DIFFERENTIAL EQUATIONS AT FREDERICK COMMUNITY COLLEGE A PERSONAL ACCOUNT

Dina Yagodich
Department Mathematics
Frederick Community College
Frederick MD 21702 USA
dyagodich@frederick.edu

Background

The comments here pertain to a 200-level 3 credit differential equations course taught by Dina Yagodich at Frederick Community College (FCC) (Frederick, Maryland) over a number of semesters, running from Spring 2014 through Summer 2016.

Teaching upper-level mathematics courses such as differential equations is challenging at a community college. Our students transfer to a variety of colleges and universities after completing their coursework with us. Our task is to ensure our students are ready for their Junior and Senior level classes. After a survey of our top ten transfer schools, certain topics and skills were deemed critical for differential equations. These include Laplace transforms and as much MATLAB instruction as possible. Starting in Spring 2016, a 1-credit MATLAB course was added as a pre-/coreq for differential equations which included basic matrix operation skills to assist instruction with systems of differential equations.

A breakdown of the class makeups is given in Table 1. Many students who are aiming for engineering use the General Studies major for more flexibility. A new major option, STEM: Sci, Tech, Eng, and Math, was added in Spring 2015.

This was a 3-credit course that met for either two 75-minute sessions each week or one 150-minute session for 15 weeks, including the final exam. Since most transfer colleges require a C or better, unsuccessful students include students who withdrew, audited the course, or earned an F or a D. See Table 2. Student grades are based on 60% exams (midterm/final), 20% weekly homework (pencil and paper), 10% weekly quizzes, and 10% on modeling and MATLAB projects.

Spring 2014	32 (2 section)	13 Eng, 12 Gen Stud, 1 Chem, 1 Math, 5 HS student
Fall 2014	9 (1 section)	7 Eng, 2 Gen Stud
Spring 2015	33 (2 sections)	17 STEM, 10 Gen Stud, 1 CS, 1 Math, 4 HS student
Fall 2015	13 (1 section)	10 STEM, 2 Gen Stud, 1 CS
Spring 2016	10 (1 section)	4 STEM, 2 Math, 1 CS, 1 Gen Stud, 2 HS student
Summer 2017	6 (1 section - online)	1 STEM, 5 Gen Stud (students attending a 4-year univ)

Table 1. Summary of student interests for 3-credit differential equations course.

Spring 2014	32 (2 sections)	23 successful
Fall 2014	9 (1 section)	8 successful
Spring 2015	33 (2 sections)	30 successful
Fall 2015	13 (1 section)	9 successful
Spring 2016	10 (1 section)	7 successful
Summer 2017	6 (1 section - online)	5 successful

Table 2. Summary of grades for 3-credit differential equations course.

In Spring 2014 through Spring 2015, the textbook [7] was used. However, in Fall 2015, the switch was made to [3], an Open Educational Resource (OER) textbook, paired with Schaum's Outline notes [1]. Excel and MATLAB were used as software support.

Motivation

Brian Winkel presented information about teaching differential equations with modeling at the 2013 Joint AMS-MAA meeting in Baltimore. His presentation included a "sure-fire" activity using m&m candies [4] to model population modeling. I tried it. It worked! Being fairly new to teaching differential equations, completely changing the format of the class from the manner it had been taught by colleagues in the past was not something I was ready to jump into. However, my background is in both electrical engineering as well as applied mathematics, so a modeling approach seemed very appropriate for the class. Rather than completely change the class, I opted to add modeling slowly, semester by semester, to see how it fit into the class.

Inital Semesters

The first three semesters I included only one or two modeling activities, including one the first day of class. I used the m&m modeling activity [4], with some minor adjustments to fit the activity in about 30 minutes. The first experiment models population decay without any immigration, and students were able to confidently predict the steady-state solution. The class evaluated the number of generations required by each of the groups to reach a population of zero, and we had a fruitful discussion about the statistics behind experiments. Students were able to, with guidance, create a difference equation and then move to a differential equation. At the time, MATLAB was not required for the class, so I demonstrated using the software to find the solution.

The second half of the m&m modeling activity involves immigration, and no student was able to predict what the steady-state value would be. Watching students continue to repeat experiment until the population settled to the number they predicted (which it never did) was very enlightening. Once the solution was found using MATLAB, students were able to come up with reasoning to explain the actual steady state solution. This lead directly into a very good discussion about the modeling cycle: taking data, making a model, testing the model against the data, and then revising the model.

