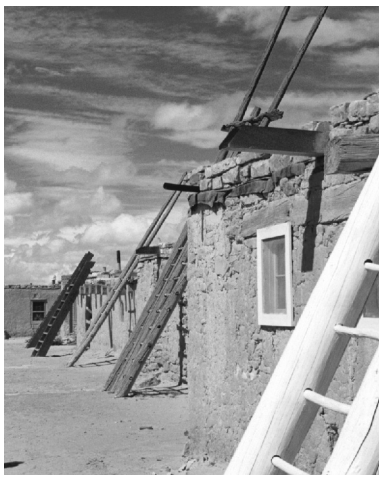
Abstracts of Papers Presented at

MathFest 2005



Albuquerque, New Mexico

August 4–6, 2005

The Mathematical Association of America

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Invited Addresses

AWM-MAA Lecture

Fern Hunt (hunt@cam.nist.gov) National Institute of Standards and Technology

Techniques for Visualizing Frequency Patterns in DNA

Many biological properties of a DNA sequence can be deduced from the frequencies of its constituent nucleic acids A,C,G,T and the subsequences they form. We will discuss some statistical properties of DNA that are amenable to visual and graphic display. Two examples among others to be presented are a visual representation of rare or avoided subsequences and an extension of Chargraff's rule.

Hedrick Lecture Series

Jeffrey Lagarias (lagarias@umich.edu) University of Michigan

Crystals, Tilings, and Packings

Tilings and packings have been a perennial source of mathematics, motivated by crystallography, number theory, geometry, coding theory, and for their own sake. Two of Hilbert's 23 problems are related to such questions (No. 3 and No. 18). These lectures, each self-contained, treat three independent topics in this area.

Lecture 1: Mathematics Crystals and Quasicrystals

Quasicrystals, discovered in 1982, are materials having long range order evidenced by their X-ray diffraction patterns, but which exhibit symmetries impossible for any crystalline structure. Understanding the structure of such materials leads to many interesting mathematical questions, not all answered. Recent developments shed new light on the boundary between crystallinity and aperiodic order.

Lecture 2: Tilings with One Tile

The first part of Hilbert's 18th problem asked about tilings of space by congruent copies of a single tile (an "Einstein"). Many questions about such tiles and the structure of their allowed tilings remain unsolved, even in one dimension.

Lecture 3: Apollonian Circle Packings

Arrangements of circles have been studied since antiquity. Apollonian circle packings are infinite arrangements of touching circles generated from an initial configuration of four mutually touching circles. The limit set of a packing (closure of tangency points) is one of the first studied fractals. Some Apollonian circle packings have an integral structure, involving both the radii and the centers of the circles. In this talk we discuss the structure of these packings and the source of these integrality properties.

James R.C. Leitzel Lecture

William Yslas Vélez (vélez@math.arizona.edu) University of Arizona

Increasing the Number of Mathematics Majors: Lessons Learned from Working With the Minority Community

In the late 1980s I began to increase the number of minorities surviving our first semester calculus course. My goal was very modest — help them pass this course. As I worked with these students my own ideas about the importance of calculus began to change. We all know that this course is the gateway to all scientific disciplines, but it is much more than this. It gives mathematicians the opportunity to entice students into the study of mathematics. Calculus should not be thought of as a service course for the university, it should be viewed as serving the intellectual needs of the student. My efforts to increase minority participation now

focus on helping students understand the importance of including more mathematics in their undergraduate curriculum. When I talk to students in calculus, I try to convince them to take more mathematics, and to become mathematics majors. This has resulted in s substantial increase in the number of minority mathematics majors in the department.

MAA Invited Addresses

Underwood Dudley (ddunx46135@yahoo.com) Florida State University

Calculus Texts

Calculus texts are important, and heavy. This talk will survey what has been in them since the first, L'Hospital's in 1696, what should be in them, and what should not be in them. It ends with a moral conclusion.

Robert L. Devaney (bob@bu.edu) Boston University

Cantor and Sierpinski, Julia and Fatou: Crazy Topology in Complex Dynamics

In this talk we will describe some of the very interesting topological spaces that arise as the Julia sets of complex functions such as the exponential and various rational functions. We will see a number of examples of Cantor bouquets and necklaces, Sierpinski curves and gaskets, and indecomposable continua, all in the guise of the chaotic regimes for these complex dynamical systems. We will also observe how these objects change from one to the other as parameters are varied.

Ruth Haas (rhaas@math.smith.edu) Smith College

Graphs, Trees, Pebbles, and Robots

The arboricity of a graph is the minimum number of spanning forests into which its edges can be partitioned. We discuss several old and new characterizations of this number and its variants, including a new method for finding this number through "pebbling" the graph. This work has application to determining if a graph is rigid and if not, what motions it allows. This in turn can be used to understand the motions of robots.

MAA-NAM David Blackwell Lecture

Leona H. Clark (lclark@bennett.edu) Bennett College for Women

Modeling the Pharmacokinetics of a Chemical Used in Household Consumer Products

Perfluorooctane sulfonate (PFOS), a member of a class of perfluorinated chemicals used in a variety of consumer products as oil, water, and grease repellants, has been shown to be persistent and widely distributed in the environment and has been detected in the blood of fluorochemical workers and non-occupationally exposed humans, there have been growing concerns about its potential health risk to humans. The mathematical model to be presented describes the pharmacokinetics (absorption, distribution, metabolism, and elimination) of PFOS following oral exposure and provides a framework for dose-response analyses needed to help assess the risk that exposure to PFOS might have on human health and the environment.

MAA Student Lecture

Annalisa Crannell (annalisa.crannell@fandm.edu) Franklin & Marshall College

Lights, Camera, Freeze!

Director/Producer Stephen "Marc" Frantzberg teams up with the world-famous actress Annalisa Monalisa Cranberry to bring you the new blockbuster hit, *Projection*. Spanning the centuries between Renaissance perspective painting and modern cinematic special effects, *Projection* reveals the true secrets behind projecting

a 3-dimensional world onto a 2-dimensional canvas (or movie screen). You'll laugh; you'll yawn; you'll cry; you'll reach the vanishing point. The movie includes a cast of thousands (or dozens, depending on how many people are in the audience).

PME/J. Sutherland Frame Lecture

Arthur T. Benjamin (benjamin@hmc.edu) Harvey Mudd College

Proofs That Really Count: The Art of Combinatorial Proof

Mathematics is the science of patterns, and mathematicians attempt to understand these patterns and discover new ones using various tools. In this talk, we demonstrate that many number patterns, even very complex ones, can be understood by simple counting arguments. You will enjoy the magic of Fibonacci numbers, Lucas numbers, continued fractions, and more. You can count on it! This talk is based on research with Professor Jennifer Quinn and many, many undergraduates.

Alder Award Lectures

Laura Taalman (taal@math.jmu.edu) James Madison University

Brainwashing and Great Expectations

Thoughts about teaching, persuasion, intimidation, expectations, bribes, and humor in the classroom.

Sarah J. Greenwald (greenwaldsj@appstate.edu) Appalachian State University

Connecting Students to Mathematics Using History, Visualization, and Pop Culture

We will explore activities and web pages I've created in order to help students connect to mathematics using history in a "What is a Mathematician?" segment, visualization in a "Geometry of the Earth and Universe" segment, and mathematical references found in popular culture such as "The Simpsons" and "Futurama."

Matt DeLong (mtdelong@tayloru.edu) Taylor University

Making Beautiful Music in the Mathematics Classroom

Teaching mathematics and making music are similar in that they require both good technique and passion to be most effective. As a full-time mathematics educator and part-time choral conductor, I will compare aesthetics in mathematics and music, and discuss the role beauty plays in inspiring teachers to teach and students to learn.

Invited Paper Sessions

Cool Applications of Complex Analysis at the Undergraduate Level

Michael Brilleslyper (mike.brilleslyper@usafa.edu) United States Air Force Academy, 9280 Chetwood Dr, Colorado Springs, CO, 80920

All Kinds of Sources and Sinks

Using conformal mappings to study electric fields or the velocity field of an ideal flow in some two-dimensional region is well known. Placing sources and sinks of various strengths at points on the boundary of the region is also known, though there are some subtle points about sources and sinks at infinity. In talk we extend the idea to entire intervals of sources and sinks along the boundary. We are thus able to simulate flows such as a levy breaking on a river or a uniform charge along a wire. We will show some very cool pictures of these types of flows in different regions.

Michael Dorff (mdorff@math.byu.edu) Brigham Young University, Department of Mathematics, Provo, UT, 84602

Minimal Surfaces by way of Complex Analysis

The soap film that forms when a wire is dipped into soap solution is an example of a minimal surface. One way to represent a minimal surface in $\mathbb{R}^3$ is to use a Weierstrass parametrization with analytic functions. Specifically, we use the real part of analytic functions which are the same thing as complex-valued harmonic functions. The study of minimal surfaces, which is an area in differential geometry, and the study of complex-valued harmonic functions, which is an area of classical complex analysis, have both increased tremendously in the last twenty years. Despite the connection between the two areas by way of the Weierstrass representation, research in these two areas is often done separately. We will discuss the connection between complex-valued harmonic functions and minimal surfaces, and we will show how results in one field can lead to new results in the other field.

Ken Stephenson (kens@math.utk.edu) University of Tennessee, Dept of Math, Knoxville, TN, 37996

Pushing Analytic Functions Around Circle by Circle

Analytic functions are all about geometry. A one-to-one onto map $f : A \longrightarrow B$ between open sets A and B of the plane can be treated as a "rubber sheet" map which distorts A onto B. If f is analytic, it somehow manages to do this while preserving the angles at which curves intersect! There is a new way to see this conformal geometry in action using "circle packings", configurations of circles having specified patterns of tangency. We will build and manipulate simple circle packings to illustrate the new "discrete" analytic function theory; then we will apply it to some practical problems, such as conformal mapping, conformal welding, and conformal "brain flattening".

