# FIRST-YEAR TEACHING STATEMENT (OUTLINE)

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For the next six years, I intend to teach undergraduate mathematics (*Single Variable* and *Multi-variable Calculus*) at CU Boulder. I see myself as a member of a community of experts responsible for establishing "the bedrock of [students'] post-secondary preparation for science and engineering" [1]. I look forward to applying pedagogical research to my teaching practice, and, as part of the SEMINAL initiative (NSF Grant DUE-1624628), promoting *active learning of mathematics* in high-enrollment undergraduate courses.

In conclusion to the pedagogy seminar for first year graduate students at CU Boulder, I have prepared an outline of provisional strategies for my teaching. I focus on four classes of questions, asked by Paul Hand [2]:

1. Knowledge-centered, i.e., What do I want students to be able to accomplish? Why?
2. Learner-centered, i.e., How can I help students build on and refine their prior knowledge?
3. Assessment-centered, i.e., How can I frequently reveal the progress students have made?
4. Community-centered, i.e., How do I capitalize on the community of learners and society at large?

The bullets below give examples of my initial responses to Hand's questions. The associated methods include both methods I will certainly and uncontroversially adopt, as well as methods which might be more difficult to put into practice while teaching at CU.

**Knowledge-Centered Aspects.**

- In collaboration with the course coordinator, I aim to present and follow a clear, structured, and mathematically coherent syllabus [1, Ch. 7].
  - In *Single Variable Calculus*, I have high expectations for my students to attain both analytic and geometric fluency in four major content areas: limits and continuity, derivatives, integrals, and sequences and series [1, Ch. 4].
  - I recognize that, working with other instructors, I will likely successively update what I perceive to be "canonical calculus" in favor of a "lean and lively" curriculum appropriate for students at CU.
- I want students to develop two specific *deeply procedural* skills, namely:
  - Knowing how to give constructive oral feedback.
  - Knowing how, with a computer algebra system, to plot, to perform simple symbolic calculus, and to share their work with peers.
- I am interested in inquiry-based curriculum as well as exploiting tools for teaching at scale, for example:
  - Class-size permitting, having "Moore method Mondays" by asking students to prepare presentations on solutions to problem sets that were assigned over the weekend [3]; or
  - Technology permitting, posting a schedule of video lectures and spending time in class to focus on group problem solving, mathematical writing, or collaborative projects with SAGE, RStudio, etc.

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*Repo:* `https://github.com/coltongrainger/fy19ta`.

**Learner-Centered Aspects.**

*The pursuit of knowledge, brother, is the askin' of many questions.*[1]

- I am determined to make students in work actively—which is well, as I have departmental support [4] to engage in *ambitious teaching* [1, Ch. 2]. My current strategy to realize ambitious teaching is:
  - After preliminary remarks, I subdivide the class into peer groups of 4–5 students.
  - I task each group to come to a consensus on a set of scaffolded arguments that makes rigorous either the example or the theory introduced in the preliminary remarks.
  - I ask each group to select a representative to present and justify a particular step in the derivation, at which time the class is expected to ask constructive questions.
  - I give a summary overview, and class ends with an exit quiz.
- To prepare students for mathematical abstraction, I prefer to structure classes so that students confront a *challenging problem from a field outside of mathematics* before I present a theoretic result that leads to that problem's solution.
  - Explicitly, in *Single Variable Calculus*, I intend to build on students' prior knowledge by adapting the following genres of physical problems for in-class, small group work:

| student's mental model | physical problems | mathematical abstraction |
|---|---|---|
| position, velocity, acceleration | particle motion, path parameterization | higher derivatives |
| (in)stability | drug-response curves, tank problems, population models | asymptotic behavior |
| static equilibria | geometric constructions, angles of incidence | optimization |
| periodic phenomena | harmonic oscillation | trigonometric manipulations |

**Assessment-Centered Aspects.**

- I intend to administer frequent and formative assessments to encourage students to work at a modest but constant pace. I plan to make use of:
  - first day *optional interest surveys* to gauge the pacing for the course [5],
  - daily 5-minute *multiple choice quizzes*, with solutions, commentary, and performance statistics posted to the course webpage [6],
  - *cold calling* on individual students to answer questions posed on a regular basis during class (provided that students are given the choice to opt-out at any point in the semester).
- For summative assessments, I may allow for revisions so that students are given multiple opportunities to demonstrate their competence with the course material (e.g., allowing oral examinations to be rescheduled until the student passes).
- I look forward to contributing to the design of projects, written homeworks, and exams, especially so as to ensure summative assessments are *fairly graded* and can be *clearly anticipated* by a diligent student.

**Community-Centered Aspects.**

- I'll give a few answers to an *extremely* motivating question: how can I connect my students to the community of learners at large?

[1] Raymond Chandler, *Farewell My Lovely*.

- There's statistically significant evidence that in-department math labs improve first year students' attitudes towards mathematics [1, Ch. 2].
- I'm inspired by Athena Sparks' review sessions, which I've seen have fostered camaraderie between students in different sections, just by virtue of having to pack into the same room together before a stressful event.
- How else can I encourage students to co-create space to work together?

- I'm curious how cleverly incorporate social media to connect students in different sections:
  - e.g., Oliver Krill's Math 21a (Multivariable Calculus) Twitter `https://twitter.com/math21a`.
  - e.g., Andrej Karpathy's course notes `https://cs231n.github.io/` and the accompanying suggestion to use *hypothes.is* to *annotate comments and discuss the notes* online.

