Sabbatical Project Report for Greg Fry – Fall 2018

My sabbatical project consisted of a study of the teaching of Differential Equations and Linear Algebra. First, I studied how other community colleges teach these as separate courses to determine how best to split our current combined Math 270 course. Next, I created documents to support such a split into two courses: Math 230 (Linear Algebra) and Math 240 (Differential Equations). Finally, I investigated several different ways to present the course material to students, especially with the use of technology.

In September I started by investigating how other community colleges organized their split classes. I collected course outlines and syllabi from several community colleges that have two courses. These include Pasadena City College, Santa Monica College, Mount SAC, LA City College, East LA College, Saddleback College and De Anza College. I created a summary chart that has all the corresponding courses listed. I also created a topic by topic comparison with some of these schools.

I studied how our new courses could best articulate with our main transfer universities, such as UCLA, CSULB and UCI. I collected course outlines and sample syllabi. I made a chart that compared our proposed outline with those of each school. I created a chart for each course showing how each topic mapped to the state required C-ID topics. I studied the prerequisites for these courses and the typical order they are offered in. The most common prerequisite for Linear Algebra was Calculus II, our Math 191 class. The prerequisite for Differential Equations was far more varied. Some schools, like Santa Monica College and Saddleback College had Calculus II as a prerequisite, but others required Calculus III and/or Linear Algebra.

My initial proposal is to provide students with flexibility by requiring Calculus II as a prerequisite for both courses and to allow them to be taken in any order. To facilitate this I propose that each course be five units, as is done at Pasadena City College. This will allow us to cover each topic thoroughly, provide background as necessary, and to incorporate useful techniques, such as the use of interactive computer graphics, if desired. Also, with the advent of AB705 students may need a little extra time in class to get direct exposure to the instructor and classmates. No corequisite course would be needed, but the five-unit format would provide the instructor with the most flexibility and the student with the best opportunity to absorb the often difficult material. Finally, these courses will not only be attractive to current students who want to be better prepared to transfer in a STEM related field, they could also attract students to come from other institutions, two-year or four-year, to fulfill these course requirements.

I then proceeded to investigate various textbook options, both traditional and online. The best books I found were all traditional hard copy texts, because they covered all topics and provided the most flexibility for instructors with available problem sets and online resources. In Linear Algebra the best texts were “Linear Algebra and Its Applications” by Stephen Lay and “Linear Algebra: A Modern Introduction” by David Poole. For Differential Equations the best were “Elementary Differential Equations” by William Boyce & Richard DiPrima and “Differential Equations” by Robert Devaney. I will link some of the best online textbooks on my website, but they are not complete enough to be the main text for either course.

In October while investigating the two courses at Pasadena City College I was inspired by Jude Socrates to learn more about the visual method of teaching differential

equations and linear algebra. I got a copy of the textbook he wrote: "A Portrait of Linear Algebra." I read through much of the text and found some of the sections to be very illustrative of key ideas, but overall this text lacks all of the topics we need for our course. However, this inspired me to investigate a more visual approach to teaching these topics.

I went through an online course by The Teaching Company called "Mastering Differential Equations: The Visual Method" by Robert Devaney. Through twenty-four interesting lectures, which incorporated innovative uses of graphics, I learned to look at things like phase planes and eigenvalues from a fresh perspective. There were some clever demonstrations of various traditional differential equations models, such as the Predator-Prey System, the Mass-Spring System, Harmonic Oscillators and all kinds of pendulums. The interactive graphics allow you to change various parameters and see the effect on the system as a whole. While this is not a replacement for finding solutions analytically, it does provide a way for students to see what is happening visually in a way that wasn't available when I took these courses. This will help students gain a deeper understanding of these key models and other differential equations and linear algebra topics. I also did an extensive search online for various tools that could achieve what was presented in the online videos that I watched. I decided to collect these as links on my El Camino Website under "Class Resources": http://www.elcamino.edu/faculty/gfry/.

Furthermore, I found some wonderful applets on the MIT website, called MIT Mathlets. These provide interactive tools to investigate various models and situations in Differential Equations and Linear Algebra. There are also some worksheets that are geared towards each interactive module. I worked through some of these and found some

that will be useful when I teach the classes. There are also some good interactive modules available at Wolfram Demonstrations Projects. I worked through many of these and linked the best, most useful ones on my website. I also viewed a lot of Khan Academy videos and linked to the best ones I found for understanding the tougher linear algebra and differential equations topics.

In November I attended the AMATYC National Conference in Orlando. Several of the talks and workshops gave me great new ideas for these courses. Additionally, I attended two talks on Desmos, a free and powerful online math platform. The first talk, "Unlocking the Magic of Desmos," by Raymond Houston, showed various apps that can be used in place of a graphing calculator. The second talk, "Teach and Learn Power Series Expansions of Functions Using Desmos," by Matthew Michaelson, showed how to use Desmos for teaching series. I was especially impressed by demonstrations that showed how to use Desmos to animate the approximation of polynomials by Taylor Series. They also discussed another online platform, Geogebra, which has a lot of good interactive modules available. At home I searched through many of these and linked some of the best on my website.

I went to several other talks but two were especially noteworthy. Inspired by Robert Cappetta, I attended his talk "Challenges of Teaching Calculus". This gave me several ideas about how to design class projects in calculus, which includes differential equations. My favorite talk was "Getting Acquainted with Proofs," by Brooke Orosz. She had created worksheets that guide students through the steps of various proofs. The examples were from Precalculus and Number Theory, but they gave me some good ideas about new ways to present proofs in our proposed new courses.

In conclusion, my study of these courses has given me a new insight on how to both design and teach the courses. I have gathered plenty of data to help me convince my colleagues and the administration that these new courses are useful. And I have many new insights into how to help facilitate student learning, especially through technology and better ways of delving into proofs.