Rich Stankewitz (rstankewitz@bsu.edu) Ball State University, Department of Mathematical Sciences, Muncie, IN, 47306

Real Chaos — Cool Complex Function Solutions

When a real valued function has multiple roots one may use Newton's method to locate (approximate) such roots. We will discuss why it is so difficult to describe the set of starting values for Newton's method that will find a given root. We will then discuss why the chaos that ensues leads one to look for and find answers in the world of complex function theory. We will also see how such complex function methods have led to great results in the study of other Real Dynamical systems. In particular, we will discuss the role played by complex functions in solving the Real Fatou Conjecture, an important result in the understanding of the real logistic maps $f(x) = ax(1 - x)$ where a is a real parameter and x is a real variable.

Double Bubbles in S^n & Gauss Space

Frank Morgan (frank.morgan@williams.edu) Williams College

Double Bubbles in S^n & Gauss Space

Members and alums of the Williams College NSF SMALL Undergraduate Research Geometry Group will report on the double bubble problem in the n-dimensional sphere S^n and Gauss space G^n. The double bubble problem asks for the least-area way to enclose and separate two given volumes. The general problem remains open in $\mathbb{R}^5$, S^3, and G^2, although there are interesting partial results.

The Many Branches of Dynamical Systems

Marc Chamberland (chamberl@math.grinnell.edu) Grinnell College, Dept of Math, Grinnell, IA, 50112

Dynamics of the Degree Six Landen Transformation

The classical Landen transformation, related to the arithmetic-geometric mean, leaves certain elliptic integrals invariant. Within the last five years, a similar transformation has been found which leaves another class of integrals invariant. A careful study of this new two-dimensional map determines its dynamics, matching exactly with what is expected from the corresponding integral. This talk is intended for a general audience.

Hal Smith (halsmith@asu.edu) Arizona State University, Dept. of Mathematics and Statistics, Tempe, AZ, 85287

Non-Monotone Systems Decomposable into Monotone Systems with Negative Feedback

Motivated by the work of Sontag and Angeli and Enciso and Sontag in control theory, we show that certain finite and infinite dimensional semi-dynamical systems with "negative feedback" can be decomposed into a monotone "open loop" system with "inputs" and a decreasing "output" function. The original system is reconstituted by "plugging the output into the input". Employing a technique of Cosner of imbedding the system into a larger symmetric monotone system, we are able to obtain information on the asymptotic behavior of solutions, including existence of positively invariant sets and global convergence.

Annalisa Crannell (annalisa.crannell@fandm.edu) Franklin & Marshall College, Box 3003, Department of Mathematics, Lancaster, PA, 17604-3003

Quasi-Continuous Dynamical Systems

We often study dynamical systems defined by functions that are continuous, but many of the standard topological theorems about dynamical systems can be generalized to a larger class of functions called "quasi-continuous". This talk will present examples of some of the more interesting properties of quasi-continuous functions, and it will explain what makes quasi-continuous functions ideally suited for chaos theory.

Interesting Topics in Difference Equations

Paul Eloe (Paul.Eloe@notes.udayton.edu) University of Dayton, Mathematics Department, Dayton, OH, 45469-2316

An Introduction to Discrete Fractional Calculus and Fractional Finite Difference Equations

We study a discrete analogue of the Riemann-Liouville fractional calculus. In this discussion, the time scale is the domain, $\mathbb{Z}$. We consider basic properties such as a Leibniz formula and a power rule. We employ a transform method to introduce the concept of a linear fractional difference equation. This work continues some initial work due to Kenneth S. Miller and Bertram Ross.

Johnny Henderson (johnny_henderson@baylor.edu) Baylor University, Mathematics Department, Waco, TX, 76798-7328

Nonlocal Boundary Value Problems for Second Order Difference Equations

Shooting methods are used to obtain solutions of the second order difference equation, $u(m+2) = f(m, u(m), u(m+1))$, $m \in \mathbb{Z}$, satisfying the three-point nonlocal boundary conditions, $u(m_1) = u_1$, $u(m_2) - u(m_3) = u_2$, where $f : \mathbb{Z} \times \mathbb{R}^2 \to \mathbb{R}$ is continuous, $m_1 < m_2 < m_3$ in $\mathbb{Z}$, and $u_1, u_2 \in \mathbb{R}$. Conditions are imposed implying that solutions of such problems are unique, when they exist; so this is a uniqueness implies existence result.

Gems in Applied Mathematics

Douglas Ensley (deensl@ship.edu) Shippensburg University, Mathematics Department, 1871 Old Main Drive, Shippensburg, PA, 17257

A Recurring Theme in Discrete Mathematics

We will discuss the many applications of recursive reasoning in a discrete mathematics course, beginning with simple number puzzles and ending with a recent joint research project with an economist in which dynamic programming played a key role.

Allan Rossman (arossman@calpoly.edu) Cal Poly - San Luis Obispo, Dept of Statistics, San Luis Obispo, CA, 93407

Choosing the Best: A Decision-Making Problem

The "secretary problem" is a classic one in probability and decision theory. The goal stated in the problem is to try to select the best among a known number of candidates, where you interview them one at a time and can rank the candidates after you have interviewed them. The biggest constraints are that after you have interviewed a candidate, you must decide immediately whether to hire him/her, and you can not go back and reconsider a candidate later. Moreover, your task is to choose the very best candidate. I present the solution to this problem for a given number of candidates and also in the limit. I also suggest ways to lead students at various levels, including high school, to investigate the problem. Finally, I suggest some extensions of the problem for further exploration.

M. Mayfield (mayfield@hood.edu) Hood College, Dept. of Mathematics, 401 Rosemont Ave., Frederick, MD, 21701

Parabolic Equation Method in Underwater Acoustics

We will get a glimpse into the world of underwater acoustics, a field populated by mathematicians, physicists and engineers. While some scientists gather data by performing experiments in the ocean, others develop mathematical models to predict sound propagation. We will focus on the latter approach, especially on a specific partial differential equation and its boundary conditions.

Dennis DeTurck (deturck@math.upenn.edu) University of Pennsylvania, Department of Mathematics, Philadelphia, PA, 19104-6395

What are You Thinking? How Eigenvectors Can Help

Mathematicians and computer scientists use eigenvalues and eigenvectors of positive matrices to aid in many decision-making processes. We will discuss one of these, the so-called *Analytic Hierarchy Process*, which turns rough pairwise comparisons into a scaled, rank-ordered list. The talk will emphasize aspects of the theoretical development of the method that are appropriate for undergraduate study.

Kay Somers (mekbs01@moravian.edu) Moravian College

What Preprocessing Can Do for an IP Problem

In this talk we will discuss two graph theory problems—the vertex cover problem and the dominating set problem—and their applications and representations as integer programming (IP) problems. We will look at the computational complexity of these IP problems and, using simplifying specialized preprocessing rules, see that some problems are NP-harder than others.

Gems in Number Theory

Jennifer Beineke (jbeineke@wnec.edu) Western New England College, Box 5005, 1215 Wilbraham Road, Springfield, MA, 01119

Great Moments of the Riemann Zeta Function

Movies have great moments and sports have great moments, but mathematics has the greatest moments of all. In this talk, we will explore moments of the Riemann zeta function (also known as mean values), and we will revisit the momentous discoveries of Hardy, Littlewood, and Ingham in the 1920s. We will also discuss memorable moments that today's number theorists have encountered as they work on open problems related to the Riemann Hypothesis.

Roger Nelsen (nelsen@lclark.edu) Lewis & Clark College, Department of Mathematical Sciences, MSC 110, Portland, OR, 97219-7899

Some Visual Gems from Elementary Number Theory

Geometry and number theory may be the two branches of mathematics richest in visual arguments. In this talk we will examine some visual gems from elementary number theory. Examples will include figurate numbers, congruences, the irrationality of the square root of 2, Pythagorean triples, perfect numbers, etc.

Marc Chamberland (chamberl@math.grinnell.edu) Grinnell, College, Dept of Math, Grinnell, IA, 50112

The Collatz Chameleon

The Collatz Conjecture (also known as the $3x + 1$ problem) is a long-standing conjecture in number theory. Let T be a map from the positive integers into itself, where $T(x) = x/2$ if x is even and $T(x) = (3x+1)/2$ if x is odd. The conjecture claims that, under iteration of the map T, any positive integer eventually reaches the value one. While the problem is still open, it has many equivalent reformulations. This general talk looks at the various "shades" of this elusive "chameleon."

Graph Theory Ideas for Undergraduate Research

Daniel Isaksen (isaksen@math.wayne.edu) Wayne State University, Department of Mathematics, Detroit, MI, 48202

Hamiltonian Circuits in Cayley Digraphs

Consider the direct product of two directed cycles. The goal of this talk is to describe conditions that guarantee that this digraph, or various variations on this digraph, is Hamiltonian. The proofs rely mainly on elementary number theory. Finite abelian groups also enter the picture because the digraphs are Cayley digraphs of abelian groups.

Aparna Higgins (aparna.higgins@notes.udayton.edu) University of Dayton, Department of Mathematics, Dayton, OH, 45469-2316

Line Graphs and Pebbling

The line graph of a graph is formed by using the edges of the original graph as vertices, with an edge between two vertices of the line graph if and only if these vertices share a common vertex when considered as edges of

the original graph. Interesting questions include determining which properties of a graph are preserved under the operation of creating a line graph. Repeating the line graph operation on a graph creates an iterated line graph. It can be shown that certain properties not possessed by the original graph are guaranteed to appear in an iterated line graph for a sufficiently large iteration. Pebbling on graphs is a popular topic for undergraduate research. Consider a connected graph with an assignment of non-negative integers, called pebbles, to its vertices. A pebbling move consists of removing two pebbles from a vertex, moving one of those pebbles to an adjacent vertex and throwing away the second pebble. The pebbling number of a graph is the minimum number of pebbles such that, starting with any distribution of this number of pebbles, a sequence of pebbling moves will allow one pebble to reach any specified vertex of the graph. In addition to answering questions regarding the pebbling numbers of specific classes of graphs, students enjoy defining variations of pebbling and finding results analogous to those known in classical pebbling. Combining the topics of line graphs and pebbling provides many questions, including how the pebbling number of the line graph of a graph relates to the pebbling number of the original graph. We will consider some results discovered by undergraduate students and some open questions on these topics.

