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 teaching philosophy has been shaped by my experience as an instructor of record for two semesters of *Calculus I* at Emory University. My instructional experience at the graduate level includes an advanced topics course in *Arithmetic Statistics* through the London Taught Course Consortium. My philosophy has also been informed by my activities outside the classroom, as an *Math Circle* instructor in the Atlanta community and as an organizer and mentor for Emory's *Directed Reading Program*. The latter underscore my commitment to inclusive excellence, and 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 had to transition 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. For example, I initially used frequent Zoom breakout rooms to simulate small group problem solving discussions. As I learned from mid- and end-of-semester surveys I sent the students, these were polarizing; some students found them highly effective, while others rated them least effective. Zoom's poll functionality proved universally popular, which I used both to review previous material and for warm up questions at the start of each class. Having regular, anonymous formative assessments helped me to see where my students were at, and students shared that they appreciated the instant feedback they received. While I'm not eager to return to the uncertain times of the pandemic, it made me a more effective instructor by forcing me to adapt and respond to promptly to student feedback.

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 and Spring 2021, 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). Full evaluations are available on my website [1, 2], as well as sample materials including lesson plans, quizzes, syllabi, and selected recordings [3, 4, 5, 6].

At a more advanced level, I use these same guiding principles to shape my instruction to the students. When I developed an advanced graduate course on Arithmetic Statistics for the London Taught Course Consortium, I designed it to appeal 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, in class 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 suggested exercises to invite students to both expand their background knowledge and explore related ideas and research areas. Course notes and exercises are available on my website [7, 8].

Math circle influence. My outreach experience as a **math circle instructor** at Emory has also helped to shape 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 advanced or quicker 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*. 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 seek to incorporate, both my math circle sessions and undergraduate classes. This and other lesson plans are available at my website [9, 10].

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 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, serving another 16 undergraduate mentees in the 2023-2024 academic year.

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*. Since I had little prior experience mentoring this topic, I began the semester by sitting down with Ezra to get an idea of his background and goals for the DRP. We found that we shared a lifelong interest in baseball and a desire to understand how events, players, and teams are valued, and he hoped to land a job in sports data analysis. I was then able to find an online university course that included the basics of expected run values and team winning percentage estimators that helped us answer many of our baseball questions. 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 [11]. 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 can 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.

References

[1] Emory University. Math 111 course evaluations, Fall 2020. https://c-keyes.github.io/files/Keyes_F20_evals.pdf.

[2] Emory University. Math 111 course evaluations, Spring 2021. https://c-keyes.github.io/files/Keyes_S21_evals.pdf.

[3] Christopher Keyes. Lesson plan on the chain rule. https://c-keyes.github.io/files/Keyes_S21_chain_rule.pdf.

[4] Christopher Keyes. Quiz on limits and IVT. https://c-keyes.github.io/files/Keyes_S21_samplequiz.pdf.

[5] Christopher Keyes. Math 111 course syllabus, Spring 2021. https://c-keyes.github.io/files/Keyes_S21_syllabus.pdf.

[6] Christopher Keyes. Asynchronous module on *limits at infinity*, Fall 2020. https://bit.ly/Keyes_module9.

[7] Christopher Keyes. Arithmetic statistics course notes, Spring 2025. https://c-keyes.github.io/files/ArithStatsLTCC_notes.pdf.

[8] Christopher Keyes. Arithmetic statistics problem sheets, Spring 2025. https://c-keyes.github.io/files/ArithStatsLTCC_exercises.pdf.

[9] Christopher Keyes. Math circle lesson on *Press Your Luck*. https://c-keyes.github.io/mc_press_your_luck.html.

[10] Christopher Keyes. Math circle lesson on the Kakeya problem. https://c-keyes.github.io/mc_kakeya.html.

[11] Christopher Keyes. Talking baseball: a series of posts on sabermetrics and the mathematics of baseball. Personal blog, 2022. https://c-keyes.github.io/blog_talking_baseball.html.