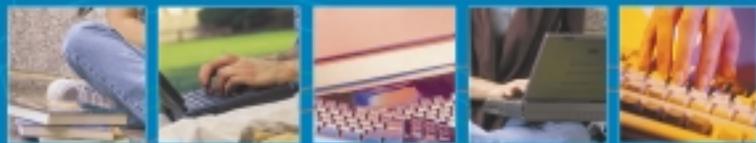# Integrating maple® Into the Math Curriculum

A Sensible Guide for Educators

"Used imaginatively, Maple can help students learn better and faster, and help prepare them using the mathematics technology that they will need throughout their professional lives."

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Waterloo Maple
ADVANCING MATHEMATICS

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Integrating Maple Into the Math Curriculum

By: Gregory A. Moore

A Sensible Guide for Educators

You probably know that Maple mathematics software is a popular tool for mathematicians, scientists, and engineers all over the world. This software is routinely used to investigate and solve problems of an inconceivable variety.

However, you may not know that Maple is an equally powerful tool for teaching mathematics and science classes. **Used imaginatively, Maple can help students learn better and faster, and help prepare them using the mathematics technology that they will need throughout their professional lives.** It can illuminate theory, clarify the abstract and give form and substance to general principles.

With such a versatile teaching tool, the challenge for the teacher is how to navigate the immense possibilities and channel the power of Maple into the classroom. With so many commands, so many options and so much flexibility, it's easy to be intimidated.

You might wonder where to start. You might also wonder what unimaginable mathemagical feats await you; and, how you can use this premier educational tool to the fullest advantage. You might also be worried about the learning curve for an unfamiliar software package and the amount of time it will take to master.

In what follows is a gentle series of steps designed to transform you gradually into an expert of Maple and catapult you to the forefront of innovative teaching. Each step flows to the next in a natural evolution. This suggested action plan is based on my first-hand experience in making the same transition - starting without any particular experience with Maple, and progressing to ever higher levels of teaching technology utilization over several years. This process is one of personal evolution and is designed to make your transition as smooth, natural, reasonable and do-able as possible. At the end of this process, you may look at mathematics teaching completely differently; perhaps even think of mathematics differently. As you push the educational envelope, you will be invigorated and enjoying your teaching experience in many new ways.
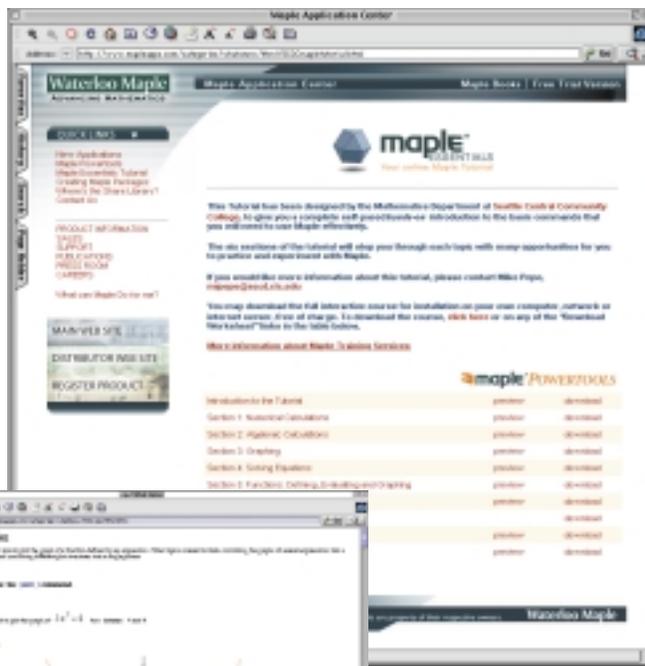
Get Acquainted

If you're new to Maple, just set your first goal to become comfortably acquainted with its capabilities and methods. Have some fun and play with it. Learn how to type commands and get responses. See what it can do. Identify the hurdles as you ascend the learning curve, so you will be able to help others later when they traverse the same path.

The Maple Essentials Tutorial at http://www.MapleApps.com/tutorial.html will get you started on many of the basics - such as arithmetic computations, solving equations, simplifying expressions, defining and using functions and making graphs. There are also more advanced topics like differentiation, integration, solving systems, using vectors, polar and three dimensional graphing,

logic, statistics, differential equations, etc. These should give you a good start. Your own playful experimentation will be the basis of a comfortable and growing familiarity.