Zszusanna Szaniszlo (zsuzsanna.szaniszlo@valpo.edu) Valparaiso University, Department of Mathematics and Computer Science, Valparaiso, IN, 46383

Some Attractive Animals of the Graph Labeling Zoo

Graph labelings were introduced by Alex Rosa in the late 1960's as a tool for decomposing complete graphs into isomorphic copies of given subgraphs. In the last forty years graph labelings became a rapidly growing area of research with close to 700 published papers. For regularly updated information on current results see Joe Gallian's excellent survey in the Electronic Journal of Combinatorics.

While labeling a graph one can assign labels to the vertices, to the edges, or to both. In most labeling problems the vertices of the graph are assigned non-negative integers as labels. The label of an edge is induced by the labels of the vertices the edge connects. Different labelings differ based on how the edge labels are derived and what conditions we require the edge and vertex labels to satisfy. Many labelings are some form of generalizations of the graceful labeling where every vertex must have a different label from the set {0,1,2,…,e-1}, e is the number of edges of the graph. The edge labels are defined as the absolute value of the labels of the incident vertices; we require every edge label to be different as well.

In this talk we will discuss several different types of labelings, open problems and the ir appropriateness for undergraduate research.

Joseph Gallian (jgallian@d.umn.edu) University of Minnesota, Twin Cities, 1049 University Drive, Duluth, MN, 55812

What Makes a Good Undergrad Graph Theory Problem?

In the talk I will give my opinion about what makes a good graph theory research problem for an undergraduate student and how one can find such problems. Specific examples will be included.

History and Philosophy of Mathematics

Janet Barnett (janet.barnett@colostate-pueblo.edu) Colorado State University-Pueblo, Department of Mathematics and Physics, 2200 Bonforte Boulevard, Pueblo, CO, 81001 - 4901

History as Travel Guide and Companion

As a travel companion, history can enrich and intensify our experiences by enhancing our understanding and appreciation of mathematics' rich culture, world-famous landmarks and exquisite natural landscapes. In addition to the usual fare of any travel guide — tips on recognizing and avoiding tourist traps, practical advice to make the journey run safely and smoothly, and suggested itineraries that enable travellers to make informed choices — history offers opportunities to create memorable experiences through unexpected discoveries and the rewards of wandering off the beaten track. By encouraging us to explore and respect the unfamiliar,

history also has potential to broaden our intellectual horizons beyond mathematics, and to teach us new ways of measuring the quality and value of our work in mathematics and teaching.

In this talk, I will share highlights from travels my students and I have shared with history in both mathematics and history of mathematics courses. In addition to specific examples of how history can be used to enhance students' own mathematical understanding *and* ability to listen to the mathematical understanding of others, I will discuss some less explicit ways in which traveling with history has informed my teaching practice and philosophy. In closing, I will comment on how historical expeditions into topics such as 'mathematics and war' have shaped my broader thinking about mathematics and its teaching, past and present.

Rodrigo Cambray-Núnez (rcnroc@hotmail.com) Universidad Pedagógica Nacional, Unidad Ajusco, México, DF, MÉXICO

Reform of the Basic Education Mathematics Curriculum in México (1992-2000)

A common belief about school mathematics, increasingly held worldwide, at least since the beginning of the 1980s, is that educational research can contribute to the improvement of teaching practices. However, researchers have come to realize that educational research can provide another kind of insight. Schubring (1987) proposed that school mathematics could "serve as an analytical tool for studying the relations between mathematics and society at large" (p. 49). The processes by which research finds its way into pedagogical practices can also contribute to improved teaching. In México, new mathematics plans and programs were implemented for mandatory basic education (grades 1–9) during the 1990s. An historical approach was used in research efforts by the presenter with the main purpose of determining what important forces drove that recent reform process of school mathematics (see: Cambray-Núñez, 2003). The research process allowed to ascertain what forces interacted to drive the curriculum change and determine what contents and instruction methods proposed by research in the area of mathematics education had an influence on or were incorporated into the reformed curriculum. This research study briefly described about curricular reform in México is an example of Schubring's comment and how educative policy making interacts with society at large-it provides some insights into the relationships between mathematics and different aspects of the development of the Mexican society from the perspective of school mathematics, which is a specific and particular corpus of knowledge and methods. Data for analyzing the process of the mathematics curriculum reform for mandatory basic education in México during the 1990s were collected from document analysis and from semi-structured interviews with some of the main leaders of the reform process. Information and judgments that interviewees shared about their personal participation served to investigate further that process as well to gather information regarding broader issues that helped form the context of that reform. The combination of data collected strengthened the identification of emphatic signs about interactions among different forces. Moreover, the analysis of combined data gave internal consistency and thereby increased reliability of an account of the development and the structure of school mathematics in México.

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1. Cambray-Núñez, R. (2003). Reform process of the mathematics curriculum for basic education in Mexico during 1992–2000. Ball State University, Muncie, IN. [Unpublished doctoral dissertation]
2. Schubring, G. (1987). On the methodology of analysing historical textbooks: Lacroix as textbook author. *For the Learning of Mathematics*, 7, 3, pp. 41–51.

Alejandro Garciadiego (gardan@servidor.unam.mx) Caravaggio 24, Col. Nonoalco, Mexico, D. F., NM, 03700

Teaching Mathematics: A Multidisciplinary Approach

Recent international evaluations have shown that, in general, high school Mexican students are unable to solve daily problems with their knowledge of mathematics, science, reading and writing skills. Although, the international mathematical community produces a great variety of excellent pedagogical resources to face this situation, most of these materials (but most important the focus), are inadequate to the average pupil. In this talk, I will argue that we need to approach this condition from the perspective of the humanities (especially history and philosophy), arts and the social sciences. Students will profit from understanding the problems intellectuals were attempting to solve and the meaning and connotation of the original concepts,

among other issues. Subconsciously,students will acquire a mathematical culture, even before the technical details are developed.

Teaching Combinatorial Mathematics

Richard Grassl (richard.grassl@unco.edu) University of Northern Colorado, Math. Sciences, Greeley, CO, 80639

Discrete Mathematics for Preservice Teachers

Discrete and combinatorial mathematics is receiving increased attention in teacher preparation programs. Given the rapidly changing needs of our secondary educators, it is incumbent upon those of us responsible for preparing these teachers to stay current in reform efforts and to incorporate successful teaching into preservice teacher undergraduate courses such as discrete mathematics. This presentation will focus on several strands: The method of content delivery , how content can be "spiraled through the curriculum", the advantages of using technology, connections(especially to calculus), data collection-conjecturing-proving, benefits of cooperative groups, multiple representations (geometric interpretations of combinatorial identities),and challenging problems.

Alan Tucker (atucker@notes.cc.sunysb.edu) SUNY at Stony Brook

How George Pólya Taught Me to Teach Combinatorics

This speaker had the opportunity to be a teaching assistant at Stanford when that school's first undergraduate combinatorics course was offered. George Pólya came out of retirement to teach the enumerative part of the course. This presentation will share the insights gained from that experience and how they have guided my own teaching and writing about combinatorics.

David Bressoud (bressoud@macalester.edu) Macalester College, Mathematics Dept, St. Paul, MN, 55105

Teaching Combinatorics in a Discrete Math Class

One of the goals of discrete math is to give students experience with and confidence in solving unfamiliar problems that require multiple steps. Combinatorics provides easily accessible yet challenging problems that are perfect for such a course. I will talk about one of the most successful of my projects that is built around the MAA video "Let Us Teach Guessing" in which George Pólya leads a class toward discovering the formula for the number of regions in space cut by n planes.

Jack Graver (jegraver@syr.edu) Syracuse University, Department of Mathematics, Syracuse, NY, 13244

Thoughts on Teaching Combinatorics

Graphs, designs, matroids, etc. are all interesting and important combinatorial structures. But, what I find most intriguing is the intrinsic structure of a finite set. For example: did you know that you can find at most n odd (in cardinality) subsets of an n-set that have pair-wise even intersections; can you prove it? I will make the case for including a study of this intrinsic structure in any upper class or graduate combinatorics course.

Contributed Paper Sessions

Advances in Recreational Mathematics

Brian Borchers (borchers@nmt.edu) New Mexico Institute of Mining and Technology, Department of Mathematics, 801 Leroy Place, Socorro, NM, 87801

Achievement and Avoidance Games on Semigraphs

A semiline $h = (u, v)$ is "one–half" of an edge that is incident to u but not to v. One can imagine that h goes halfway from u to v. Starting with four vertices, two players, A and B, take turns adding semilines. In the triangle achievement (avoidance) game, the first player to complete a triangle wins (loses). We will show that player B has a winning strategy in both games. We will also consider quadrilateral achievement and avoidance games on four and five vertices. This is joint work with the late Curtis Barefoot and Frank Harary.

Matthew Horak (matthew.horak@trincoll.edu) Trinity College, Hartford, CT, Hartford, CT, 06106

A Disentanglement Puzzle Leads Through Knot Theory

Mathematical puzzles have long been a source of entertainment and inspiration, and indeed the solutions to many puzzles involve mathematical ideas accessible at various levels. As such, puzzles can often be used as tools for introducing students to interesting fields of mathematics in a recreational setting. Examples include the combinatorial puzzles, Peg Solitaire and Instant Insanity, whose solutions involve elementary ideas from algebra and graph theory. The class of puzzles known as *disentanglement puzzles* serves as a nice introduction point to topology and knot theory. In this talk, I will focus on an analysis of the possible solutions to the disentanglement puzzle Quattro and show how this analysis leads on a self-contained tour through the first ideas of knot theory.

