Christopher Keyes
Teaching Statement

christopher.keyes@kcl.ac.uk
https://c-keyes.github.io/

Overview

My goal in communicating mathematics is to make it accessible and relatable to students. Math should resonate with their experiences and feel relevant to their lives. To achieve this, I prioritize active learning, incorporate diverse and meaningful examples, and bring genuine enthusiasm into every lesson. This approach has been shaped by my experience as an instructor of record for two semesters of *Calculus I* at Emory University and for an advanced graduate topics course in *Arithmetic Statistics* through the London Taught Course Consortium. My philosophy has also been informed by my activities outside the classroom, as a *Math Circle* instructor in the Atlanta community and as a founding organizer of Emory's *Directed Reading Program*. The latter underscore my commitment to inclusive excellence; I have taken steps to ensure that they are both accessible to and *actually serving* students from groups historically underrepresented in mathematics.

In the classroom

I incorporate **active learning techniques** as a key part of my instructional style. In a typical lesson, I like to alternate between modeling problem solving at the board and active components, namely independent and group work followed by a discussion of the students' solutions and the challenges they faced. This approach allows students to receive rapid feedback from myself and each other, helping them identify what they should be focusing on when working outside of class.

When courses moved online in response to the Covid-19 pandemic, I transitioned my approach to the virtual classroom. During this time, I experimented with different virtual features and solicited **student feedback** to determine what was most effective. Mid- and end-of-semester surveys revealed that Zoom's breakout rooms were polarizing; some students found them highly effective, while others rated them least effective. Moving forward, I was more thoughtful and selective about how I used this feature. The poll functionality, on the other hand, proved universally popular. We all appreciated the instant feedback offered by these anonymous formative assessments, so I made them a regular feature in our sessions. While I am not eager to return to the uncertain times of the pandemic, having to adapt in response to student needs made me a more effective instructor.

Essential to my teaching style are **thoughtfully chosen examples**. When selecting problems to work out in class and crafting worksheets, I deliberately choose a diverse selection of topics and problem types in order to maximize the ability for each student to relate to the content. I also consider that my students may have a different background than mine or one another, and aim to avoid problems that assume specific contextual knowledge that students may lack. For one calculus lesson on viewing the derivative as a function, I presented a topic relevant to all college students: tuition costs. From an exponential model, built from historical Emory tuition data, I asked students to compute and reason with the derivative. I then had them brainstorm further examples on their own and share them with the class, offering an opportunity for them to take ownership of their own examples, while adding to my ever-expanding list to present to future students.

My view that mathematics can and should be accessible to everyone manifests in my enthusiastic teaching style. Especially at the entry undergraduate level, I want to exemplify to my students that math can be as exciting and joyful as it can be useful. This extends beyond classroom demeanor, to making myself available outside of class for one-on-one discussion and conversation, where I learn more about their individual motivations and background, tailoring my strategy accordingly. I received some of my highest average marks for enthusiasm and accessibility outside of class in end-of-semester student evaluations: for Calculus I in Fall 2020[1] and Spring 2021,[2] I received **8.26 out of 9 for enthusiasm** and **8.39 out of 9 for accessibility for individual discussion** (averaging over 44 student responses); see also the student comments included below. Along with the full evaluations, sample materials including lesson plans[3], quizzes[4], and selected recordings[5] are available at the links below.

[1] Fall 2020 Math 111 (Calculus I) evaluations: https://c-keyes.github.io/files/Keyes_F20_evals.pdf
[2] Spring 2021 Math 111 (Calculus I) evaluations: https://c-keyes.github.io/files/Keyes_S21_evals.pdf
[3] Lesson plan on *the chain rule*: https://c-keyes.github.io/files/Keyes_S21_chain_rule.pdf
[4] Quiz on *limits and IVT*: https://c-keyes.github.io/files/Keyes_S21_samplequiz.pdf
[5] Asynchronous module on *limits at infinity*: https://bit.ly/Keyes_module9

Graduate courses. In Spring 2025, I developed a short (5 two hour lectures) graduate course on Arithmetic Statistics for the London Taught Course Consortium, which was offered to a broad audience of PhD students in number theory and geometry. Indeed, the students who enrolled had a range of backgrounds, particularly in their command of analytic techniques. To keep the course accessible, I focused on key examples, such as counting squarefree numbers, which demonstrate the core techniques we would actually use later in the course. At the same time, I used the assigned exercises to invite students to expand their background knowledge and explore related research areas. Course notes[6] and exercises[7] are available on my website.

Math Circle Influence

My outreach experience as a **math circle instructor** at Emory has also shaped my approach to teaching. Over eight semesters spanning Fall 2018 – Spring 2023, I served a total of more than 200 middle and high school students, developing and leading biweekly math exploration activities with my class, and assisting other instructors with their sessions. In 2022, I also co-organized a Julia Robinson Math Festival. For this one day event, attended by about 150 students and families from the Atlanta community, I worked to select and prepare engaging activities, then recruited and trained 15 volunteers to lead them. These programs were offered free of charge, to facilitate the participation of students of all socioeconomic backgrounds.

