

Materials Grant Proposal

Project Director: Brian T. Gill

Director Title & Department: Assistant Professor, Mathematics Department

Institution: Seattle Pacific University

Eligibility Code: 21AA06

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Other People Participating

Anthony Donaldson, Chair, Department of Electrical Engineering, SPU

John Lindberg, Assistant Professor, Physics Department, SPU

Various instructors from area high schools list available on request

Faculty stipend for Brian Gill only

Title of Project: Interactive Web-Based Materials for Calculus Using LiveMath

Project Description

Project summary:

The goal of this project is to develop a collection of interactive web-based materials that illustrate each of the key ideas of first-year Calculus. Most currently existing interactive materials for calculus are not web-based and require the use of expensive software packages. The project will develop interactive animations, simulations, activities, and labs that can be used for free on any computer with Internet access. The materials are intended for use at both the college level and the high school level.

Background and description of project:

Calculus is fundamentally different from the mathematics that you have studied previously. Calculus is less static and more dynamic. It is concerned with change and motion; it deals with quantities that approach other quantities.

So begins the first chapter of one very popular calculus textbook (Calculus: Concepts and Contexts, by James Stewart, Brooks/Cole, 1998). Unfortunately, this statement is followed by more than a thousand pages of static text, equations, and images. By their very nature, traditional textbooks struggle to convey the dynamic nature of the subject.

In the last decade, the calculus reform movement has put substantial effort into developing computer-based labs and activities to give students a more active, hands-on learning experience in calculus courses. However, most of these activities involve the use of expensive software packages that are typically available only on a limited number of campus owned computers. Some campuses do not have such software available at all, particularly at many high schools. In addition, most of these software packages are quite complex. As a result, significant amounts of class time must be spent teaching students how to use the software before the students can use the software to learn calculus.

More recently, development of Java applets has allowed some simple interactive materials to be distributed freely via the Internet. Unfortunately, file sizes and download times restrict the power and adaptability of such applets, so they have been of limited usefulness.

A brand new software package developed by Theorist Interactive goes a very long way toward solving some of these problems. The software comes in two parts. The main commercial package, called LiveMath Maker, is designed for the development of interactive notebooks for publication on the Internet. The second component of the software is the LiveMath plug-in, a freely distributed add-in for Netscape and Internet Explorer which permits users to view and interact with LiveMath notebooks available on the Internet. Users can change input values, see calculations recalculate, turn graphs, zoom-in ñ all within the webpage using the LiveMath plug-in. This can be done for free by anyone at any computer with Internet access. All that is required is a one-time download (about 1 megabyte) and installation of the plug-in. As a part of this project, the plug-in will be installed this summer on all computers in SPU s campus computer labs. The use of the plug-in allows very powerful and adaptable interactive notebooks to be included in web pages without excessive file sizes and download times.

As a very simple example of the capabilities of this software, a notebook containing a three-dimensional graph of a surface $z = f(x, y)$ can be created and posted on a web page. Any user with the LiveMath plug-in can view the web page and interact with the graph. They can zoom-in, zoom-out, spin, and turn the graph. They can even change the original function to see graphs of other surfaces. In addition, the interface is quite simple: for example, to spin or turn a graph, all that is required is to drag the mouse over the image while holding down the mouse button. As a result, virtually no class time needs to be spent teaching how to use the software.

This project will use LiveMath to develop interactive materials to help students visualize, experiment with, and better understand many of the key ideas of calculus. Activities, simulations, and labs will be developed for each of the following topics from the course:

- the intuitive idea of a limit of a function
- the formal epsilon-delta definition of a limit
- limit definitions of the slope of a tangent line to a curve
- linear approximations

- Newton's method
- introduction to chaos theory using Newton's method
- graphs of functions in two and three dimensions
- estimation of area
- Riemann sums and the definition of a definite integral
- solids of rotation
- graphing in polar coordinates
- graphs of vector-valued functions
- convergence of sequences and series
- estimation using Taylor polynomials

Additional topics will be added if time permits.

Innovation, Impact on Learning, and Portability:

The positive effects of interactive computer activities on student understanding of the central concepts of calculus are well documented as a result of much of the excellent work done in this direction over the last decade. The key innovation of this project is to make such activities much more widely accessible through the use of freely distributable software. All materials produced as a part of the project will be published on the Internet and will be accessible from any computer with a web browser, so they will be readily available to students and faculty at other schools. This will be particularly beneficial to area high schools that currently have no access to any kind of computer algebraic systems. An additional important element of these materials is that students can work with them at any time of day (or night) in any location with a computer, including their own home or dorm room. They will not be restricted to certain labs with fixed hours.

Collaboration: Since our calculus courses are primarily service courses for other disciplines, two members of the faculty from client disciplines will collaborate on the project in order to ensure that the needs of their departments will be met. In addition, both Dr. Donaldson and Dr. Lindberg are actively involved in technology delivery on the web in their own disciplines.

Leverage: see the section below regarding other sources of project support.

Feasibility: The project director has eight years of experience working with computer algebraic systems and three years of experience developing webpages. All necessary hardware resources are already available through the university. All necessary software is either already available or is included in the project budget.

Sustainability: The SPU Division of Science and Engineering has made a commitment to fund web delivery of course materials over the next three years, as evidenced by the matching funds provided for this project. Dr. Gill regularly teaches the calculus sequence and will continue to improve, upgrade, and add to the materials developed as a part of this

project. An effort will be made to recruit students to participate heavily in the ongoing development of these materials.

Accessibility: The SPU Library has computing facilities which are accessible to individuals with disabilities. All materials from this project will be available on those computers.

Project Schedule

April: purchase full software license

May: recruit student assistance for summer

June through August:

- develop interactive LiveMath notebooks;
- have other faculty and student assistants test and experiment with the notebooks;
- student assistants set up navigation structure and layout for the web pages;
- install plug-in on computers in all campus labs during usual summer maintenance and upgrades on hard drives.

September: publish final LiveMath notebooks to the web prior to start of fall quarter.

September through March:

- class-test materials in Calculus I (fall) and Calculus II (winter);
- update, modify and upgrade materials as needed, particularly using student input;
- encourage students enrolled in the classes to help with the development of further activities.

Project Budget

Faculty summer stipend (\$3,000 maximum):	3000
Programming or technical assistance:	
Student Assistance:	1250
Hardware and software:	750
Travel/conference fees:	
Materials and supplies:	
Use of special instruments or media conversion:	
Any other expenditures	
 TOTAL (may not exceed \$5,000):	 5000

Other Sources of Project Support (including amounts)

Matching funds (\$3000) will be provided by the Seattle Pacific University Electrical Engineering Department: \$2000 for faculty stipend, \$1000 for travel/conference fees.

SPU Instructional Technology Services will install the plug-in on all computers in campus computer labs (using labor from their budget).

Student assistance with web page development (5-10 hours per week) paid for by SPU College of Arts and Sciences.