

Pedagogical Inquiry Grant Report: “An Introduction to Calculus: Adding a Pre-Calculus Co-requisite.”

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In May 2022, we sought to develop a new course to accommodate students with little or no experience in Calculus. Up until the 2021-22 school year, Whitman offered 4-5 sections of Calculus 1 each Fall (and usually 1-2 in the Spring), but all sections were the same. All assumed a pre-calculus background with little time for review of topics. With the pandemic and an increasingly academically diverse incoming student population, we saw a need to make our introductory course more accessible. After summer discussions and planning, we developed our new course **Math 124: Introduction to Calculus**. We have attached the catalog copy for both the new course and our existing Math 125: Calculus 1, in an appendix to this report.

Placement: Our group discussed whether to offer a placement exam to incoming students, and whether this exam would be mandatory for students who wanted to take Math 124. For reference, our current calculus placement exam (for students who have a background in calculus and are looking to assess the appropriate level) is not mandatory and non-binding. We did look at several options, both external and internal. We ultimately decided not to add a placement test for students, and rather, worked through advising channels to get students into the appropriate class. We reached out to first-year advisors, introducing the new course and giving advice on helping students decide which course to take. We also gathered names from the admissions office for students that showed no background in pre-calculus on their high school transcripts and reached out to them advertising the class. Of the aforementioned students (69 in all), none reached out for more information, and only 3 signed up for the course (most were not interested in STEM majors). Ultimately, students placed themselves into 124 or 125, and we allowed for more second and third year students to take this course (the final breakdown was a little more than half of those enrolled were first-year students).

Course Construction The group worked on an outline for the course that would incorporate both calculus and precalculus content. The first two weeks were spent discussing basic concepts of functions, slope, and change. The class then covered polynomial functions (with particular attention to linear and quadratic functions). We then discussed the concepts of slopes of functions and average rates of change. We then moved into the definition of a limit as a means to discuss instantaneous rates of change. With the basic calculus machinery in place, the course went back and took a pre-calculus look at exponential and logarithmic functions, then incorporated our calculus concepts with those. We then spent a great deal of time on trigonometry (from a fresh standpoint, not one of ‘review’ that is done in the Math 125 course), and looked at calculus on trigonometric functions. From this point forward, the course looked a lot like a Math 125 course, covering rules on derivatives, applications of derivatives, and meanings and calculations for antiderivatives. Students finished the course in about the same

place that a Math 125 course would be (in Balof's Math 125 course in the Spring, for comparison, students spent an extra day or two on antiderivatives).

Textbooks: This course used the Active Calculus series by Boelkins (www.activecalculus.org). This series had texts in both Pre-Calculus (An Active Prelude to Calculus) and Calculus. The textbooks were free and available online to students (reducing the economic barrier that can accompany other math courses). Course chapters had many examples and ample homework exercises (both short and long form) for students to work on. Additionally, many of the topics, examples, and exercises were tied into the natural and physical sciences and economics, giving students a first-hand understanding of how the topics could be applied elsewhere in their studies.

Assessment: Written homework was assigned daily and collected weekly in this course (as opposed to other Calculus courses, where much of the daily assignments are done via webwork). Written homework counted for 40% of the student grade. This weight and quantity of written work allowed the professor to give ample feedback to students and to pinpoint areas of misunderstanding or weakness in student preparation. Additionally, students took a bi-weekly quiz over the previous two weeks' worth of material, and there was one final exam.

There were 46 students who completed the course (enrollment was steady after the first two weeks of the semester), and all passed with a grade of at least C-. Despite the extra material to be covered, the pace of the class felt more relaxed, owing in large part to the extra class meeting each week (four 50-minute periods instead of only three). Students were well engaged, even during an 8AM class, and made good use of office hours and extra tutoring sessions. Student evaluations showed general satisfaction with the course and its outcomes, with more than one student praising the course for 'getting them back into mathematics.'

We plan to run the course again in Fall 2023 and to make it a regular part of our Fall rotation. While the course was, by most measures, successful this Fall, we hope to continue to measure future outcomes, particularly as the landscape of incoming student backgrounds changes over the post-pandemic years. We envision being able to share the outcomes of this course as well as the status of the Fall course with the community, perhaps in early Spring 2024.

Data Analysis Ideas

One measure of the success of Math 124 is measuring how students fare in future mathematics courses. We are just beginning to look at data from this year, and have some ideas about how to interpret it.

- How do students from 124 do in 126 compared to those that didn't?
 - Problem with self selection, not a randomized trial.
 - At what rate did students drop 124 (historical 125, Barry only, not Fall 2022, but other Falls).

- At what rate did these and other students drop 126.
- Different ways of analyzing student outcomes: Compare pass/completion rates? Compare GPAs?
- Tracking historical 125 to 126 transitions. Did some take a semester off? Matt will share his 126 rosters for Fall '23 to check.
- How did students use quantitative skills acquired in Math 124 in their future coursework outside of the Math Department? (Possibly interviewing students at the end of next year.)

While the scope of the grant and this report is limited to the 2022-23 academic year, we hope to monitor this data over the next few years as Math 124 becomes a more permanent fixture in our rotation. Additionally, Albert Schueller will be presenting on this project in a special session devoted to co-requisite mathematics at this summer's MAA MathFest in Tampa, FL in early August.

Appendix: Catalog Copy for Math 124 and Math 125

124 Introduction to Calculus

Fall Hundley 4 credits

Topics include limits and continuity. Definition, computation and applications of the derivative. An introduction to integration, including the fundamental theorem of calculus. Of the 4 credits, approximately 1 credit will be committed to a parallel track of instruction that introduces and/or reviews topics in algebra, trigonometry, exponential and log functions and graphing as they are being encountered in the calculus curriculum. *Prerequisites:* two years of high school algebra; one year of plane geometry

125 Calculus I

Fall, Spring Fall: Keef; Spring: Petersen 3 credits

Topics include limits and continuity. Definition, computation and applications of the derivative. An introduction to integration, including the fundamental theorem of calculus. *Prerequisites:* two years of high school algebra; one year of plane geometry; and knowledge of trigonometry and exponential/logarithmic functions or consent of instructor.