DEMOS AND PROJECTS THAT MAKE A DIFFERENCE

David R. Hill	Sarah L. Mabrouk	Lila F. Roberts
Mathematics Department	Mathematics Department	Math/CS Department
Temple University	Framingham State College	Georgia Southern Univ.
Philadelphia, PA	Framingham, MA 01703-2752	Statesboro, GA 30460
hill@math.temple.edu	smabrouk@frc.mass.edu	lroberts@gasou.edu

INTRODUCTION

A variety of sources acknowledge that there is currently a shift from an instructor centered classroom toward one in which students are more active participants in the teaching and learning process [1]-[4]. This situation indicates that instructors need to establish an environment that encourages active participation by students and find additional learning tools that work well in this new environment. An instructor may need to modify content delivery by using techniques that address a variety of learning styles. The modifications can be in the form of the instructor's actions or role in the classroom and in the form of independent assignments that foster experiences in the scientific method.

In this article we look at two aspects of mathematics instruction. First, we examine the instructor's role in the classroom and illustrate some effective instructional demonstrations. Demos are intended to engage the learner's attention and encourage understanding of mathematical concepts beyond the instructor's oral presentation. Second, we present some ideas for student-centered projects that encourage the student to interact with the real world through projects. These projects are designed to develop an appreciation of the importance of mathematics as a tool for problem solving.

INSTRUCTOR AS FACILITATOR: EFFECTIVE CLASSROOM DEMOS

As the traditional learning scenario of an instructor centered approach gives way to a more student centered atmosphere for learning, the role of the instructor can be greatly improved by carefully planning what and how we present in our mathematics classrooms. We must maintain a careful balance on the type of communications we use in the classroom. Communication via oral expression complemented with student involvement and visual tools requires close coordination in order to achieve a high level of effectiveness for the variety of learners we teach. The verbal component of instruction is crucial to expose students to the aspects of verbal training requiring the ability to absorb, filter, and process information involving words, numbers, symbols, and concepts. These lecture oriented learner skills require that students concentrate and remain focused as we perform our delivery functions. As experienced instructors know, the student can much too easily veer off the track of the ideas we are trying to present.

To keep students "with us" and help to maintain their focus, teachers use a multitude of devices. As technology has changed so have the teachers' bag of tricks. The tricks-of-the-trade now include physical manipulatives, calculators, data banks, and computer driven tools, which are often visually oriented. All of these instructional devices are demonstrations designed to involve students on learning levels complementing our oral presentations. Since our time with our students is so precious and seemingly quite short, the choice of demonstrations we use in class is extremely important.

The use of demos in class can provide students with a situational or visual model of a concept. Hence demos often set a mental reminder for a concept that students recall later and provide teachers with an opportunity to build connections between topics. Demos can be used for a variety of purposes, including, introduction of a topic, clarification of a point, emphasis of an idea, to add variety, to change focus, and to highlight important points.

Experienced mathematics teachers have over time, developed, refined, and sifted through collections of instructional demos, creating "teaching kits" containing demos they have found to be effective. Communication of these personal toolkits to others in the profession has the potential to greatly improve mathematics instruction and benefit our students. The NSF-funded project, *Demos with Positive Impact*, is directed toward establishing a web-based collection of such effective instructional demos.

The project *Demos with Positive Impact* has as its goals:

1. The creation of an easily accessible resource of demos that experienced teachers have found to be effective. (Web-based.)
2. Presentation of the demos in a way that makes them easily adaptable in the classroom.
3. The inclusion of visual components for demos, when possible.
4. Suggestions about how to use a demo, including first-hand reports from developers and users.
5. References to pertinent materials that go along with a demo's theme, including software programs, web-sites, and instructor tips.

The URL for *Demos with Positive Impact* is **http://www2.gasou.edu/facstaff/lroberts/demos**. The site categorizes demos into the areas of Physical, Calculator, Data-based, Browser-based, and Software. In each of these categories the demos are further classified as Pre-calculus, Calculus, or Post-calculus. We briefly describe three of the demos currently in the database.

