation Date: January 21, 2020

Raters	Students
Responded	34
Invited	77

Section 1: Course Evaluation Overview

Part A. Core Institutional Items

Scale: 1 - Not At All 2 - Somewhat 3 - Moderately 4 - Mostly 5 - A Great Deal

Question	Summary	
	Mean	Median
I found the course intellectually stimulating.	4.1	4.0
The course provided me with a deeper understanding of the subject matter.	4.1	4.0
The instructor (Balazs Elek) created an atmosphere that was conducive to my learning.	4.2	5.0
Course projects, assignments, tests, and/or exams improved my understanding of the course material.	4.2	4.0
Course projects, assignments, tests and/or exams provided opportunity for me to demonstrate an understanding of the course material.	4.2	4.0
Institutional Composite Mean	4.1	-

Scale: 1 - Poor 2 - Fair 3 - Good 4 - Very Good 5 - Excellent

Question	Summary	
	Mean	Median
Overall, the quality of my learning experience in this course was:	4.0	4.0

7. Please comment on the overall quality of the instruction in this course.

Comments
very good
Course was pretty good in general, but it was v slow on the beginning with the basic content, and pretty fast in the end with the hard content
Good lectures
He's very helpful, appreciates (and stimulates) questions, open to office hours. Overall, excellent, highly recommended.
Prof Elek is super nice and does really take the responsibility seriously. Super kindful
The instruction is clear and interesting, but it was a little confusing for students had no experience in problems involves probabilities in the beginning.
Intuitive lectures, well explained
It's just a well run, organized course on cool material. I have zero complaints. This is not an empty compliment, I usually have many complaints. But good work on this one. It was fun.
Henry and Balaz are both very good instructors. notes are very clear and good for review. Course content is not only interesting but also requires many practice. So really a good course.
good
It was moderate in all senses. Although the class is really hard I think the instructors and TAs helped us good
Great instructor, explained concepts in depth and elaborated/clarified on any points that were unclear.
The class went pretty well and gain a lot of knowledge from it.
My professor was very nice and he prepared lectures very well. He was also very generous and kind to give us help and support. I enjoyed this course a lot.
Material was presented very clearly and room was left for thinking and attempting solutions. Course notes were very high quality, very easy to read, and contained many examples.
good
Great
This has been one of the best courses I've taken at UofT! I have loved the content of the course but also the instruction in this course has been incredible. Prof. Balazs is an excellent lecturer and his explanations in class are very helpful. His office hours as well are very informative. What I am most impressed by is the speed at which questions are answered on Piazza. More often than not, questions are answered within 1hr of them being posted which is record time for any Math/CS course I have taken at UofT to date. Course notes are comprehensive, Prof. Balazs is very approachable and kind, problem sets and the midterm have all been fair. Prof. Balazs might be the most friendly math instructor at UofT I have to date and for that, I thank him very much. The only criticism I have would be that at times Prof Balazs can be a bit disorganized in his lectures with what he writes on the chalkboard and explains. But even then, if anyone has a question, he is always more than willing to explain further which makes up for any disorganization.
Elek was very personable and provided a good, fun learning environment. He was, at times, quite disorganized however and seemed unprepared for the lecture which was frustrating.
I cannot understand this course well, especially meet new questions, maybe the reason is that the course is difficult. Tough life......

8. Please comment on any assistance that was available to support your learning in this course.

Comments
maybe post problem set answer after due
Great ta, Monday 1 pm section
Piazza was extremely helpful, it should be mandatory in every course. I'd suggest anonymous questions even to Professors, because I feel worse knowing my Professors will read my questions and might think it's stupid.
Office hour really helps alot
I really love all the notes post on course webpages, it helped me a lot.
Very quick responses to questions
Piazza was a MAJOR help (besides office hours).
problem sets helps a lot for practice after class. TA is great and answer questions with patience,
good
I liked the tutorials but it would be better if the pace in tutorial is faster so we can actually finish answering them in class
Prepare more for the class, organize the teaching material more.
Problem sets were very helpful with understanding the course materials. There were lots of office hours and my professor even spent extra time to answer our questions.
Great
The instructor's collective use of Piazza in this course has been incredible. The amount of support for Piazza has been incredible! My TA has likewise been very approachable and always willing to help with any questions I may have had. The approachability and friendliness of the instructors of this course is also very very high and much appreciated. The course notes were also very helpful.
Elek's office hours were very helpful and he was extremely welcoming.
No assignments answers.

Part B. Divisional Items

Scale: 1 - Not At All 2 - Somewhat 3 - Moderately 4 - Mostly 5 - A Great Deal

Question	Summary	
	Mean	Median
FAS001 The instructor (Balazs Elek) generated enthusiasm for learning in the course.	4.4	5.0

Scale: 1 - Very Light 2 - Light 3 - Average 4 - Heavy 5 - Very Heavy

Question	Summary	
	Mean	Median
FAS002 Compared to other courses, the workload for this course was…	3.8	4.0

Scale: 1 - Not At All 2 - Somewhat 3 - Moderately 4 - Mostly 5 - Strongly

Question	Summary	
	Mean	Median
FAS003 I would recommend this course to other students.	4.0	4.0