It's often more rewarding to form a group of like-minded mathematical adventurers to work together as a team - sharing the joys, helping overcome the minor frustrations, inspiring each other to progress continually and explore.

You can also visit Maple's Postsecondary Mathematics Education site at http://www.MapleApps/postsec.html for ready-made examples.

Step 2

Use Maple Behind the Scenes

Maple can be used behind the scenes in your teaching. You can create handouts using graphics, symbolics, and tables created in Maple. You can export Maple output as graphic files that can be imported into word processors (like Word, Wordperfect, AppleWorks), page layout programs (like Quark, Pagemaker, or InDesign), or graphics programs (like Freehand or Illustrator). These can be the basis of class projects, exams or the exposition of new ideas.

You can also use the symbolic capabilities of Maple to help create examples and exam problems that work out "nicely." For example, to create a problem in partial fractions, you can set up the denominators with unknowns for numerators, simplify, and gradually substitute to eliminate the coefficients on the higher order terms. You can also check the answers to long problems effortlessly - problems you can do yourself, like finding the inverse to a 5x5 matrix, but you will quickly become accustomed to getting an instant answer.

Step 3

# Introduce Maple into Your Teaching

When you've mastered some of the basic operations, it's time for a public performance using Maple. You can demonstrate in front of your class on a projection monitor, or just have students crowd around behind a computer monitor. Some simple demonstrations of what you have learned will be sufficient to awe students with the power at your fingertips. This is usually a fascinating experience for students just to be exposed to this kind of software. It usually amazes students to see a computer multiply large polynomials, or rotate a 3-D function plot in real-time.

Later, you'll want to demonstrate concepts that relate directly to the material you are teaching. For example, you might discuss how changing the parameters in a function affects its graph, and show both the original and the new version simultaneously on the same set of axes. Or show an animation of a graph's tangent line rolling along the graph as the independent variable increases. There are endless possibilities.

The beauty of these examples is that they immediately provide you with materials ready for classroom demonstration. They illustrate mathematical ideas using Maple in a variety of ways, with a clear effort to demonstrate imaginative and useful applications of the technology. Because these downloadable files are simply Maple worksheets, you can alter them as you see fit, inserting additional examples, or copying and pasting to your own worksheets. This can be an extremely rewarding experience.

As I crafted materials for demonstration, I found that I was gaining a deeper understanding of topics that I had been teaching for many years. It was a personal joy to discover new depth to even familiar topics.
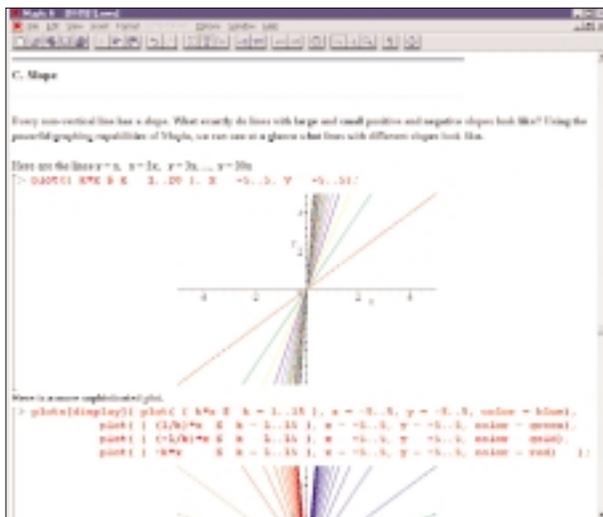
Step 4

Create Student Projects

As your Maple classroom demonstration worksheets become longer and more detailed, the next step is to transform them into student projects. Instead of simply lecturing on a topic and providing the conclusions, you can instead design your Maple projects to lead your students down the path of discovery, drawing conclusions on their own. Concepts learned by discovery are seldom forgotten.

Your first projects can be used for extra credit projects or honor projects - to 'beta' test the projects. When perfected, you can give these as assignments to the class. This will work out best if you take the entire class into a computer lab and spend an hour with them. It's important to have an experienced Maple person there - in this case, you - to assist with any little impediments to enlightenment. As you develop more class materials, you can make this a regular part of the class, perhaps even an hour per week. From my experience, students enjoy this much more than sitting through a 'boring' lecture or doing 'real' work.