Have your students ever asked, 'Where do parabolas come from?' We could answer this by cutting a cone with an appropriate plane, but the demo ***Parabola!*** takes a different approach and provides a dramatic example of how parabolas arise as graphs of a natural phenomenon. A ball is given a push up an inclined plane, and its progress up and then down is recorded by a motion sensor. The time vs. distance graph appears on a computer monitor. The graph is a parabola. This demo has been used as a quickie with students studying quadratic functions. It makes quite an impression on some of them: one student said that this demo shows that parabolas are real.

When we introduce infinite series, it is often a painful experience for instructors and students alike. As mathematics teachers we may recall that, a "lets imagine that … " scenario and formal definitions worked just fine for us when we were students, but, as we know, this doesn't apply to all students. Students that are in engineering and other applied fields often work better physically and visually than they do abstractly. The demo ***A "Sweet" Introduction to Infinite Series*** apportions a donut to a group of students in such a way that it holds the attention of a class and accurately introduces the abstract ideas of the terms of a series, the partial sums of a series, and convergence or divergence of a series. In fact, in one 50-minute lecture/demonstration/feast we get all that plus alternating series and the divergence of the Harmonic series.

By the time our calculus courses get to the topic of partial derivatives, students are able to differentiate many functions of a single variable with few major difficulties. Then we spring functions of several variables on them and effectively tell them to use the differentiation techniques they already know "pretending" that all the unknowns, except the one with respect to which they differentiate, play the role of constants. Many students successfully buy into this algebraic mechanism but very few have a clue as to what is going on geometrically. The demo ***Partial Derivatives Geometrically*** provides a visual foundation for partial derivatives of functions of two variables, $z = f(x,y)$. The demo sketches a surface, cuts it with a plane perpendicular to an axis to regard one unknown as a constant, generates the curve of intersection, and animates a tangent line moving along the curve while displaying the values of its slope. This demo provides a lecture tool that has been used successfully in large and small classes for both math/science and non-science majors. It is simple to use and lets the instructor narrate the actions as they evolve on the screen. It provides a visual enhancement to the usual algebraic statements about partial derivatives.

STUDENT AS ACTIVE LEARNER: STUDENT-CENTERED INVESTIGATIONS

In general, students do not understand the purpose of many activities they are asked to perform and make no connection between these activities and the instruction that they have received [5]. They do not link course topics, concepts, methods, or problems they analyze with other disciplines or with their previous knowledge. Projects can help students make these associations as they apply course material in more realistic settings. These applications are usually more difficult and require more analysis than standard homework problems. Higher order thinking is required, especially when problems are open-ended in nature. Exploring how ideas fit together and can be applied in a variety of situations helps students to relate to the material they learn and helps them to "take ownership" of course concepts. Group or individual projects enable students to put course material into context. This provides an opportunity to integrate current concepts with previous experiences from other courses, disciplines, or real life.

Projects provide students with an opportunity to clarify thinking through discussions of and writing about course concepts and methods, to test their ideas against those of other students, to appreciate new perspectives, and to practice communication skills [6]. Discussions arising from project analysis provide students with important feedback regarding their understanding of course material. Students get an opportunity to question, explain, express opinions, admit confusion, and reveal misconceptions. Simultaneously, they listen, respond to questions, and share information to clear up confusion [4]. These activities help to emphasize to students that they are central to the learning process. Another valuable lesson is responsibility: the group cannot succeed unless each member of the group contributes.

Writing a report or paper as part of a project provides an opportunity for students to test their understanding of concepts, symbols, and techniques through explanations given in their own words. They must clarify the problem and define all variables, notations, and terminology used. In addition, they must communicate their approach and elucidate the significance of solutions. These activities require students to actively organize their own understanding of course concepts and ideas in order to explain and solve the project "problem". The writing component of the project can be serious or creative in nature. Rather than a workplace style report, a project paper might be in the form of a story or letter in which the problem explanation, analysis, and solution are presented. For example, presenting students with a narrative containing a veiled optimization problem can be useful in helping students to decode and solve problems presented within more realistic scenarios. A written response such as a reply to the letter or a continuation of the story can use characters, fictitious or real, to carry out the discourse that provides the development of the project and leads to the culmination of the assignment.