Part C: Departmental Items

Scale: 1 - Not At All 2 - Somewhat 3 - Moderately 4 - Mostly 5 - A Great Deal

Question	Summary	
	Mean	Median
The course instructor (Balazs Elek) explained concepts clearly.	3.9	4.0

Scale: 1 - Not At All 2 - Somewhat 3 - Moderately 4 - Mostly 5 - A Great Deal

Question	Summary	
	Mean	Median
The course instructor (Balazs Elek) was approachable.	4.4	5.0

Scale: 1 - Not At All 2 - Somewhat 3 - Moderately 4 - Mostly 5 - A Great Deal

Question	Summary	
	Mean	Median
The course instructor (Balazs Elek) answered questions clearly.	4.2	4.0

Scale: 1 - Poor 2 - Fair 3 - Good 4 - Very Good 5 - Excellent

Question	Summary	
	Mean	Median
UNIT(OQI) Overall, the quality of instruction provided by (Balazs Elek) in this course was:	4.1	4.0

Cornell University
Course Evaluation Response Summary
Semester: Spring 2018 Course Owner: MATH
Course: MATH 1110 LEC 001 CID: 5651
Title: Calculus I
Instructor: Elek
9 Responses, 13 Enrolled, 69.23% Response

Question	Mean	StDevP	Count	1	2	3	4	5	6
1. Did the lecturer stimulate your interest in the subject? [L1] 1 = not at all 5 = stimulated great interest; inspired independent effort	4.11	0.73	9	0	0	2	4	3	
2. Was the lecture presentation organized and clear? [L2] 1 = disorganized and unclear 5 = very organized and lucid	4.33	0.66	9	0	0	1	4	4	
3. Was the lecturer willing and available to help you overcome difficulties in this course? [L3] 1 = was of no help 5 = was very helpful	5.00	0	9	0	0	0	0	9	
4. Rate the overall teaching effectiveness of your lecturer compared to others at Cornell. [L4] 1 = worse than average 5 = much better than average	4.56	0.49	9	0	0	0	4	5	
5. Was the homework returned in a timely manner? [G1] 1 = never 5 = always	4.56	0.68	9	0	0	1	2	6	
6. Were the grader's comments helpful? [G2] 1 = no help 5 = very helpful	3.56	1.16	9	1	0	3	3	2	
7. How valuable were the homework assignments? [C1] 1 = taught me little 5 = extremely educational	3.89	1.09	9	1	0	0	6	2	
8. Rate the examinations in this course as a test of your knowledge. [C2] 1 = too easy, not adequate 3 = adequate 5 = too difficult, not a fair test	3.78	0.78	9	0	0	4	3	2	
9. Rate the level of difficulty of this course. [C3] 1 = too easy 5 = much too hard	4.25	0.96	8	0	1	0	3	4	
10. How suitable was the textbook? [C4] 1 = lousy 5 = great	3.78	0.78	9	0	0	4	3	2	
11. How many hours each week (on the average) did you spend on this course outside of class? [C5] 1 = 0-4 hours 2 = 5-7 hours 3 = 8-10 hours 4 = 11-13 hours 5 = 14 hours or more	2.89	1.28	9	2	1	3	2	1	
12. What was your most important reason for taking this course? [C6] (Use the answer that is closest to correct.) 1 = field or major requires it 2 = prerequisite for further courses 3 = interest in the subject matter 4 = reputation of the course 5 = reputation of the instructor 6 = distribution requirement	1.67	1.56	9	7	1	0	0	0	1
13. Have you attended homework study sessions this term? 1 = Yes, I attended often. 2 = Yes, I attended occasionally. 3 = Yes, I attended once or twice. 4 = No, I chose not to attend. (Please explain your reasons for not attending in the second comment space below.)	3.11	1.19	9	2	0	2	5		

16. If you have any comments about the instructor, please include them here.

398. He was really a master at the subject material. Although lecture was disorganized and I could tell we had to rush through a few things he was very good at explaining complex topics. I really enjoyed class with my instructor.

25522. Explained things well, he made the class feel pretty low pressure which was nice

22032. Very helpful, nice, and encouraging.

8151. Very good and wasn't boring.

8165. Balasz was a great instructor, really glad I had him. Just a very nice and patient guy.

28909. Sometimes ran out of time to go over worksheets in class

11546. Balazs was a very good instructor. He always made sure that we understood the subject material and he always explained concepts in multiple different ways so that we'd understand them. He was also very nice and accessible during office hours

7 References

[DMM+19] Louis Deslauriers, Logan S. McCarty, Kelly Miller, Kristina Callaghan, and Greg Kestin. Measuring actual learning versus feeling of learning in response to being actively engaged in the classroom. *Proceedings of the National Academy of Sciences*, 116(39):19251–19257, 2019. 2

[FEM+14] Scott Freeman, Sarah L. Eddy, Miles McDonough, Michelle K. Smith, Nnadozie Okoroafor, Hannah Jordt, and Mary Pat Wenderoth. Active learning increases student performance in science, engineering, and mathematics. *Proceedings of the National Academy of Sciences*, 111(23):8410–8415, 2014. 2

[KB12] Manu Kapur and Katerine Bielaczyc. Designing for productive failure. *Journal of the Learning Sciences*, 21(1):45–83, 2012. 3

[Met17] Janet Metcalfe. Learning from errors. *Annual Review of Psychology*, 68(1):465–489, 2017. PMID: 27648988. 3