- How can I exploit resources created at other Universities and academics? What are the most important pieces of Calculus to develop in-house? What's less essential, and is done better elsewhere?
  - e.g., Robert Ghrist's *Calculus Blue* `https://www.math.upenn.edu/~ghrist/calculus.html`
  - e.g., Ohio State's *Mooculus* `https://mooculus.osu.edu/handouts`

- Should we curate a library of mixed multi-media resources for students?
  - With what content? Archived final exams? Recorded lectures? Parametric plot galleries?
  - See, e.g., this panoply of Mathematica objects: `http://www.math.harvard.edu/archive/21a_fall_17/gallery/index.html`

- In terms of efficacy to implement active learning in mathematics, I have had **good luck** coming to CU Boulder in 2018. Really, it's hard not to see my work as a graduate student instructor at a large public university in the historical context of three decades of pedagogical reform [1, Ch. 8]. Here's my (not too wildly) impressionistic vision of that history:
  - In 1985, Laura Border becomes the founding director of CU Boulder's Graduate Teacher Program.
  - In 1992, the GTP Lead Network is established.
  - By early '90s, perhaps new CU faculty Robert Tubbs,[2] David Grant,[3] Judith Packer,[4] and Eric Stade[5] begin to advocate for the adoption of Harvard Consortium Calculus [7].
  - By trading in faculty lines, going into Fall semester 2001, the math department is large enough to offer 18–24 sections of Calculus 1 and 10–16 sections of Calculus 2 with sections capped at 35 students [8].
  - In 2003 the Undergraduate Learning Assistant program is established "to assist science faculty in making their courses student centered, interactive, and collaborative" while also "recruiting learning assistants to become K-12 teachers" [9].
  - In 2005 David Webb[6] joins the school of eduction at CU.
  - Spring semester 2014, design principles for "group-worthy" curriculum materials[7] are ported from ULA supported recitations for use in classes traditionally dedicated to lectures.
  - Tubbs, Webb, and Grant obtain an NSF funding until 2021 to answer the question: "What conditions, strategies, interventions and actions at the institutional, departmental and classroom levels contribute to the initiation, implementation, and institutional sustainability of ALM in the undergraduate P2C2 (Precalc to Calc 2) sequence across varied institutions?"
  - 2016, *Faan Tone Liu!*

[2] https://experts.colorado.edu//vitas/101761.pdf
[3] https://experts.colorado.edu//vitas/100868.pdf
[4] https://experts.colorado.edu//vitas/100338.pdf
[5] https://experts.colorado.edu//vitas/100456.pdf
[6] https://experts.colorado.edu//vitas/141204.pdf
[7] http://math.colorado.edu/activecalc/

- 2016–2018, the Math Department has a string of successively awesome GTP Leads!

## What's to come?

In this outline I've shared, formally at first, then with increasing informality, a variety of approaches I hope to try out as a GSI at CU Boulder.

Main take-aways:

- I see myself as *tasked with training practitioners of mathematics*.
- As such, I have high expectations for their progress and the efficacy of my own teaching.
- Throughout the P2C2 sequence, I want undergraduate students to feel rallied on by the "community of experts", that is, the community comprised of the LAs, the GSIs, the instructing faculty, the course coordinators, and each department at CU whose research mission is advanced by the presence of quantitatively literate undergraduates on campus.

## References

*Therefore, go forth and become great scientists!*[8]

[1] D. M. Bressoud, V. Mesa, and C. L. Rasmussen, *Insights and Recommendations from the MAA National Study of College Calculus*. MAA Press, 2015.

[2] P. Hand, "Teaching Statement." 2013 [Online]. Available: `https://www.caam.rice.edu/~hand/docs/statement_teaching_learning_2013.pdf`. [Accessed: 07-Dec-2018]

[3] C. Stallmann, "Calculus I: Notes and Problems," p. 76, 2015 [Online]. Available: `http://jiblm.org//downloads/dlitem.php?id=103/&category=jiblmjournal`

[4] W. M. Smith, D. C. Webb, J. Bowers, and M. Voigt, "SEMINAL: Preliminary Findings on Institutional Changes in Departments of Mathematics," p. 8, 2017.

[5] D. Rosoff, "Files and media related to my Math 251 course at the College of Idaho.: Daverosoff/Math251ModelCourse." Apr-2014 [Online]. Available: `https://github.com/daverosoff/Math251ModelCourse`. [Accessed: 08-Dec-2018]

[6] V. Naik, "Math 152 Course Notes," 2012 [Online]. Available: `https://vipulnaik.com/math-152/`

[7] O. Knill, "On Harvard Calculus." 2004 [Online]. Available: `http://www.math.harvard.edu/~knill///pedagogy/harvardcalculus/index.html`. [Accessed: 08-Dec-2018]

[8] D. Webb, "Applying Principles for Active Learning to Promote Student Engagement in Undergraduate Calculus," *School of Education Faculty Contributions*, Jul. 2016 [Online]. Available: `https://scholar.colorado.edu/educ_facpapers/4`

[9] V. Otero, S. Pollock, R. McCray, and N. Finkelstein, "Who Is Responsible for Preparing Science Teachers?" *Science*, vol. 313, no. 5786, pp. 445–446, Jul. 2006.

[8] *Richard Hamming* (talk at Bellcore, 7 March 1986).