You don't necessarily need to develop all this from scratch. Worksheets available at http://www.MapleApps/postsec.html can also be used as a starting point for many projects because the projects are organized by mathematical topic.
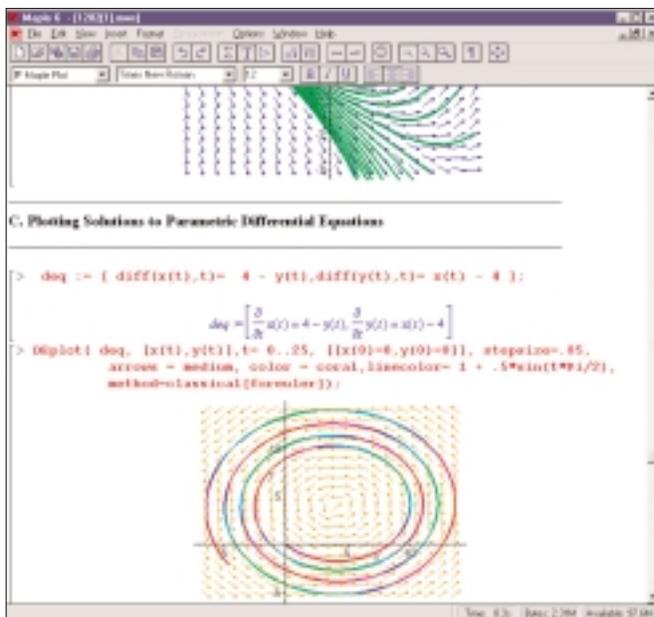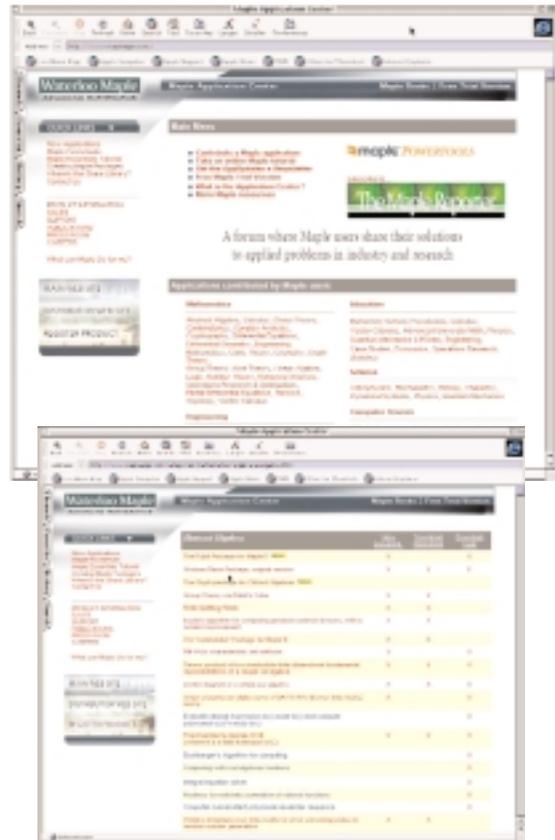

The essential method for creating a project is to write up an example with detailed explanations of the commands being used and ask the students to report what they can deduce. Then, ask them to go through the same procedure with other examples. In this way, they get exposure to a modern mathematical software package, while learning mathematical concepts. Learning through direct discovery and exploration usually has a greater impact than looking over someone else's shoulder.

Maple Classes & Lab Components to Math Classes

After a few semesters of excursions to the Maple computer lab, you can consider attaching a laboratory component to your math classes - much like a chemistry lab accompanies a chemistry lecture class. It's widely recognized in the sciences that theory and practical application must be intimately connected by a marriage of lecture and lab. There is no reason why mathematics should be exempt from this rule. For example, a one unit "Maple For Calculus 1" could be used as the laboratory component for Calculus 1. You will already have the materials and expertise. Maple lab components are feasible for every class from Trigonometry through Differential Equations and Linear Algebra, including Finite/Business Math.

Alternatively, you can create one or more separate Maple classes. I would suggest that such a class have two main goals: to expose the students to modern mathematical software, and to learn mathematical ideas using the software in ways not possible on the blackboard. Each class or lab should begin with an introductory section, then course-specific material.

