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Dynamic Web Tools for Undergraduate Mathematics

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for Excellence and Innovation with the use of
Technology in Collegiate Mathematics
– Application –

DYNAMIC WEB TOOLS FOR UNDERGRADUATE MATHEMATICS

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Description

Beginning in the summer of 2002, the authors and an undergraduate student, Andrew Cousino, began developing interactive web pages to complement the delivery of a variety of undergraduate math courses. These pages make use of a product, web*Mathematica*, that enables the authors to create interactive web pages which allow students and faculty to compute and visualize results directly from a web browser. web*Mathematica* calls on a server running a *Mathematica* kernel to produce results in a *Mathematica* session and display them on a web page. Users visiting a web*Mathematica* page do not need to know how to use *Mathematica* to obtain results. The user interface utilizes standard web elements such as text fields, check boxes, and drop-down lists. The results displayed can be numeric, graphics, a sequence of graphics, or an animation. Authors of web*Mathematica* pages must not only know how to code in *Mathematica*, but also use the webMathematica extension, and be able *HTML* coders and web page designers. *MathML* and *Java* are desirable. Recognizing the significance of adding dynamic visualization and computation to their courses, the authors set about refining their web authoring skills.

The creation and utilization of pages has greatly enhanced the curriculum and offerings of this institution and others. A list of some of the web*Mathematica* pages can be found at

http://staff.jccc.net/mmartin/webmath.html

web*Mathematica* pages have been created for a wide range of courses including, but not limited to, algebra, discrete math, statistics, calculus, differential equations, biomathematics, and engineering mathematics. Faculty members at JCCC have made good use of these resources in their classrooms. Although there is no way to directly account for the number of students involved, we can estimate that a good percentage of the 7500 students enrolled in JCCC math classes each semester have seen and used these pages. Additionally, some of the pages have a decidedly biomathematics and physics focus and have been utilized in a number of JCCC science courses. JCCC web*Mathematica* pages have also been promoted at a number of local, regional, national, and international talks given by the applicants of this award. Attendees of these talks have been invited to make use of these pages within their courses and with their students. JCCC server support staff report a large number of hits from all over the United States and abroad.

Innovation

Our incorporation of web*Mathematica* pages into the curriculum is highly innovative. First, lab activities are designed to use these pages without having to teach students the specifics of a particular computer-algebra system or calculator model. This is advantageous when an instructor is not afforded the time to teach the computing/visualizing platform, but still wants to make use of the results in the context of a course. Second, the pages can be integrated into typical course management systems, such as WebCT and Blackboard. Students can use this tool as they progress through course materials in an online or hybrid course. This has proved to be very beneficial for the expanding number of online math courses that JCCC now offers.

Last, and perhaps most significantly, the use of these pages creates a synergy in areas where technology has helped forge new areas of study and emphasis. In the field of social choice, weighted voting systems can be studied mathematically. The calculations of power indices can be tedious, but it is the interpretation of results that is of great interest in JCCC's discrete math course. The following web*Mathematica* page automates that calculation:

http://math.jccc.net:8180/webMathematica/MSP/swilson/powerindices.msp

Biomathematics is a rapidly emerging area that is a prime example of the convergence of technology, mathematics, and the biosciences. The powerful new technologies that are transforming fields of biology are increasingly quantitative and mathematical at their core. One of the authors has developed a new undergraduate course, *Calculus for Biology & Medicine*, which is in line with these recent transformations. The course is greatly facilitated by the use of these web*Mathematica* pages. The course uses both difference and differential equations and considers behavior as parameters are varied. Although there are a number of good differential equation applets on the web, there is a void for difference equations (or updating functions). A good example is a model of electrical conduction in the heart that is given by such a discrete updating function and can be visualized via the following web*Mathematica* page:

http://math.jccc.net:8180/webMathematica/MSP/mmartin/heart.msp

The authors are also currently working on developing another new course, *Math & Physics for Games*, which covers foundational interdisciplinary material for aspiring computer game developers. The course should debut in 2005, and the applicants are beginning to work on web*Mathematica* pages to facilitate learning in that area and anticipate it to be quite useful in getting concepts across. The endeavor is a collaborative effort with the physics and computer science departments at JCCC.

Significance

The development of web*Mathematica* pages relevant to traditional and emerging math and science courses has a far-reaching impact. Since the pages are accessible to anyone on the web with a contemporary web browser, anyone is free to make use of this development. Although the web*Mathematica* pages are not searchable by engines such as Google, the main index page is searchable. Our site is featured by Wolfram as being an exemplary instance of web*Mathematica*'s use in education. Our web*Mathematica* pages are featured on the Society for Mathematical Biology's web pages and, as a result, are used in several calculus for the life sciences and related courses. In the spring of 2004, one of the authors gave a mathematics departmental colloquium at Arizona State University and established a working relationship with the mathematics education and biomathematics group there. JCCC's web*Mathematica* pages are now used in ASU's calculus for the life sciences course and also in a continuing education workshop they offer for secondary and community college educators that focuses on emerging interdisciplinary approaches for their classrooms.

Understanding

The use of JCCC's web*Mathematica* pages helps students understand certain concepts by seeing the effects of changing parameter values. In statistics, the normal and student t distributions can be compared as the degrees of freedom are varied. In biomathematics, the heart can be studied as the recovery rates of certain nodes are varied. The best model is not necessarily the one that agrees faithfully with the data, but instead the one that allows you to ask the most meaningful questions. What precision may be lost by approximating with a normal distribution? With a decreased recovery rate, will a heart beat normally or will there be a qualitative change in the dynamics? What happens to a neuron as its input current signal increases? Can a small third party have a large effect in a democracy? Students can answer their own questions with the use of

JCCC's web*Mathematica* pages. Classroom evaluations have produced positive results using our WebCT course management system.

Technology

Technology is pervasive in this application. web*Mathematica* pages can be generated using *Mathematica* servlet pages (*.msp files) or *Java* servlet pages (*.jsp files). web*Mathematica* is a robust product that offers access to *Mathematica* applications through a web browser or other web clients.

Scholarship

The following presentations have been solicited of and given by the authors of this application. There have been varying degrees of web*Mathematica* inclusion in these presentations.

- **Mike Martin**, *Calculus for the Life Sciences: Advancing Interdisciplinary Instruction*, Mathematics Department Colloquium, Arizona State University, Tempe, AZ, March 2004
- **Steven Wilson** with **Mike Martin**, *A Bare Bones Guide to webMathematica*, Kansas City Regional Mathematics Technology Expo, Rockhurst University, Kansas City, MO, October 2003
- **Mike Martin**, *Biomathematics in the Two-Year College*, International Conference on Mathematical Biology, Dundee, Scotland, August 2003
- **Steven Wilson** with **Mike Martin**, *A Bare Bones Guide to webMathematica*, Joint Meetings of the Missouri and Kansas Mathematical Association of Two-Year Colleges, Overland Park, KS, March 2003
- **Mike Martin**, *Biomathematics: Curriculum & Technology*, Conference on Information Technology, The League for Innovation in the Community College, Long Beach, CA, November 2002
- **Mike Martin**, *Biomathematics: Curriculum, Models, & Technology*, Kansas City Regional Mathematics Technology Expo, Rockhurst University, Kansas City, MO, October 2002
- **Steven Wilson**, *A Bare Bones Guide to Beginning webMathematica*, Math Department Colloquium, JCCC, Overland Park, KS, September 2002

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