Sabbatical Report
Jerry Morris
Department of Mathematics and Statistics
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The goal of my sabbatical project was to produce a set of teaching materials for one year of our calculus sequence, including the courses Calculus 1 and Calculus 2. As the project evolved, it was determined that Calculus 1 was the class that was most conducive to the addition of application problems to its curriculum. As a result, the library of problems that was produced consists mostly of problems designed to be used in a Calculus 1 class, though some of the problems can be used in Precalculus and Calculus 2. Before these problems could be written, it was necessary to spend a significant amount of time reviewing and learning relevant curriculum from physics, chemistry, and economics and thinking about ways to construct problems of a reasonable difficulty level for calculus classes. The final result was a 36-page library of 68 different problems and their full solutions.

During the course of the project, it occurred to me that this was a unique opportunity to write application problems that call for students to combine their understanding from various portions of the course, and to differentiate between key concepts learned in the course. In looking at our current calculus curriculum, it is surprising how little effort is made by our textbook to ask students to do these things. Therefore, six of the problems in the library were designed with this goal in mind. I am especially eager to see how these "combination" problems will be received by students; I think finding ways to incorporate them into our calculus courses will provide the potential to deepen students' understanding of calculus and how it is applied in the sciences.

Many of these problems can be used as examples that instructors can use to present new concepts or as exercises for students that are suitable for either homework problems or in-class group discovery problems. Some of the longer problems could also be used as writing projects to support the standard material learned in calculus. These problems were designed to emphasize the understanding of calculus concepts from multiple perspectives: numerical, graphical, and verbal. They encourage an active exchange of ideas between students during group work, thus solidifying conceptual understanding that is more difficult to achieve when students simply work alone. The teaching materials include complete written solutions for the convenience of instructors who are using the materials with their classes. Below are some specific goals that guided the development of these materials.

- **Evolving Pedagogy in Math Teaching**: Over the course of teaching calculus, I had already developed teaching materials similar to those that I developed for this project, but they were outdated in the sense that they were written to accompany a very traditional calculus textbook that tends to exclusively stress calculations. The new problems have been designed to embody a more balanced perspective of calculus teaching. In particular, the new problems provide more opportunities for students to understand and

verbally explain calculus concepts graphically, numerically, and computationally.

- **More Emphasis on Applications in the Sciences**: Calculus is an area of mathematics that is rich in applications in physics, chemistry, engineering, economics, and the social sciences. While the previous set of activities that I taught from contains some application problems, the new set of problems places much more of an emphasis on applications and has a wider variety of applications. My hope is that the new problems will illustrate the broad usefulness of calculus outside of the realm of pure mathematics.
- **More Textbook Flexibility**: In the math department, we consistently try to provide affordable textbooks for our students, which often involves using older editions of textbooks. This library of new problems provides enough variety for instructors to choose problems for class discussion and homework problems without being dependent on a particular textbook.
- **Continued Collaboration With the Harvard Calculus Consortium:** For the past 15 years, I have worked with the Harvard Calculus Consortium in writing and editing calculus books. Instructional materials that I have already developed are part of the online resources for several of these books. As my work with the consortium continues, these new problems will become part of the online resources for the Harvard Calculus Consortium, resources that can be accessed by instructors around the country who use the Consortium texts in their courses.
- **A Lasting Contribution to the Math Department:** In the spring semester of 2014, I had the honor of receiving one of the Sonoma State University's Excellence in Teaching Awards. In letters of support for this award, several of my colleagues mentioned explicitly how influential and helpful teaching materials I had already developed were in teaching their classes. Instructors from other universities have also written to ask permission to use my materials in their calculus and precalculus courses. It is my hope that these new materials will continue to be beneficial to my colleagues, while at the same time providing them with new and more flexible teaching options.

In conclusion, I have already begun the process of disseminating these materials. I provided all current Calculus 1 instructors with copies of the problem library and the complete solutions so that they are free to incorporate these problems into their courses as they see fit. I am in the process of writing the next edition of the Calculus 1 workbook that several calculus instructors and I use when teaching the course, and I have included exercises that I developed during this project in the new workbook. Finally, the research that went into developing this problem library has provided me with a wealth of ideas for new precalculus and calculus problems that I will be writing in the coming months for inclusion in the new editions of the Harvard Calculus Consortium textbooks.