A major challenge when designing a lesson for this audience is the variability in abilities and prior knowledge possessed by the students. In a given class, we might have a student trying math circle for the first time alongside one who excels in math competitions and has already had exposure to algebra and trigonometry at school. To make sure my lesson is maximally impactful for both of those students, I strive to include multiple "jumping in" and "jumping off" points. That is, I shape the lesson so that a student with minimal experience could get started and make meaningful progress, while a more experienced student will stay engaged throughout the lesson and be challenged by plenty of follow up questions.

One of my favorite lessons I developed for high school math circle students is based on the TV game show *Press Your Luck*.[8] The lesson begins with students playing a toy version of the game in small groups with dice, to get a feel for the rules and start building some intuition about strategy. Then, students worked on a worksheet with questions getting at some of the basic probability principles behind the game. For some students this proved a sufficient challenge, and I was happy to see them come out of the lesson understanding that the likelihood of something happening *at least once* is complementary to it *never happening at all*. For the others, we encouraged them to go further, for example by considering how to calculate the expected value of each roll when the outcomes depend on the player's starting conditions. Students then used their answer to to devise an optimal strategy for the game and investigated how rule changes would impact their strategies. I particularly enjoyed this lesson, because it exemplifies the active participation and accessibility for a variety of backgrounds that I incorporate in both my math circle sessions[9] and undergraduate classes.

Students, their parents, and the community benefit from the math circle approach to mathematics, which differs from that in a typical classroom environment. Rather than focusing on standards or proficiency, we aim to cultivate students' curiosity through inquiry, collaboration, and fun. Beyond the lessons themselves, access to a PhD student instructor provides a role model and contact for young students interested in math, many of whom lack such a figure who can share in its joys. In my years of involvement with this program, I have helped to connect several students to summer programs such as Georgia's Governor's Honors Program, math competition opportunities, and universities where they have furthered their mathematical exploration.

Directed reading and mentorship

In Spring 2021, I founded a Directed Reading Program (DRP) at Emory University, which brings undergraduate students together with graduate mentors to learn an advanced topic. Beyond offering an opportunity to study a topic not typically found as a traditional course, we provided students —— including and especially those underrepresented in the mathematical community —— with a window into the experience of a PhD student, while cultivating a mentor-mentee relationship between them and their supervising graduate student. From the program's founding to my graduation in 2023, we had 16 PhD students mentor a total

[6] Arithmetic statistics course notes: https://c-keyes.github.io/files/ArithStatsLTCC_notes.pdf
[7] Arithmetic statistics problem sheets: https://c-keyes.github.io/files/ArithStatsLTCC_exercises.pdf
[8] *Press Your Luck* Math Circle lesson plan: https://c-keyes.github.io/mc_press_your_luck.html
[9] Another Math Circle lesson plan on the *Kakeya problem*: https://c-keyes.github.io/mc_kakeya.html

of 45 undergraduate students through the program. I personally worked with a total of 9 students on topics including p-adic numbers, elliptic curves, and sports analytics. Since my departure from Emory, the program has become a fixture of the department and continues to flourish.

My favorite part about mentoring a student in a DRP is the level of **personalized guidance** I can provide — the entire course can be shaped to the interests of the student. No more is this exemplified than by Ezra, a student who reached out to the DRP wishing to study *sports analytics*. While I had little prior experience with the topic, Ezra and I found that we shared a lifelong interest in baseball and a desire to understand the inner workings of the game. I found an open access university course covering the basics of expected run values and team winning percentage estimators to get us started. It also covered technical skills like SQL database management that would help to make Ezra more competitive in this field. This experience spurred my own interest in the mathematics of baseball, leading me to write several expository and investigative blog posts on the subject.[10] I envision using this experience to develop and teach a course on sabermetrics, intended to serve as an introduction to the applicability of mathematics to everyday life.

While serving as the director of this program, my responsibilities included recruiting graduate student mentors, designing the application process, advertising the program, reviewing and selecting applications, and coordinating an end-of-semester event featuring student presentations. In carrying out these duties, I initiated changes in an effort to make our DRP more inclusive. The most substantial was a shift from having small group reading courses to a focus on **one-on-one mentorship** in Spring 2022. In my first two DRPs, I worked with small groups of 3-4 students, and while this allowed us to work with more students, it came with drawbacks. The atmosphere was too similar to that of a typical class, with students often deferring to me or to their classmates rather than taking initiative themselves. After discussing with fellow mentors, consulting DRP leaders at other universities, and seeking guidance from national organizations such as the DRP Network, we opted to make the shift to a one-on-one format; part of our aim was to promote an environment in which underrepresented students would not be marginalized and could forge a stronger relationship with their mentor.