George Bell (gibell@comcast.net) 5040 Ingersoll Pl, Boulder, CO, 80303
John Beasley (johnbeasley@mail.com) 7 St. James Rd, Harpenden, United Kingdom, NL, AL5 4NX

New Results in Peg Solitaire

The game (or puzzle) of peg solitaire has been around for more than 300 years; it is commonly played on a 33 hole cross-shaped board or a 15 hole triangular board. Much has been proven regarding problems on the 33 hole board without resorting to exhaustive computer search. For larger boards, however, the computer can be useful for tackling certain unsolved problems. Many of these involve finding elegant solutions where a large number of pegs are captured in a single multi-jump move.

We will discuss computational techniques for solving the game, as well as pitfalls of using a computer without thinking. We will summarize several new results for boards larger than the standard boards.

Annela Kelly (akelly@ulm.edu) University of Louisiana at Monroe, 2909 Magellan Place, Monroe, LA, 71201

Nim for Three or More Players

The classical analysis of the two-player Nim game bases on binary representations. In the case of three or more players, the result of the game can not be completely determined without considering alliances. We define Survivor Nim for more than two players, where we will assume that each player will consider their personal interests first, and after that they will support their alliance partner(s). This talk discusses how the structure of the alliances determines the winning positions.

Paul Coe (coepaul@dom.edu) Dominican University, Dept. of Mathematics and Computer Science, 7900 W. Division St., River Forest, IL, 60089

Optimal Strategy for "Trick Your Neighbor"

My middle-school-age children play a card game called "Trick Your Neighbor." In this card game, each player is dealt one card, and the object of the game is not to end up with the lowest-valued card (Ace = 1, Two = 2, . . . , King = 13). Starting with the player to the left of the dealer, each player in turn decides to keep the card that he or she has or trade it for the card held by the player on his or her left. When it is the dealer's turn, she can keep her current card (whether dealt or received from the player on her right), or she can trade it for the top card of the deck. My students call this game "Screw Your Neighbor," and I have heard it called by other names as well.

In my paper I derive the optimal strategy for the two-player version of this game. That is, I derive what card values the first player should trade and what values he should not trade, and, given this, under what conditions the second player (the dealer) should trade her card for the top card of the deck. I also discuss the impact of modifications to the rules of the game and extensions to more than two players.

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Simulating Alcohol Use Among College Students

Many aggregate social phenomena are characterized by individuals making decisions based on very simple rules. Taken together, these simple individual decisions can cause very complicated societal structures. For example, colonies of bees and termites, though very simple creatures, can construct extremely complicated dwellings. The premise for "Agent-Based Modeling," a.k.a. "Artificial Societies," is to use mathematical functions and randomness to simulate each individual's actions, decisions, and experiences in order to observe how these individual actions affect the society as a whole.

An artificial society program was written to simulate alcohol use among college students. Using a normal distribution, each student is initialized with a set of randomly-assigned properties, such as shyness, attitude towards alcohol, and grade point average. The student "agents" are also assigned a list of friends based on shyness and attitude compatibility. The binomial distribution is used to assign initial alcohol usage rates. As the program runs, days go by and students meet other students, make new friends, host and attend parties, and base their decisions of whether or not to drink on attitude and peer pressure. Each time a student drinks, he/she will have a normally-distributed positive or negative experience. A cubic function normalized by usage rate determines how this experience affects the agent's attitude towards drinking. The student's experiences will affect the attitudes of their immediate friends and to a decaying extent the attitudes of other students depending on the degree of separation (a friend of a friend has a degree of separation of 2). Additionally, every 21 days students who are drinking heavily can suffer a bad experience due to poor school work. At the end of the semester, grades can be affected by drinking rates and students can be expelled.

Initial results from the program show a high sensitivity to the mean and standard deviation of the random number controlling experience level. A set of bad experiences can cause "tipping" in which almost all attitudes become negative resulting in drinking rates quickly decreasing to zero. Many times the students will become polarized; the ones who do partake will drink a lot while many others won't drink at all. Also, when there are only 100 students in the simulation, the drinking rate seems to be much higher than when there are 500 or more.

The presentation will include an explanation of the program, a discussion of results, and a summary of future plans.

David Finn (david.finn@rose-hulman.edu) Rose-Hulman Institute of Technology, Department of Mathematics, CM140, 5500 Wabash Avenue, Terre Haute, IN, 47803

Some New Results on the Geometry of Tire Tracks

Based on the title problem of the book "Which way the bicycle go?" by Konhauser, Velleman and Wagon, the speaker has shown in recent papers, "Can a bicycle create a unicycle track?" and "Which way did you say that bicycle went?" that it is possible to construct a unicycle track with a bicycle and a set of bicycle tracks for which you can not determine the direction the bicycle went. The results in these papers showed the existence of such tracks in a general way. In this talk, we will answer several questions posed to the speaker

about whether it is possible to construct closed unicycle tracks with a bicycle and closed bicycle tracks for which you can not determine which way the bicycle was going.

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Jamie Shackelford (jamieshack@yahoo.com) St. Edward's University, Math Dept; 3001 South Congress Avenue, Austin, TX, 78704

The House of Many Gables

We consider the problem of finding the largest square that can be covered by n equilateral triangles of side length one, where all figures must have one side parallel to a fixed line. For a given n, the side length of an optimal square is denoted by $z(n)$. This problem has been studied as an undergraduate research project and we present results, including the result that $z(n)$ is increasing with n. We also state open questions.

Aligning Assessment Methods w/Learning & Teaching for Majors

Luz DeAlba (luz.dealba@drake.edu) Drake University, 2507 University Avenue, Department of Mathematics, Des Moines, IA, 50014

Assessment Strategies for Linear Algebra

While many instructors have developed diverse and novel methods for teaching mathematics, and the focus has shifted from teaching to learning, assessment of student learning in mathematics is in the early stages of its development. As a result, departments are conducting rigorous self-examination processes. Such a thorough review of a program is now accompanied by a formulation of general core student competencies, designated as Intended Student Learning Outcomes for the program. These learning goals represent the beginning of the assessment cycle and must be mapped back into the curriculum. The next step in the assessment cycle is for a program to ensure that students are given sufficient opportunities to achieve those outcomes, and must have in place a means of systematically gathering and interpreting evidence about student learning. The assessment cycle is completed with a discussion and analysis of assessment results to improve learning.

In this presentation we outline a set of intended learning outcomes for the Department of Mathematics at Drake University and endeavor to align these outcomes to the introductory linear algebra course. We also present specific learning opportunities that will help students to achieve these outcomes. Finally, we discuss several assessment techniques, including classroom assessment, competency quizzes, projects, essays, rubrics, and portfolios for measuring these outcomes and collecting evidence of student learning.

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Course-Embedded Assessment in Math Courses

Teaching Abstract Algebra last semester, I have found that our students tend to think that reasoning of mathematics ideas are mostly conveyed in symbols and hence a mathematical proof is all about manipulating symbols — in which most students find very little interest. Our students do not recognize other important aspects such as oral and written communication skills that one must possess to be mathematically literate. Most students have little opportunity to talk, draw, and write about mathematical ideas throughout their Mathematics Education. Consequently, our students have difficulty to reason clearly when being asked to express their understanding in words.

According to the pre-test assessment that was given during the first week of class, I found more than 75% of students failed when being challenged to make their thinking "visible" through writing. The percentage increases even more when students were challenged to confront their own understanding of a mathematics concept presented in a variety of forms.

In order to help students begin to develop and refine their mathematical communication skill, I adopt a course-embedded assessment for this course. Part of the guidelines/ideas of this assessment came from "teaching and learning strategies for language minority students," a workshop given by Dr. Sharon Snyder (Kean University). The following process is used in each class:

1. Determine what the reasonable expectations are. These expectations are shared by both the students and the instructor and clearly stated/listed in a written form served as the evaluation criteria.
2. Use appropriate assessment method to promote active learning: an oral presentation in class (5-minute and 10-minute talk) for each student, and a follow-up written assignment to conclude or extend (mathematical journal) the lesson.
3. Reference to the criteria is embedded in the course from the beginning to the end. Students monitor themselves in relation to the criteria. Instructor will use the same criteria to evaluate students.
4. Students and instructor conference regarding each presentation and assignment, including discussion of their respective ratings on the criteria. Both sides also discuss the positive and the negative aspects in students work and find the area for improvement in relation to course criteria.
5. Student will rework on the assignment and turn-in their second draft.
6. Such format will iterate throughout the entire semester.

In this talk, we focus on the assessment methods (short oral presentation and journal entry) and the effectiveness of using these methods to help students gain a wide range of understandings, higher order intellectual skills and values. We will also look at the systematic analysis of students performance on assessed tasks and use it to identify areas of the curriculum/teaching method which need improvement.

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The Mathematics-Language Skill Connection at STU

Last century has witnessed a colossal advance in many areas of science, from system biology to astronomy, from social sciences to linguistics, from pure and applied mathematics to bioinformatics and computer science. However, an increasing resistance to study and apply mathematical ideas has been observed in all levels of education. Motivated by these facts and the statistics on student's performance accumulated at Saint Thomas University, in this contribution, the connection between basic skills in both mathematics and language are analyzed. A regretional model combining different factors affecting the student's performance is considered and preliminary results will be presented.

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Using a Course-End Report for Assessment

What we assess in some way defines what we value. Lynn Steen writes that at the summative stage, assessment seeks to record impact, compare outcomes with goals, rank students, and stimulate action either to modify, extend, or replicate. It is this summative stage that reveals if we are successful in developing our students into educated learners. When the course ends and we have finished with our assessment tools (grading projects or final exams, for example), we need to reflect back on our goals. Are the goals appropriate? Did we meet the goals of the course? This reflection is enhanced if done formally in a course-end report. We believe there are tremendous advantages in keeping the implementations and an analysis of their meaning in one record. In addition, the course-end report should include a summary of the initiatives implemented within the course and a discussion of suggested changes for the next cycle of the course, as well as a review of the course's learning outcomes. This paper will offer insights to creating and maintaining the course-end report, a compilation of the instructor's (or, if several instructors teach the same course, the course director's) assessment of the recent course, as well as actual course-end reports for both core courses and electives, which have been used to support accreditation.