A memorable quote from a student evaluation from that semester answered the question "What class assignment or activity did you find to be the most useful?" with the following:

> *Believe it or not, the M&M activity on the first day of class really stood out to me. It helped to show the real world applications of Differential Equations and I thought it was amazing that we could build an equation using real world data.*

Even if no other modeling is done the rest of the semester, starting a class with a modeling activity such as this paints a clear picture on the types of problems differential equations can be used to solve, demonstrates the modeling cycle, and introduces numerical solution methods such as MATLAB.

Later Semesters and Online Experience

By Fall 2016, I added more modeling problems. One that stood out was not based on data; rather, it asked the students to calculate how much additional anesthesia is needed to administer to a dog who was undergoing surgery after the original dosage begins to wear off. This activity is found at SIMIODE [5]. The problem took students by surprise; they did not realize that they had already learned the tools to solve this problem. Working in groups, students were able to formulate a differential equation to model the situation. At this point, analytical techniques to solve this type of equation had been taught, so students were able to solve it without computer assistance. A student commented in his/her course evaluation that the activity that was the most useful was "*The dog drug, it was fun and it was a real life example.*"

The SIMIODE community allows for continual renewal in the modeling classroom. I made a change to the m&m modeling scenario based on a conversation at the 2016 Joint AMS-MAA meeting in Seattle, Washington with another member of SIMIODE. When immigration is added to the modeling problem, I gave each student a different number of m&m's at the beginning of the experiment. Some groups had a number greater than the steady-state solution, others had a number less than the steady-state solution, and one group was given the exact number of the steady-state solution. Students were truly surprised when all groups settled to the same number. This was a great way to bring the class together as a whole and understand how population modeling works.

In Summer 2016, the class was offered online for the first time. Because of the repeated success with the m&m modeling in the classroom, I created an assignment for students to do on their own following the procedures from the face-to-face class. They discussed the results in a discussion board and I then posted a video [6] explaining the modeling project. In future online sections, I hope to integrate more of the material available at the SIMIODE web site as well as have a class discussion board hosted there.

Conclusions and Future Plans

Student comments from Fall 2015 helped keep me focused on continuing to use more modeling in the classroom. Answering the question "What specific recommendations do you have to improve the course?" two student commented *"Maybe do theory after we do examples of the problem first"* and *"I suggest more focus on example/model based learning."* And another comment which answered "What class assignment or activity did you find to be the least useful?" was negative only because more modeling was desired: *"At first I enjoyed the modeling problems, but I don't feel like we did enough, or went through enough of them to really benefit from it."*

Over this sequence of semesters, the move was made from the expensive textbook that was used to OER resources in addition to the move towards modeling first. I initially settled on one OER book for the theory, paired with Schaum's Outline notes [1] for a larger homework set. I will start branching to more than one OER book as well as [2] to meet the needs of the course. Since there is no textbook currently published teaching differential equations as modeling first, using a variety of textbooks and resources will allow for tailoring the material. Making a textbook change, however, took my focus off more fully integrating modeling throughout the course.

My Spring 2017 schedule will be very similar to my Fall 2016, and we have a 5-week break between Fall and Spring semesters. I am going to use that time to completely convert my class to a modeling-first approach. In particular, I will be using more MATLAB to give students the ability to solve modeling problems that students cannot yet analytically solve. My biggest challenge will be the Laplace Transform topics, but systems of differential equations can easily be reworked using a modeling focus.

In Fall 2016, two of my students from that first Spring 2014 stopped by say, "Hello." After chatting about their experiences at their respective four-year universities, I asked them if they remembered the m&m candy experiment. One said, "Oh, the population modeling experiment" and the second commented it was a great way to start the class. There are not many first days that my students remember, but these two students still remember that first day two and a half years later. This reinforces my belief that hooking students early into the "why" of differential equations sets the tone for the entire semester and beyond.

REFERENCES

[1] Bronson, and G. Costa. 2014. *Schaum's Outlines: Differential Equations*. New York: McGraw-Hill Education.

[2] Dawkins, P. 2016. *Paul'sOnLine Math Notes: Differential Equations.* http://tutorial.math.lamar.edu/Classes/DE/DE.aspx. Accessed 23 September 2016.

[3] Lebl, J. 2016. *Notes on Diffy Qs: Differential Equations for Engineers*. http://www.jirka.org/diffyqs/. Accessed 23 September 2016.

[4] Winkel, B. J. 2015. 1-1-S-MandMDeathAndImmigration. https://www.simiode.org/resources/132. Accessed 18 July 2016.

[5] Winkel, B. 2015. 1-16-S-DogDrugs. https://www.simiode.org/resources/680. Accessed 23 September 2016.

[6] Yagodich, D. 2016. diff eq lecture m and m. youtu.be/Ji8a_Elkj08 Accessed 23 September 2016.

[7] Zill, D. 2013. *A First Course in Differential Equations with Modeling Applications*. Boston MA:: Brooks/Cole.