The application process is another place where we made efforts to enhance the inclusivity of the program. While we do ask students to list their courses taken in order to help get an idea of their background and better match them to a mentor, there are no strict course or grade requirements to participate. Undergraduate participants were primarily selected by the availability of graduate student mentors for their topic(s) of interest, as well as their responses to **open-ended questions** such as "what do you hope to gain from the DRP?" These questions are designed to reward students who express their curiosity and desire to grow through the program, rather than those who merely list their accolades and tout high grades. Both of these changes were met with positive feedback from students and mentors on our end-of-semester surveys.

Future goals

I am eager to expand my teaching portfolio and to broaden the range of courses I offer. In teaching courses such as Calculus and Linear Algebra, I enjoy connecting with students from a wide range of majors and interests and making mathematics accessible to them. I also look forward to teaching core math major courses, such as Proofs or Abstract Algebra, where I will further encourage students to explore their mathematical curiosity. I am excited for opportunities to develop new topics courses, including by expanding and modifying my existing notes on Arithmetic Statistics to suit either an advanced undergraduate or early graduate student audience. Another ambition is to lead an introductory course on baseball statistics; such a course illustrating real-world applications of basic statistical methods would appeal to a broad undergraduate audience in a world where data science skills are increasingly essential.

I am also enthusiastic about mentoring students who are seeking to engage with research and scholarship, especially those from groups historically underrepresented in mathematics. My research interests in number theory and arithmetic geometry offer several accessible points of entry for undergraduates (please see my research statement for specifics). Drawing on my one-on-one mentoring experience through the Directed Reading Program, I will find projects to challenge them and further accelerate their growth as problem solvers, opening the door to the exciting possibilities of mathematical research.

[10] My posts about the mathematics of baseball are available at https://c-keyes.github.io/blog_talking_baseball.html.

Student evaluation summary

Comments from students. The following responses are from student evaluations from my Math 111 (Calculus I) courses at Emory University.

- Organized, empathetic, understanding, accessible! He was great and truly enthusiastic about the material.
- I liked the worksheets he made for us as it really helped us stay engaged and see how a concept is applied in not only a math question, but a real-life application problem. He truly is organized and cares a lot about what he teaches. He makes it easy to want to learn.
- Professor Keyes is a good teacher that tried his best to keep everyone engaged. He even made changes throughout the semester and added more break out rooms to try and keep us engaged. He cares for his students and always went out of his way to reach out to me if I didn't do well.
- He carefully and thoughtfully responded to all student questions and set aside time after class to help students individually. He was also very proactive in helping students do their best by suggesting study methods and by providing additional help in office hours and review sessions.
- He is a great professor who wants you to succeed. He will take his time explaining things to you in office hours and is a fun person to talk to. He makes all the concepts clear and I am usually never confused about something after he explains it. If I am confused, I can ask a question that he enthusiastically accepts and easily answers it in a way that I can understands.
- He exuded commitment, patience and knowledgeability of the subject: all key qualities for succeeding as a math instructor. Not only was he capable and able to seamlessly generate real-world examples (often on the spot), Chris was very motivating and highly invested in us, as students.
- I would highly recommend students enroll with Chris because he is going to deliver the content in such an eager manner and make sure you understand the material. No question was dumb in his class.
- Without hesitation, I would recommend Christopher Keyes. He knows how to organize the course properly on Canvas, and is in constant communication with the class and gives us reminders. All of my classmates, including myself, improved a lot in our mathematical abilities this semester. Professor Keyes was more than available for interaction outside of the class.
- His passion for the subject matter is infectious and he clearly cares about his students success and well-being. I will recommend Professor Keyes to everyone who has yet to take Calc 111. He is willing to take extra time for his students if a subject or topic does not "click" right away. He allows students the opportunity to selfcorrect before telling them what they did wrong.

Evaluation score summary. The table below summarizes student evaluation scores for classes I taught at Emory University. Scores are on a **scale of 1 to 9**, with 1 indicating "not at all" and 9 indicating "very."

Course	Calc I	Calc I	Weighted
Term	F2020	S2021	Average
Number of responses	27	17	(out of 9)
How well organized was the class?	7.48	7.71	7.57
Was the instructor enthusiastic about the material?	8.30	8.18	8.26
How concerned was the instructor with what students learned from the course?	7.59	8.00	7.75
How clearly did the instructor explain specific concepts relevant to the course?	7.33	7.12	7.25
How clearly did the instructor communicate the course objectives and requirements?	7.59	7.71	7.64
How well did the instructor respond to students' questions?	7.93	7.65	7.82
How accessible was the instructor for individual discussion about the course?	8.19	8.71	8.39
How useful was the instructor's feedback?	7.41	7.06	7.27
How effectively did the instructor engage with students in the remote environment?	7.37	7.18	7.30
Weighted instructor average	7.77	7.66	7.73