

Enriching Teaching with Technology

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Abstract

Here are some general thoughts about the use of technology in the classroom. This is a working draft.

Variety for learning

Learning works best when many different channels are used.

Lectures in Classes	sometimes with demonstrations
Reading textbook, handouts	usually done in private
Homework assignments	usually from book
Computer based quizzes	QA tool, "webwork" etc.
Online activities	for example with Java applets
Question Center	in public location, CA/TF staffed
Online Question Center	www.math.harvard.edu
Electronic voting system	Project Galileo at Harvard
Labs using technology	Mathematica computer algebra projects
Problem sessions	by course assistants
Meeting with instructors	office hours

The use of technology provides many opportunities to enhance a lecture. How it is done depends of course personal preferences and taste.

Available Technology

I) CAS systems <ul style="list-style-type: none"> Mathematica Maple Matlab Mathcad Macsyma 	II) Problem Solving <ul style="list-style-type: none"> Webwork Multiple Choice quizzes Electronic Voting systems Gateway exams 	III) Webpages <ul style="list-style-type: none"> Javascript interactive pages Dynamic HTML Java applets Flash pages
IV) Multimedia <ul style="list-style-type: none"> Graphics Movies Animations Slideshows 	V) Databases <ul style="list-style-type: none"> Online Encyclopedias Online Courses Databases of problems Chatbots 	VI) Communication <ul style="list-style-type: none"> Email, ICQ Course Websites Online Discussions Taped lectures online Electronic conferences

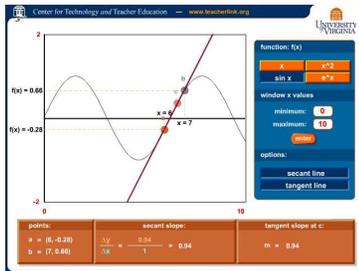
Pitfalls in using technology

The question, how a teacher should enrich class room experience is difficult. It is easier to list some pitfalls.

I) Technological challenges <p>Technology should not be used for the sake of using technology. Pitfalls:</p> <ul style="list-style-type: none"> teacher is not comfortable with technology cable forgotten, projector compatibility not tested. application crashes, machine needs to reboot. projector needs adjustments, i.e. picture not sharp. overhead projector using slides which are unreadable 	II) Illustrating the obvious. <p>Enrichment which focus on simplistic concepts only offend the intelligent mind. Examples:</p> <ul style="list-style-type: none"> Applets illustrating the "rate of change" using the tangent. Interactive matrix multiplication Animating the Riemann sum Animating a function like traveling wave 	III) Overuse <p>Too much technology can be like adding too much salt to a well prepared dish.</p> <ul style="list-style-type: none"> A teacher is proud about a specific software program and spends time explaining the inner details of it. Online problems which are routine and boring and of the same multiple choice type. Students sit behind computers in classrooms. No class-time left to cover essential material. 	
IV) Too much Complexity <p>A in class or online demonstration should be memorable, fun and still easy to use.</p> <ul style="list-style-type: none"> Assignments in CAS, which need serious programming from the student. Assignments which challenge the CPU of the computer too much and don't run on older machines. Assignments with unnatural problems. Assignments requiring too much background knowledge. 	V) Big brother <p>Technology can be used to gauge and monitor the learning progress of students.</p> <ul style="list-style-type: none"> Monitored online homework is as stressful as an exam. Computer security is known to be lax at educational institutions. Students fear that scores are used for grades and letter of recommendations. 	VI) Laziness <p>Technology can enhance but not replace the direct student-teacher interaction. Pitfalls:</p> <ul style="list-style-type: none"> Using technology to save human resources. Automated grading does not reveal key obstacles. Series of lectures in power-point format. Too much information on overhead. Reusing problems for exams. 	
VII) Lack of time to prepare <p>Preparing a class using technology needs lots of time</p> <ul style="list-style-type: none"> Testing equipment and program before class. Having alternative in case of failure Embed the module with didactic merit Try out many many things and throw what does not work. 	VIII) Outdated/emerging technology <p>Languages for the web like SVG, VRML, AIML, MathML, Flash are evolving and changing.</p> <ul style="list-style-type: none"> Emerging not yet fully standardized technology does not yet work. Older technology is often no more supported. Even simple programs need attendance. 		
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Interactive examples

Interactive Flash Example



The shown example from the center of technology and teacher education is quite useful. It allows the student to experiment a bit get the idea for Rolles theorem. Flash works pretty well on all browsers. Disadvantages are that one needs proprietary software on limited operating systems to develop the code.