Current Issues in Mathematics Education Courses

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3M at ULM

For the past two summers, a federal grant has allowed the University of Louisiana at Monroe to conduct "Making Mathematics Meaningful" workshops for in-service middle school and high school teachers. Two

of the strengths of the program have been the commitment to modeling active learning strategies and the inclusion of a wide spectrum of technologies for teaching. After briefly outlining our training approach, the talk will discuss the funding, the interactions with area school districts, and the issue of graduate credits.

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A Curriculum and Assessment Course for HS Teachers

In this presentation the course syllabus and student work from my curriculum and assessment in grades 7-12 course will be shared. This graduate course supports pre-service and in-service teachers in developing and enhancing knowledge and use of a variety of curricula and types of assessments used in the United States and other countries in the secondary school environment. Assessment of students and teachers have varied significantly in recent years to replacing "a test" which is a one-time event, with "ongoing evaluation." In this class we discuss many of the new and exciting methods and means to evaluate students and improve understanding and instruction. Readings include sections of The Principles and Standards in School Mathematics (NCTM, 2000) and other articles. We view videos about different curricula, standards based classrooms, and the TIMSS study. Students participate in weekly online discussion forums related to the readings and/or the videos. The students are required to write an annotated bibliography focusing on some area of curriculum and assessment. They also give a twenty minute presentation of either a snapshot of a lesson from some curriculum or look at a specific assessment.

Archie Earl (awearl@nsu.edu) Norfolk State University, 4728 Barn Swallow Dr., Chesapeake, VA, 23321

A High-Tech In-Service Graduate Math Course

This paper discusses some of the technologies used in a new graduate level mathematics course for in-service middle and high school teachers. The course is offered by the Mathematics Department of Norfolk State University, in Norfolk, Virginia, USA. Technologies are identified and examples of how they are used in the course are presented. Some of the technologies covered include the internet, the graphing calculator, instructional CD and VS videos, and Microsoft Excel.

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A New Hands-on University Calculus Course for High School Teachers

In fall 2005 at New Mexico State University we will offer for the first time a new mathematics course, Calculus with hands-on applications for teachers. It is substantially different in approach and choice of topics from calculus courses offered to the general population of students because it addresses the specific needs of high school teachers. Below (and in the talk) we describe the content and format of the course and the rationale for it.

N. Leveille (nleveille@houston.rr.com) One Main Street, Houston, TX, 77002-1001

Assessment for Pre-service Teachers

While the "Principles and Standards for School Mathematics" encourages K–12 teachers to use "many assessment techniques . . . including open-ended questions, constructed-response tasks, selected-response tasks, performance tasks, observations, conversations, journals, and portfolios" (NCTM, 2000, p. 23), many students in mathematics education courses may not yet have experienced some of these. In order to use many different assessment methods in their future teaching, pre-service teachers would benefit from their own mathematics knowledge being assessed via a large variety of assessment methods. This talk will encourage discussion and provide resources for a variety of assessment techniques.

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Capstone Courses for Future Mathematics Teachers

The mathematics that future teachers understand is critical to their ability to be good mathematics teachers (Carlsen, 1993; Brown & Borko, 1992; Mosenthal & Ball, 1992; Stein, Baxter, & Leinhardt, 1990; Van

Dooren, Verschaffel, & Onghena, 2002; Winsor, 2003). Thus it is important that mathematics faculty pay close attention to future teachers' mathematical understanding. This paper will describe a capstone course for secondary preservice teachers, as recommended by CBMS (2001). Topics of this paper will include what future mathematics teachers know and do not know mathematically, how a capstone course might benefit future teachers, and how the capstone course is administered. Data from the capstone course at UTEP will be used to help demonstrate the need and effects of the capstone course on future secondary teachers.

Ekaterina Lioutikova (elioutikova@sjc.edu) Saint Joseph College, 1678 Asylum Avenue, West Hartford, CT, 06117

Connecting Mathematics and Pedagogy in a Mathematics Course for Future Elementary Teachers

According to recommendations stated in the *Mathematical Education of Teachers* and other national reports, prospective teachers need to develop a deep conceptual understanding of the mathematics they will teach. In addition, it is important for future elementary teachers to build connections between their own mathematical knowledge and the pedagogy of elementary mathematics. This talk will describe a new mathematical content course for pre-service elementary teachers designed with the above goals in mind. Topics, materials and activities for this course have been selected to emphasize mathematical reasoning and sense-making, clarify and overcome common misconceptions, and provide opportunities to hold conversations about mathematical ideas. To help build mathematical connections, students analyze the mathematical thinking of children through case studies written by practicing elementary teachers. Based on data collected via pre-tests and post-tests, we will discuss the effect of the course on students' beliefs about mathematics as well as their pedagogical content knowledge. This work is supported by a PMET (Preparing Mathematicians to Educate Teachers) mini-grant.

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How to Help English Language Learners Succeed!

A current vital issue in mathematics education courses that affects both pre-service and in-service teachers is how to promote mathematics success among English language learners.

This issue has been highlighted by the 2000 U.S. Census Report, which described the rapid growth in the Hispanic population and projected that Hispanics would be the largest minority (13.8% of total US population) by 2003 (17 years earlier than originally projected). This number reflects a 58% increase in the Hispanic population from 1990–2000. The Census Report also indicates that each year through 2050, 1 in 8 Americans over the age of 5 will speak a language other than English in the home and that 1 in 10 Americans over the age of 5 will speak Spanish.

The Texas Education Agency (TEA) has identified English language learners (ELL) as the lowest performing group on all of the statewide-standardized Texas Assessment of Knowledge and Skills (TAKS) tests, scoring below African Americans, Hispanics, Whites, Special Education students, and the Economically Disadvantaged.

This paper will describe a research-based framework for classroom practices that is designed to foster awareness of the problems, issues, and successes related to closing the gaps in mathematics achievement for English language learners.

Donna Beers (donna.beers@simmons.edu) Simmons College

Infusing Writing to Promote Students' Knowledge of Mathematics for Teaching

A summer workshop led by Deborah Loewenberg Ball and her colleagues at the Center for Teaching Proficiency in Mathematics (CPTM) at the University of Michigan inspired our efforts this spring in revising a course for prospective elementary school teachers. The workshop, Developing Teachers' Mathematical Knowledge for Teaching, proposed that the mathematics which prospective teachers need for teaching entails specialized knowledge beyond the content covered in traditional mathematics courses. As noted by Ball, it entails skills in giving mathematical explanations as well as evaluating those made by students, providing

"on-the spot" analysis of student errors, choosing and using a variety of representations for modeling and reasoning about procedures.

Many of our prospective elementary school teachers say they feel more confident in writing than in mathematics, and this presentation will describe how we used writing as a vehicle for students to learn mathematics and to transfer their knowledge of content to the practice of teaching. This talk will include the following aspects of our course: examples of writing assignments and samples of student work, the role of a student writing assistant, the use of a significant new textbook for elementary school teachers, the alignment of formative assessment with content and pedagogy, and the results of pre- and post-attitudinal surveys and course evaluations. Last, we will describe lessons learned and plans for developing a learning community next year that will integrate our content course with a methods course taught by the education program.

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Sybille Clayton (sclayton1@aacc.edu) Anne Arundel Community College, 101 College Parkway, Arnold, MD, 21012
Mike Lueke (hmlueke) Anne Arundel Community College, 101 College Parkway, Arnold, MD, 21012

Integrating Service Learning in Classes for Teachers

Involving pre-service teachers in the community by giving them the opportunity to help at local schools, in after school programs, or in other related fields is a worthwhile learning experience called "Service Learning". We have used Service Learning in several courses and encountered challenges and success along the way. We would like to share our experiences with setting up and integrating a Service Learning component in mathematics classes for pre-service teachers. We will focus on its impact on our students as well as on ways to make it effective.

Diane Spresser (dspresse@nsf.gov) Math and Science Partnership Program, 4201 Wilson Boulevard, Suite 875, Arlington, VA, 22230

NSF's Math and Science Partnership Program

The Math and Science Partnership (MSP) program at the National Science Foundation is recognized as an important research and development effort for integrating the work of higher education — especially that of faculty in mathematics, the sciences and/or engineering — with that of K–12 to strengthen and reform mathematics and science education at all levels. All funded Partnerships are required to address teacher quality, quantity and diversity; challenging courses and curricula; and the institutional changes needed in both higher education and K–12 to sustain the work. The program places a premium on evidence-based design and outcomes for all funded projects. Examples of projects and interim findings since the MSP program began in 2002 will be presented.

Paula Stickles (pstickle@indiana.edu) Indiana University, 233 West 44th Street, Jasper, IN, 47546

Overview of a Technology Course for Pre- and In-Service Mathematics Teachers

Using technology in the mathematics classroom is not just an option anymore. It is a necessity. We as mathematics educators must arm our students with the proper tools before they leave our classrooms for their own. In this session, a newly developed technology course for pre-service and in-service secondary mathematics teachers will be discussed. The course is designed so in-service teachers earn graduate credit and pre-service teachers earn undergraduate credit. Discussion will include the syllabus and course design, innovative assignments, and student response/work.

Judy O'Neal (joneal@ngcsu.edu) North Georgia College & State University, Department of Mathematics & Computer Science, Dahlonega, GA, 30597

Partnership Grant for MG Mathematics Teachers

Developing and retaining competent mathematics teachers who possess appropriate depth of content knowledge in the mathematical sciences, pedagogical skills for mathematics teaching excellence, and the ability to bring students from diverse groups to high levels of achievement is a common and attainable goal throughout the

country. A critical step toward this goal is tailoring in-service training for grades 6–8 mathematics teachers so that specific needs of the teachers, the school districts, and the state mandated curriculum are addressed. As Georgia's new Performance Standards for Mathematics begin the phase-in process with 6th grade mathematics in Fall 2005, followed by 7th and 8th grade mathematics in subsequent years, middle grades teachers are expected to facilitate students' deeper conceptual understanding by forgoing breadth. Consequently, a deeper understanding of the content middle school mathematics teachers are expected to develop in their students must first be developed in themselves.

