

Web-based Graphing Tutorial
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Students in all levels of calculus are required to sketch graphs of functions using derivatives and limits. It was previously found that technology enhanced graphing of polar coordinates enabled students to better graph and set up the integrals for computing enclosed area(s) for polar graphs (significant difference found: $t(33) = 4.14, p = .0047$).

Drs. Evelyn C. Bailey and Fang Chen created a web-based graphing tutorial¹ for students to *visualize* graphs of functions studied in Calculus I and Calculus II. The web page was designed in the summer of 2002 and implemented beginning fall of 2002.

Past experience shows that students have the most difficulty with visualization while working volume problems in Calculus I and while determining area between polar graphs in Calculus II. The web-based graphing tutorial was conceived with these two as the main sections. In order to help all students to visualize graphs of functions, other sections were added to make the web page a comprehensive tutorial on graphing.

The web-based graphing tutorial is organized to provide the various types of graphs: piecewise defined functions, polynomials, rational functions, functions with vertical tangents, polar coordinates and volume of solid of revolution. The "Curve Sketching Checklist", which has been the main summary of and guidance on important graphing aspects is included. The checklist also serves as a blueprint for the design of all of the web sections with the exception of the sections on polar coordinates and volume. Led by the tutorial, the students are expected to work through the examples, answer the questions, study the solutions and explanations, and gradually achieve competency and confidence in curve sketching, volume, and area in polar coordinates. In each section, the examples selected for display were problems previously used on tests and quizzes, thus having the appropriate difficulty level and variety to match courses taught at Oxford College. The format was carefully chosen based on previously identified needs.

The evaluation of the effectiveness of the web-based graphing tutorial included: (1) performance data from students enrolled in the calculus courses before and after the implementation of the graphing tutorial; (2) responses on a questionnaire given to the students at the completion of the courses.

The scores from identical quizzes on polar coordinates from Calculus II spring, 2002 (control, without the use of the web) and from Calculus II fall, 2002 (treatment, with the use of the web) were compared. The result of a t-test ($H_0: \mu_T \leq \mu_C$) showed that the mean of the treatment group is significantly higher than the mean of the control group ($t(40) = 1.81, p = .039$). This quiz was given immediately after the unit on polar coordinates during which the homework assignment included working through the problems on the Web.

Student responses to a questionnaire about this web page: Calculus II students used the web page primarily for the checklist and for the polar coordinates. They found the polar coordinates section the most helpful. Twenty-two Calculus I students stated that they used the web, seven students stated that they did not. Calculus I students used the checklist and different types of graphs. Most found the color-coded section useful.

¹Web address for the graphing tutorial:

http://www.oxford.emory.edu/OXFORD/RESTRICTED/UNIVERSITY/Classes/Chen/Calculus/Graphing/Graphing_Main.htm