Interactive Javascript Example

0	1	0	scale by	0.333	Add	1	times	row 2	row 3
-1	2	-1	scale by	1	Add	1	times	row 1	row 3
-1	1	0	scale by	1	Add	1	times	row 1	row 2

Number of elimination steps: 0

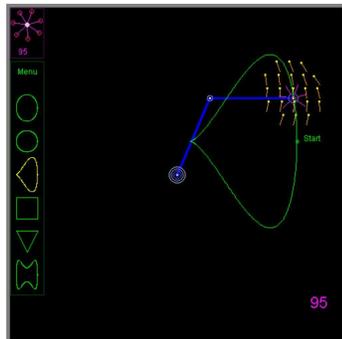
Take back Give hint

Try the challenge and solve the Gauss-Jordan Puzzle!

row: scale or add multiples of other rows to a given row.

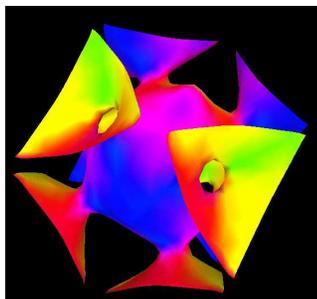
Simple javascript programming can be quite effective to do simple things. The example allows students to play with Gauss-Jordan elimination.

Interactive Java Example



Java is widely used in educational pages. Unfortunately, certain combinations of browsers and Java versions do not work properly. This example allows students to measure the area of simple regions using the planimeter.

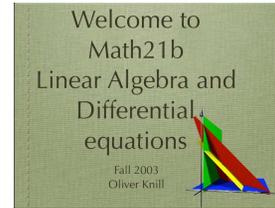
Interactive Virtual Reality Example



Virtual reality allows to explore surfaces and objects by moving around in a virtual world. It is effective for demonstrations in class. There are plug-ins for VRL for most browsers.

Multimedia examples

Presentation software



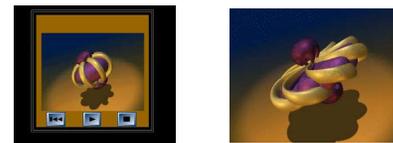
Presentation software like Power-point or Keynote are suitable for introduction meetings or reviews. Using presentation software for lectures is dangerous because the teacher does not more see the need to develop the thoughts and is in general too fast. One sees this often in conferences.

Quicktime Video



Here is the example of a movie published 1995 by the geometry center. It is originally published in the quicktime. In order that one can see the movie on every platform, one has to place the movie in different formats.

Other Video Formats



The same movie embedded into a flash movie or converted to the avi format. The flash version is a fifth of the size and viewable on any browser. The avi size is of less quality and a 10'th of the original movie.

Slideshow

Mathematics Math21b
Fall 2003

Course Head: Oliver Knill
Office: SciCtr 434
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Linear Algebra and Differential Equations

News

- Mathematics Math21b: An overview of the course

The web browser is a decent presentation software too. It can be used for example to present an exhibit of graphics.

Interactive Problems

Online Quizzes

The screenshot shows a web browser window displaying a quiz page for 'Multivariable Calculus'. The page title is 'Some T/F question practice'. Below the title, there are navigation links for 'Quiz 1', 'Quiz 2', 'Quiz 3', and 'Quiz 4'. A note states: 'Notes: This page is for training purposes only. No scores will be recorded. Some of the questions are randomized each time you access the page. Especially, the "True" or "False" can be on either side. When finished click on the "Grade" button below.' The main content consists of a table of 9 questions. Questions 1-6 are True/False questions about vector and plane geometry. Questions 7-9 are multiple-choice questions about the surface $z^2 + y^2 - x^2 = 1$, with options for 'above the surface' and 'below the surface'.

Multiple Choice quizzes, which are graded instantaneously are easy to build and maintain, work. Students like them.

Online Homework

The screenshot shows a web browser window displaying a homework page titled 'Problem Set final from math21a for Oliver Knill'. The page includes a 'Problem Set' tab and a 'Get Problem' button. The main content area contains instructions: '#WebWorkC weighted number final is due 0/3:02 at 2:00 AM.' and 'Your score from this webwork set will not count toward your final grade. Its purpose is to have additional practice questions available. In addition to doing the screen problems, you may print out a problem set.' It also provides information about the primary purpose of WebWorkC and instructions for using the system.

Webwork is an internet based method for delivering homework problems over the internet. Students get instant feedback and progress can be monitored. Webwork was developed at the University of Rochester.