This presentation will outline how a university and local school system partnered to implement a sustained contact three-year project for upgrading the mathematical content and pedagogical knowledge of middle grades mathematics teachers. Specifics related to the procurement of funding, content selection, instructional delivery components, instructional tools such as manipulatives and technology, unit writing by participants, assessment of participants, summer project evaluation, and follow-up phase will be included. Samples of manipulative and technology-based activities, performance-based assessment rubrics, and participant comments will also be included.

Elizabeth Burroughs (eb38@humboldt.edu) Humboldt State University, Department of Mathematics, 1 Harpst Street, Arcata, CA, 95521

Supporting Teachers of English Language Learners

Most mathematics teachers are in classrooms where the student population includes English Language Learners. Those who prepare pre-service teachers and provide professional development for in-service teachers are challenged to support these teachers with second-language acquisition methodology specialized for mathematics content. This talk will report on the use of a professional development program designed by the California Mathematics Project to provide in-service and pre-service mathematics teachers with English language development strategies in the context of an Algebra curriculum. Particular focus will be on integrating the content of this program.

Ted Gamelin (twg@math.ucla.edu) UCLA, Mathematics Department, Los Angeles, CA, 90095-1555

Symbiosis of Mathematician and Classroom Teacher

How can a mathematician and a teacher/educator combine to co-teach a capstone course? We report on the experimental course we have developed at UCLA for math majors interested in a teaching career. We describe several problems that we have encountered in mounting a capstone course at a research mathematics department, and we also point to some bonus benefits.

Jeff Johannes (johannes@member.ams.org) SUNY Geneseo, 1 College Circle, Geneseo, NY, 14454-1213

Why Are We Math Majors?

While coteaching our department's secondary education capstone course, I collected students' thoughts on the connections they see between their undergraduate curriculum and their future career as secondary mathematics teachers. I will share several items from students and discuss ways of further emphasizing these connections.

Environmental Mathematics

Magdalena Luca (magdalena.luca@bos.mcphs.edu) Massachusetts College of Pharmacy and Health Sciences, School of Arts & Sciences, 179 Longwood Avenue, Boston, MA, 02115

Developing Mathematical Problems for Pharmacy Students using Alzheimer's Disease Models

In this presentation I will discuss how I use results from the mathematical modeling of Alzheimer's disease to develop problems for pharmacy and health sciences students. These problems can be efficiently utilized to teach undergraduate courses in Statistics, Calculus, and Algebra. The intent in using actual examples of applications of mathematics in biology, even in entry level courses, is two fold: to aid students in understanding mathematics and to introduce them to interesting medical issues. My goal is to also address how the challenge

of teaching mathematics to future health care workers could become an extremely rewarding endeavor when students understand and enjoy mathematics through the use of real biomedical applications in lectures.

Robb Sinn (rsinn@ngcsu.edu) North Georgia College & State University, Math/CS Dept, Dahlonega, GA, 30597

Ecosystem Simulations on the Graphing Calculator

Why would an ecologist want to know about linear iterations? Three reasons. They can model a simple ecosystem, can be performed on a standard graphing calculator with a half-dozen keystrokes, and are accessible to middle grades students with extensions appropriate to precalculus and beyond. This presentation will discuss an ecosystem unit with incredible flexibility for use in general education mathematics and science courses. The iterations can be done quickly, understood readily and serve well to introduce myriad topics. The extensions to discrete mathematics are exciting, non-trivial and have many important real-world connections. The mathematics content applies to linear and exponential functions, rate of growth, geometric series, compositions and recursion. The applications possible extend beyond ecosystems to most exponential models: annuities, Newton's Law of Cooling, and the elimination rates of pharmaceutical drugs from the blood stream. The presentation will focus first on the mathematical model and then on several different ways these activities could be altered to fit the needs of general education mathematics and science courses at the collegiate level. A handout will provide details and references.

David Gurney (dgurney@selu.edu) Southeastern Louisiana University, SLU 10541, 500 Western Avenue, Hammond, LA, 70402

Extensions of Daisy World

The Daisy World model is presented in Hardisty, Taylor and Metcalf, *Computerized Environmental Modelling: A Practical Introduction Using Excel*, Wiley 1993. Though the Daisy World model is fairly complex, it can be created quite easily using basic Excel commands. This paper looks at ways to use the building blocks of the Daisy World model to create some more realistic models.

George Rublein (gtrubl@math.wm.edu) College of William & Mary, Department of Mathematics, Williamsburg, VA, 23187-8795

Matrix Methods in Elementary Chemistry

Conservation of energy and conservation of mass rely on Hess's law for the calculation of enthalpy changes in chemical reactions. In this context, we describe the role of the rational row-reduced form in stoichiometry problems. Hess's law is shown as an example of the use of linearly independent solutions of a rank deficient system of homogeneous linear equations.

Jim Brandt (jbrandt@prescott.edu) Prescott College, 220 Grove Ave, Prescott, AZ, 86301

Modeling with Dynamic Systems

An introductory mathematical modeling course offers significant opportunities to convey some of the beauty and power of mathematics to non-science majors. This presentation will recount some of my experiences teaching a popular introductory modeling course focused on environmental issues. In this course, offered at a college algebra level, students use difference equations and graphing calculators to build and analyze models for natural systems. Examples illustrating the quantitative, symbolic, and graphical perspectives that are inherent in a dynamical systems approach will be included.

G. Zimmer (bzimmer@sci.tamucc.edu) Texas A&M-Corpus Christi, CAMS Department, 6300 Ocean Drive, Unit 5825, Corpus Christi, TX, 78412

Using Large Amounts of Data on Coastal Phenomena

The Division of Nearshore Research at Texas A&M University-Corpus Christi measures and predicts coastal and ocean phenomena. From their website, http://lighthouse.tamucc.edu/pquery a wealth of data can be down-

loaded in graphical or text or data formats. These data can be used to study water level fluctuations or salinity changes or water temperature changes or wind fluctuations in visual or computational ways for a number of stations along the Texas coast. Statistical methods, regression, neural networks or harmonic models are used to make water level predictions. A number of undergraduate students have been successfully involved in related research projects.

Joe Harris (harrisjt@sapc.edu) St. Andrews Presbyterian College, 1700 Dogwood Mile, Laurinburg, NC, 28352

Waste Accumulation and Decay of Resources

One of the most important issues in the study of environmental issues is the decay of resources and the accumulation of waste. Here I report on work done by a student and myself to study these phenomena mathematically in a relatively simple situation: A growing colony of bacteria. A substantial part of this work was done as part of a standard first course on ordinary differential equations; I plan for further modifications to be the basis for future laboratory projects and undergraduate research for my students.

A central part of the philosophy of this presentation is the idea that learning in mathematics is at its most vivid when the student works with data collected by the student. Accordingly, a significant part of the project described involves the student (and the mathematics professor!) learning some techniques for studying the growth of populations of bacteria by measuring the turbidity of the growth medium and by plating samples of the culture. We measured the size of the population of bacteria by measuring the absorbance of the growth medium using a spec-20. Once this data was collected, the objective was to design a suitable modification of the standard logistic model to describe the behavior of the population.

During the early stages of the growth of a bacteria colony, its growth is described fairly well by a simple logistic model. However, once the population has reached the "carrying capacity" of the environment, something happens which the logistic model cannot predict: due to decay of the food supply and accumulation of the waste products of the bacteria, the bacteria begin to die out and the population declines. Such a phenomenon cannot be described by any single differential equation; a system describing the interaction of the bacteria, the waste products, and the amount of food available is required.

The model we propose uses the three dependent variables P, w, and L. These are, respectively, measurements of population size, waste, and food availability. We propose the following differential equation system.

$$\frac{dP}{dt} = \kappa(1 - \frac{P}{L}) - \alpha w P \tag{1}$$

$$\frac{dw}{dt} = P \tag{2}$$

$$\frac{dL}{dt} = -\beta P \tag{3}$$

Equation (1) is the basic Logistic equation, modified to take into account the effect of accumulated waste in the environment of the bacteria; equation (2) describes the accumulation of waste due to the bacteria; equation (3) describes the decay of the food supply.

Now we must work to select appropriate parameter values to fit this model to our numerical data. This is done by a "Logistic least squares" procedure; one finds the parameter values which minimize the sum of the squares of the differences between the predicted and actual values. We did this by means of a Maple routine; thus this project reinforced and demonstrated the ideas of modeling using differential equations and of optimization, in a highly applied setting.

Innovations in Teaching Discrete Mathematics

Mike Pinter (pinterm@mail.belmont.edu) Belmont University, 1900 Belmont Blvd, Nashville, TN, 37212

An Exercise Set for Initiating a Course

I will offer a set of familiar discrete mathematics exercises that I use as an introduction to problem solving in two different courses that I teach. The two courses are Introduction to Mathematical Reasoning (which is one option for fulfilling the quantitative reasoning requirement in our new general education program) and Analytics (the math general education requirement for students in our Honors Program). Discrete mathematics topics comprise significant components of both courses The exercises at the beginning of the course involve problems that students quickly understand, yet whose solutions typically require the students to develop or enhance some good problem solving strategies. I use the problems in a particular sequence or cluster and also encourage collaborative group activities with them. From my experience, the problems I use generate interest in the courses and sometimes generate excitement about latent mathematical abilities.

Stephen Maurer (smaurer1@swarthmore.edu) Swarthmore College, 206 Benjamin West Ave, Swarthmore, PA, 19081-1421

DNA Alignment as a Capstone Discrete Math Topic

It is well known that there are many discrete problems in modern biology, yet the topic of DNA alignment (optimal matching) is still far from common in introductory discrete math texts and courses. This deserves to change, because alignment is a wonderful concluding topic, especially for a discrete math course emphasizing algorithmics. The speaker will explain how he has used alignment as a summary topic, since it allows for a recapitulation of such key themes as graph algorithms, optimization, algorithmic efficiency, induction, iteration and recursion. There is plenty of depth to this topic, so it can also lead to extended student projects. Perhaps some of your biologists would like to sit in if you present this materials in class (this has happened at Swarthmore) and it might help lead to cross-department collaboration. The speaker will explain how he presents this topic and provide references to teaching materials and scholarly literature.