In either case, I would suggest beginning any type of Maple class with a first assignment based on web research. **Maple's web site has an extensive Applications Center (at www.MapleApps.com)** has hundreds of applications in pure and applied mathematics, cryptography, engineering, physics, chemistry, biology, economics, computer science, graphics, signal processing, and many other fields. I ask the students to choose a topic of interest to them, and to find three articles relevant to their field of interest. Then I ask them to write a page or two summarizing how the software is used in support of the applications in a general way. I have found that this is a vital step in motivating students, for they are otherwise completely unaware of the pervasiveness of this software in the modern scientific world, and how relevant it is to every scientific discipline.

Step 6

Full Seamless Integration

The ultimate step in this evolving process is to integrate Maple fully into existing mathematics classes. Imagine a classroom with both computers and writing surfaces. Each day's class would be a combination of traditional lecture and problem solving, along with examples using Maple demonstrated to the class as a whole, or worked out on individual workstations. The relevant lessons of the day could be preloaded on a network, so students need only open the correct file and work through the instructions. A teacher could also lead the students through examples using Maple, and then ask them to postulate an underlying mathematical principle.

In general, the use of software would be as natural and relevant as the use of pencil and paper. Ideally, if all instructors in a college or high school used Maple in this way, students would be increasingly familiar with the technology as they progress from one class to the next. They will understand this as a normal part of learning and doing mathematics in our time. Many students will also opt to put the student version of Maple on their home computers and laptops, and use Maple as a daily tool, like the use a word processor or calculator.

I believe that this is the future of all mathematics teaching. Many of us can still remember when a technical diagram in an engineering class or a spreadsheet in an accounting class involved hand computation with reams of scratch paper and possibly the help of a slide rule. Of course, **computer software has become a fully integrated part of those tasks now, and the old ways of doing things seem ridiculously antiquated. The day will soon be upon us when mathematics will make a similar transformation** - after which the use of the technology will be part and parcel of learning the subject matter. The great part of this concept is that all of the tools and capabilities are in place and remain only to be utilized by those on the cutting edge of modern teaching.

Integrate Maple In Science Classes

In addition to aiding mathematics instruction, Maple can be used just as effectively to aid all of the subjects that rely on mathematics. In particular, Physics, Chemistry, Biology, and Computer Science, Economics, and Engineering classes can benefit greatly. **In fact, Maple is perhaps even more valuable in the sciences than in mathematics because it can open up entire new topics for study.**

In a science class, mathematics frequently underlies the important concepts. However, these topics are usually not covered if the students are not familiar with the mathematics behind these ideas. For example, an introductory science class would avoid applications of differential equations, and possibly differentiation, integration, and series because these topics are beyond the grasp of the student's mathematical training at that point in their academic lives.

However, the mathematical power of Maple can make these topics feasible. The science teacher can use the basic concept of the mathematical method and use the results without the need to explain or justify the theory.

The science teacher can advance through the same series of steps above with his or her subject in mind. Examples can be created in Maple to demonstrate to the class via a projection monitor. Handouts and student projects can be created. Students can be taught how to perform the relevant tasks in Maple, and how to interpret the results in a scientific way. Class projects can be created to use Maple to do science.

And of course, there is a synergy if students are learning and using Maple in their math classes and their science classes. **Ideally, an entire campus could standardize on a versatile software package like Maple to be used in various math, science and other classes.**

Although Maple is a serious tool for real mathematicians and scientists, it is also an amazing teaching and learning tool. The view of any impressive peak from ground level looking up, is daunting and intimidating. However, great heights can be achieved by taking many small steps. And so it is with Maple also. Hopefully, this note has cast a little light on the steps you can take to become a master of the new mode of teaching.

For more information on integrating Maple into your curriculm, contact Waterloo Maple Inc. at 1.800.267.6583 or Email applications@maplesoft.com.

Outside of North America, visit www.maplesoft.com for a Maple partner in your region.

About the Author

Gregory A. Moore, Professor of Mathematics at Cerritos College, was first introduced to Maple while teaching at Loyola Marymount University in Los Angeles in 1989.

He has since integrated Maple into his teaching in a variety of ways in order to help students learn better and faster, and help prepare them using mathematics technology that they will need throughout their professional careers. Moore has given numerous workshops in the use of Maple as a teaching tool at math conferences and in various community colleges.

A graduate of UCLA and Cornell University, Moore resides in Huntington Beach, California, and enjoys playing and writing music, photography and hiking.

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to the Math Curriculum

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