While providing a valuable learning experience for students, projects can keep a course fresh and provide a challenge to the instructor. Projects help to remove routine aspects from a course, energize discussions, and motivate students to assume a more active role in learning**.** The activities within a project can enable the instructor to share interests or relevant developments in the discipline.

Projects give an excellent opportunity to use and to teach students about technology, such as the graphing calculator, World Wide Web, or various computer programs like Microsoft Excel, MATLAB, Derive, Maple, or *Mathematica*. These technologies are useful for function and graph exploration projects. Precalculus students can explore and compare the graphs and equations for constant, linear, and quadratic functions that result from taking different values of coefficients for the function $f(x) = ax^2 + bx + c$. Students in Multivariate Calculus courses can explore and compare quadric surfaces resulting from varying the coefficients in $Ax^2 + By^2 + Cz^2 + Dxy + Exz + Fyz + Gx + Hy + Iz + J = 0$. Either type of project enables students to make connections between graphical and symbolic forms, acquire an understanding of the roles of the coefficients in identifying graph types in two or three dimensions, and develop a better graphical understanding of the equations and functions that they study and use.

While a graph analysis project is an example of a project designed to help students to make connections between concepts and associated graphical and symbolic forms, a **Find-Your-Own-Data Project** is a project designed to provide students with an opportunity to apply techniques and analysis that they have learned in a simulated workplace. One scenario for a **Find-Your-Own-Data Project** is an activity where students select a real data set and analyze the data as if they were working for a company or for the government. Students explore the World Wide Web as a source of information and real data: they can obtain current data for companies and government as well as access newspapers, magazines, and almanacs. In addition to performing any necessary background research relevant to their data set, students analyze their data to determine appropriate model type(s) and equation(s), provide realistic analysis of the significance of trends displayed in the data, and discuss the relevance of interpolation and extrapolation of the data. Students can perform the data analysis and determine the model equation(s) using both the graphing calculator and a spreadsheet program like Microsoft Excel; this technology can enable students to generate graphs that illustrate their analysis of the data for the project report.

SUMMARY

Demos and projects are instructional tools that are designed to reach out to students and involve them in a variety of ways. Demos provide an immediate form of involvement by presenting a path for "buying into" a concept or idea. Students are provided with a type of physical link to the verbal or symbolic expressions involved. Projects, requiring more time, are designed so that students must backtrack, assess, and solidify their perceptions about material. Both demos and projects are opportunities for students to acquire a better grasp of salient features of a course. They are also opportunities for instructors to have a positive impact on the learning process.

Acknowledgement: Partial support for this work was provided by the National Science Foundation's Course, Curriculum and Laboratory Improvement Program under grant DUE-9952306.

REFERENCES

1. Michael Yerushalmy and Juday Schwartz, 'A procedural approach to explorations in calculus', ***Int. J. Math. Educ. Sci. Technol***.(30), No. 6, 1999, 903-914.
2. Michael P. Lambert, 'Context versus Content: fresh look at the ongoing debate over place-based vs. distance education,' ***Syllabus*** (13), No. 10, June 2000, 24.
3. William H. Graves, 'The Dot.xxx Challenge to Higher Education,' ***Syllabus*** (13), No. 10, June 2000, 30-36.
4. William J. McKeachie, **Teaching Tips: Strategies, Research, and Theory for College and University Teachers**, Ninth Edition, D.C. Heath, Lexington, Massachusetts, 1994.
5. Jon Saphier and Robert Gower, **The Skillful Teacher: Building Your Teaching Skills**, Research for Better Teaching, Acton, Massachusetts, 1997.
6. Chet Meyers and Thomas B. Jones, **Promoting Active Learning: Strategies for the College Classroom**, Jossey-Bass, San Francisco, California, 1993.