Diagnostic Tests

The screenshot shows a diagnostic test interface from Harvard College. The page title is 'HARVARD COLLEGE' and 'DIAGNOSTIC TEST'. The main content area contains a question: 'QUESTION 1: A line whose slope is 2 passes through the point (1, 7). Which of the following points also lies on this line?'. The options are A. (1, -2), B. (7, 1), C. (5, -1), D. (5, 5), and E. (3, 5). On the right side, there is a 'SELECT YOUR ANSWER' section with radio buttons for each option. Below that, there is a 'TEST EVALUATION' section with buttons for 'CLEAR YOUR ANSWER', 'PREVIOUS QUESTION', 'NEXT QUESTION', 'PRINT QUESTION', and 'GO TO QUESTION'.

Internet based diagnostic tests are of similar form to the above two examples. In this case, students have to do the test supervised.

Online resources

Just a few examples

Connected Curriculum Project

The screenshot shows the homepage of the Connected Curriculum Project. The page features a navigation menu with 'Materials', 'About the CCP', and 'Resources'. The 'Materials' section lists various topics such as 'Differential Calculus', 'Integral Calculus', 'Multivariable Calculus', 'Differential Equations', 'Linear Algebra', and 'Engineering Math'. The 'About the CCP' section includes 'Site Map/Search', 'About The Authors', 'Design Principles for Interactive Tools', and 'Contact Us'. The 'Resources' section lists 'For Teachers', 'For Students', 'Design Principles for Interactive Tools', and 'Contact Us'. The page also includes a 'CCP was funded by the National Science Foundation' logo.

One of the best collection of interactive learning materials is the CCP project. <http://www.math.duke.edu/education/ccp/>

Mathworld

The screenshot shows the homepage of Mathworld. The page features a navigation menu with 'WOLFRAM|SEARCH', 'mathworld.wolfram.com', and 'OTHER WOLFRAM SITES'. The main content area includes a 'HEADLINE NEWS' section with a featured article titled 'ERIC WEISSTEIN'S world of MATHEMATICS A WOLFRAM WEB RESOURCE'. The article includes a description of the resource and a 'More from Eric Weisstein's World of Mathematics' section. The page also includes a 'Mathworld's 20th Anniversary' section and a 'Privacy Policy' section.

One of the best collection of online knowledge with sometimes interactive demonstrations is Mathworld.

MacTutor

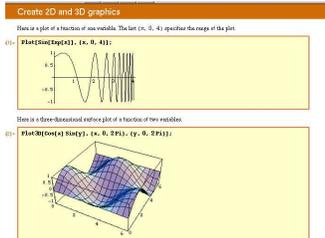
The screenshot shows the homepage of MacTutor. The page features a navigation menu with 'Indexes of Biographies'. The main content area includes a search bar and a list of biographies. The biographies are organized into 'Alphabetical Index' and 'Chronological Index' sections. The 'Alphabetical Index' lists biographies from A to Z. The 'Chronological Index' lists biographies from 500 AD to 1900. The page also includes a 'Search Biographies' section and a 'Main Index' section.

One of the best collection of articles on Math history and Biography is the Mac Tutor History of Mathematics archive <http://turnbull.mcs.st-and.ac.uk/history/>.

Computer algebra systems

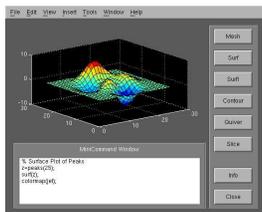
Just three examples. The highest obstacle for a student in all CAS systems is to learn the graphics user interface (GUI), which are often confusingly built, unstable and too complex.

Mathematica



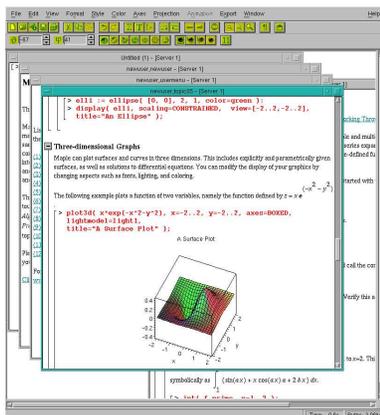
Mathematica is one of the best CAS for beginners.

Matlab



Matlab has the possibility to build nice interfaces and is strong in linear algebra.

Maple



Maple is similar to the above mentioned CAS. It is also widely used at many places.

Interfaces



A Chatterbot which knows math and can access CAS systems is in development by a project supported by the Provost at Harvard.