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Early Writings on Graph Theory: Three Projects

The ability to apply mathematics to other disciplines requires more than mathematical understanding. Additionally, one needs a strong understanding of concepts and problems within the application field *and* the ability to move between verbal descriptions of problems within that field and precise formulations in terms of abstract mathematical structures. One means for providing practice with this latter skill is the use of projects such as those being developed at New Mexico State University based on original source writings.

This talk reports on three such projects in graph theory which the speaker developed for and piloted in a Discrete Mathematics course at Colorado State University - Pueblo in Fall 2005. Based on foundational papers in graph theory by Euler (*Solutio Problematis Ad Geometriam Situs Pertinentis*, 1736), Hamilton (*The Icosian Game*, 1857) and Veblen (*On Application of Modular Equations in Analysis Situs*, 1922), these projects or parts thereof could be used independently or collectively in a discrete mathematics course at the sophomore or senior level. Student demographics, course goals and project objectives and design will be detailed, and student feedback reported.

Jason Grout (grout@math.byu.edu) Brigham Young University, Mathematics Department, 292 TMCB, Provo, UT, 84604

Graph Database

I will describe a comprehensive, interactive internet database of thousands of graphs and how this database can be used in teaching and research. I designed this database to motivate a student in exploring relationships between graph properties. The web interface enables a student to easily query for all small graphs with specific properties. This allows the student to make simple conjectures, such as the relationship between the sum of the degrees of the vertices and the number of edges, and to conjecture less obvious relationships, such as

sufficient conditions for a graph to be nonplanar. I will provide a number of exercises which illustrate how instructors can use this database to engage students in exploring, conjecturing, and proving relationships in graph theory.

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Doug Ensley (deensl@ship.edu) Shippensburg University, 1871 Old Main Drive, Shippensburg, PA, 17257

Interactive Online Material for Discrete Math

Under an NSF grant, (DUE 0230755) we have created interactive computer-based tools (using Flash applets embedded in web pages) to assist in the teaching and learning of mathematical logic and proofs. These tools have been tested with students in a variety of majors, including math, computer science, and elementary education. In addition to the grant-supported work, we have written additional tools to support a broad range of discrete math topics (truth tables, functions and relations, graphs, counting and probability, etc.). In this talk we provide general information on the breadth of tools available, along with details and demonstrations of a small sampling of the tools.

Inna Pivkina (ipivkina@cs.nmsu.edu) New Mexico State University, Department of Computer Science., PO Box 30001, MSC CS, Las Cruces, NM, 88003

Lamé Project for Computer Science Students

We discuss using primary historical sources in teaching discrete mathematics to computer science students. This is a part of a group effort at New Mexico State University on teaching discrete mathematics via original historical sources. This approach stimulates students interest in mathematics providing them an opportunity to rediscover the ideas of the historical source on their own. In the talk we present Lamé project which was given to junior level computer science students. The project is based on an expert from a letter of Monsieur Lamé to Monsieur Liouville on the question: Given a convex polygon, in how many ways can one partition it into triangles by means of diagonals? A variety of tasks in the project, which includes reading, writing, drawing, proving statements, deriving formulas, writing computer programs and analyzing them, help students to develop verbal, analytical and discrete mathematics skills, necessary for computer science. We also discuss student reactions to the project.

Jerry Lodder (jlodder@nmsu.edu) New Mexico State University, Math Sciences, Dept. 3MB, Box 30001, Las Cruces, NM, 88003

Primary Historical Sources in Discrete Mathematics

A course in discrete mathematics is a relative recent addition to the modern American undergraduate curriculum, serving to instruct students in logical and algorithmic thought, needed for further courses in mathematics or computer science. The roots of discrete mathematics, however, are as old as mathematics itself, with the idea of counting a basic discrete operation. In this talk we examine how primary historical sources can be used to introduce, instruct and provide motivation for several topics in a finite mathematics course. For example, Archimedes' (c. 287–212 B.C.E.) statement about the sum of squares offers a rich verbal articulation, which students can transcribe into modern symbolic logic, write algebraically, and then grapple with its verification, comparing Archimedes' geometric argument with present-day induction techniques. Additional historical sources which have been used in the classroom include an explanation of binary arithmetic from the work of Gottfried Leibniz (1646–1716), the formulation of induction from the work of Blaise Pascal (1623–1662), and the use of base two arithmetic for electronic digital computers from the work of John von Neumann (1903–1957). The original sources provide context, motivation and direction to a subject that is often reduced to a list of facts and formulae.

Mazen Shahin (mshahin@desu.edu) Delaware State University, 1200 N. DuPont Highway, Dover, DE, 19901

Technology Explorations in Difference Equations

We will share the pedagogy and the methodology of introducing some discrete mathematics concepts. We will demonstrate how a computer algebra system, such as Derive, can be utilized as an effective tool to help

students explore and discover discrete mathematics concepts on their own. To explore these concepts, students will work in small groups using technology on carefully designed activities. This presentation will focus on first and second order recurrence equations. Given a real life situation students need to translate the situation into mathematics notation as a single or a system of difference equation(s). They may use iterative routines to create tables of values for linear and nonlinear systems, graph it, and make conclusions and conjectures about the behavior of the system. In addition, Derive has routines to find the solutions of first and second order difference equations. These formulas are used to find solutions at certain times as well as study the long-term behavior of a system. Students discuss and write about their findings and observations.

Innovative Mathematics Majors in Small/Medium Departments

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Kelly Cline (kcline@carroll.edu) Carroll College, Department of Mathematics, 1601 N. Benton Avenue, Helena, MT, 59625
John Scharf (jscharf@carroll.edu) Carroll College, Department of Mathematics, 1601 N. Benton Avenue, Helena, MT, 59625
Holly Zullo (hzullo@carroll.edu) Carroll College, Department of Mathematics, 1601 N. Benton Avenue, Helena, MT, 59625

An Integrated Applied Mathematics Program

Carroll College is a small liberal arts college in Helena, MT having a combined faculty of 10 in the Department of Mathematics, Engineering, and Computer Science with 4 positions dedicated to mathematics. Inspired by emerging technology and participation in the NSF-sponsored Project InterMath, over the last 10 years Carroll College has been developing a new undergraduate curriculum model. Our goal is to create a program focusing on applied mathematics emphasizing:

- the integrated nature of mathematical concepts
- the interdisciplinary nature of applied mathematics
- the use of technology to explore mathematical topics
- the use of open-ended projects to challenge students to explore topics in-depth
- the use of writing and presentations to develop mathematical communication skills

Our department is not large enough to offer multiple tracks in the major, so we have carefully selected our offerings to include various areas of applied mathematics. In this talk we will discuss the rationale for these decisions, the structure of our major, and how we accomplish our goals by changing both what we teach as well as how we teach it. We will also discuss our experiences placing students in REUs, industry positions, and graduate schools.

Kyle Riley (Kyle.Riley@sdsmt.edu) South Dakota School of Mines and Technology, Dept. of Math & Computer Science, 501 East Saint Joseph Street, Rapid City, SD, 57701

Applied Math and the Magic of Double Majors

The South Dakota School of Mines and Technology is a small Engineering and Science University with roughly 2,300 undergraduates. The natural focus for our mathematics program is in applied mathematics enhanced with computer science courses. The two primary goals to our mathematics program is to provide a rigorous enough background for students to prepare for graduate work and provide courses that would be helpful for a career in industry. Some distinctive features of our program would include: two semesters of computer science programming, at least four credits of statistics, partial differential equations, dynamical systems, mathematical modeling, a three course emphasis area, and a two semester sequence in undergraduate research. Another distinctive feature of the program is that over a third of the math majors are double majors. The vast majority of the double majors are math combined with Computer Science, but we also have Electrical Engineering, Mechanical Engineering, and Physics.

Vadim Ponomarenko (vadim123@gmail.com) Trinity University, One Trinity Pl., San Antonio, TX, 78212

A Seminar For Majors

At Trinity University, we have a weekly seminar that mathematics majors take for four semesters. For just the four credits they receive, they gain the following benefits:

1. Friendship and community with other majors
2. Technical writing skills
3. LaTeX experience
4. Insight into mathematics careers
5. Mathematics beyond their coursework
6. Capstone research project

This seminar increases the math department's visibility within the university and elsewhere, and even helps with recruiting majors. This talk will give details about this seminar, as well as place it in the context of other requirements for our majors.

M. McKemie (mckemie@acad.stedwards.edu) St. Edward's University, 3001 South Congress Ave., Austin, TX, 78704

Choice of Track With Research for All

In light of our goals of attracting more math majors and minors and meeting more student needs, our department of 6-7 full-time faculty recently changed degree plans. We now offer Applied (BA, BS) and Traditional (BA , BS) math tracks. In conjunction with Education we offer a math track for those seeking teaching certification, and in conjunction with a new interdisciplinary Bioinformatics degree, we offer courses for a Biomathematics track. Our signature feature is that all of our majors have a research experience. This is accomplished though a 4 semester sequence of courses: research methods, undergraduate research (twice), and senior seminar. We redesigned this research sequence so that each course is taught in multiple sections of small size, so that each faculty mentor guides students through the entire sequence.We will describe the math core, the different tracks, and the philosophy and implementation of the research sequence and its impact on load.

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Sylvia Bozeman (sbozeman@spelman.edu) Spelman College, 350 Spelman Lane, Atlanta, GA, 30314

Experiences in Attracting Women to Mathematics

Spelman College is a small, private, historically Black women's liberal arts college in Atlanta, GA. Over 100 of our 2000 students major in mathematics, and their needs are met by 12 full time faculty. The curriculum is rather classical in its structure, with a few innovative features. It has been made attractive to students by including some special experiences in the program for majors, and by creating a departmental community which promotes academic achievement and the development of leadership skills. Our graduates go on to pursue a great diversity of careers, from academia to medicine and law (see the April 2004 issue of MAA Math Horizons). Significant numbers of our students engage in undergraduate research, on topics ranging from fractals, image processing, wavelets, statistics, and data mining to financial mathematics, DE, coding theory, cryptography, and Groebner bases. This talk will focus on how the efforts of a diverse and committed faculty have been combined to promote the success of African American women in the mathematical sciences in this institution.

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Integrating Math & Science for Math Majors

Traditionally, science and mathematics content are taught as discrete courses. Consequently, students often fail to make connections between disciplines. To resolve this "mismatch," we have created a freshman and

sophomore integrated science curriculum for all mathematics, science, and secondary mathematics and science education majors. The primary focus of this curriculum is a 6-course mathematics sequence and an introductory science laboratory series. The mathematics sequence consists of calculus, differential equations, just-in-time algebra and trigonometry topics, and a unit on statistics. Among other things, the science lab series (chemistry, biology and physics) models the use of mathematics in context. The mathematics courses are designed to emphasize mathematical thinking, problem-solving skills, good scientific reading habits, early awareness of innovative teaching techniques in education majors, and development of learning communities of students and faculty. They incorporate examples and problems from multiple disciplines, as well as integrate effective use of technology for instruction. The curriculum is taught in cooperative, technology supported classrooms/labs that facilitate use of student teams and technology. These facilities were specifically designed for this curriculum and were funded by NSF-CCLI and university grants.

Lisa Townsley (ltownsley@ben.edu) Benedictine University, 5700 College Rd, Lisle, IL, 60532

Math Majors at a "Science Serious" Liberal Arts College

Benedictine University enjoys a national ranking in percentage of students who go on to earn a PhD in the sciences. How does the math major fare in such a serious science environment? To compensate for a small (5 faculty) department, we make sure the major curriculum includes both sufficient breadth that the student sees the algebraic, analytical, and applied branches of mathematics and also some mathematical branch in depth. The outline of the curriculum and the nature of this depth experience will be discussed at the talk as well as the success stories of our math majors, as they advance to graduate school and other careers.

Joe Stickles, Jr. (js298@evansville.edu) University of Evansville, Department of Mathematics, 1800 Lincoln Avenue, Evansville, IN, 47722

Pre-Doctoral Mathematics Major

In an attempt to draw highly-talented and motivated mathematics students to the University of Evansville, we designed a program geared specifically to ready students for the rigors of graduate study. The different facets of this program will be discussed, as well as the challenges we face delivering this program.

Kai Brunkalla (kbrunkalla@walsh.edu) Walsh University, 2020 East Maple Street, North Canton, OH, 44720

The Mathematics Major at Walsh University

We developed the B.S./B.A. in mathematics at Walsh University to update and streamline the program. Walsh wanted to prepare students to enter today's master and doctoral programs. The mathematics department at Walsh is small; we currently have three full time professors. Due to our size, we faced many obstacles that were overcome by several strategies. First, we staggered courses and secondly, we made a pledge to strive to offer special electives that cover a variety of subjects as needed by the students.

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J. Patrick Brewer (brewer@lvc.edu) Lebanon Valley College, 101 N. College Ave., Annville, PA, 17003

The Mathematical Sciences in the Liberal Arts

For the last 30 years between 6% and 8% of Lebanon Valley College's students have majored in the Mathematical Sciences. Our relatively large number of majors stems in part from our actuarial science major, but our successes are more deeply rooted in our commitment to traditional liberal arts ideals: precise reading, sound reasoning, and clear communication. This talk will stipulate the stated goals for our majors, enumerate some of the objectives derived from those goals, convey a few successes and potential obstacles, and give a brief outline of our future course.

Nifty Examples in Discrete Mathematics

Raymond Greenwell (matrng@hofstra.edu) Hofstra University, Department of Mathematics, 103 Hofstra University, Hempstead, NY, 11549

A Class Activity for Teaching Recursion

A classroom activity will be demonstrated that makes recursion clear and concrete to students. Each student is given a set of instructions in which the student acts out one level of the recursion. The instructor initiates the process by giving several students a number and telling them to begin following the instructions. All students in the class are involved in some level of the recursion, and the final answers are correctly calculated and returned to the instructor. The two sample activities involve squaring a number without multiplication and calculating a Fibonacci number. Exercises will be given that involve calculating a factorial, a greatest common factor, and a value of Ackerman's function. This activity may be used in a course on discrete mathematics or in any computer science course in which recursion is discussed.

David Hunter (dhunter@westmont.edu) Westmont College, 955 La Paz Road, Santa Barbara, CA, 93108

Exercises in Reconstructing Evolutionary Trees

A central problem in bioinformatics is the inference of an evolutionary tree from genetic data. This task is a natural application of many topics covered in an introductory discrete mathematics course. This talk will explore how to present this problem in the context of such a course. Definitions and examples should be conceptually appropriate for discrete mathematics students, without assuming any biological prerequisites. Sample exercises will be presented.

Hugh McGuire (mcguire@cis.gvsu.edu) Grand Valley State University, School of Computing & Information Systems, 1 Campus Drive, Allendale, MI, 49401+9403
Andrius Tamulis (atamulis@stritch.edu) Cardinal Stritch University, Department of Math and CS, 6801 N. Yates Rd., Box 370, Milwaukee, WI, 53217

Harry Potter's Potions Puzzle

An engaging, didactic puzzle involving reasoning and counting is presented in *Harry Potter and the Sorcerer's Stone*, by J. K. Rowling. Given seven unlabeled bottles containing poisons or wines or desired potions, and with a scroll providing clues, one needs to determine what each bottle contains. This puzzle can serve as an engaging in-class exercise, or homework exercises can explore different aspects of this puzzle involving counting (permutations/combinations) and reasoning.

Beyond the niftiness of the puzzle itself and the popular appeal of *Harry Potter*, another value of this puzzle involves the need to encourage women in computer science. This puzzle may encourage women in this field because the character in *Harry Potter* who solves this puzzle is a young girl.

References

1. Roger Howe, Hermione Granger's Solution, *Mathematics Teacher* 95 (2002), 86–89.
2. J. K. Rowling, *Harry Potter and the Sorcerer's Stone*, Scholastic Press, 1998.

Colm Mulcahy (colm@spelman.edu) Spelman College, 350 Spelman Lane, PO Box 953, Atlanta, GA, 30314

Mathematical Idol 2005

A randomization technique will be used to select Mathematical Idol 2005 from these finalists: Archimedes, Euclid, Euler, Gauss, Hilbert, Newton, Pythagoras and Riemann. Mathemagician Aodh offers an innocent bystander a completely free choice of any 3 of these 8. This selection is further refined to yield a single winner. Mathemagician Bea then joins the gathering, and identifies the winning mathematician knowing only the two runners up.

Benjamin Collins (bvccollins@hotmail.com) University of Wisconsin-Platteville, 1 University Plaza, Platteville, WI, 53818

Mathematics to the Rescue: Centrality in Graphs

The theory of location of facilities in networks combines tools from graph theory, basic analysis, optimization, and complexity theory. The major focus of the theory of location of facilities on networks is to determine where to locate facilities of some sort in a network of sites that include both potential facility sites and facility user sites. Facilities might be emergency installations, supply depots, switching stations, pumping stations, power facilities, transfer stations, communication devices, obnoxious facilities, or the like. Location(s) are required that "best" serve the users, where "best" is measured by criteria given in each particular example.

While the theory of location of facilities is a rich and deep subject of current research, I have found that there are enough basic results to provide an interesting unit in a Discrete Math course. I will share some of the materials that have been developed by myself and others, and outline my experience using the material in the Discrete Math classroom.

Diane Spresser (dspresse@nsf.gov) Math and Science Partnership Program, 4201 Wilson Boulevard, Suite 875, Arlington, VA, 22230

Nifty Explorations in Sequences and Summations

Sequences appear in discrete mathematics in numerous domains. Sequences [strings] are also of importance in computer science. We use a summation problem and elementary properties of sequences as a platform for a set of related explorations that, taken as a whole, satisfy general expectations – similar to those articulated by Nick Parlante for the Nifty Assignments session at ACM's SIGCSE (listserv communication of August 11, 2003) – that a "nifty" problem will: (1) possess a "fun factor" that entices the student to "play around" with the problem and its variations; (2) have a good topical "fit" with the curriculum and difficulty level; (3) be sufficiently rich to operate at both mainstream and more advanced levels; and (4) be "adoptable" by and of interest to other instructors.

Hugh McGuire (mcguire@cis.gvsu.edu) Grand Valley State University, School of Computing & Information Systems, 1 Campus Drive, Allendale, MI, 49401-9403

Number Representations Can Help Gold Diggers

The puzzles presented here can serve as engaging introductions to binary and other number representations. Such material is particularly germane to computer science. One of the puzzles is as follows:

> Suppose you are a supervisor in a company and for seven days you will be paying an employee one ounce of gold per day, and suppose you have one seven-ounce bar of gold for this purpose. Suppose also that at the end of each of these seven workdays, this employee should actually have their proper pay so far — an additional ounce of gold at the end of each additional day; and for this purpose, suppose that the bar of gold has graduated one-ounce markings along its length, and that you have a saw for cutting it. But suppose sawing the gold is actually difficult (involving complications such as proper handling of the valuable gold sawdust...), so you want to minimize the number of cuts. Explain how you can handle this situation doing only two cuts.

Another engaging aspect of this first puzzle is that a version of it has been used as an interview question by Microsoft.

Reference

1. Jerry Lodder, Binary Arithmetic: From Leibniz to von Neumann, manuscript, 2004.

Suzanne Doree (doree@augsburg.edu) Augsburg College, Campus Box #61, 2211 Riverside Avenue, Minneapolis, MN, 55454

The Coins Go 'Round 'n 'Round; Bulgarian Solitaire

One player begins with coins arranged in piles. At each turn she rearranges the coins according to the following rule: remove the top coin from each pile, possibly eliminating piles, and form a new collected pile

of coins. The game continues until she revisits a previously encountered (unordered) arrangement, having reach a terminal cycle. Where are fixed points, if any? Where are two cycles, if any? Which states are cyclic?

This problem was dubbed "Bulgarian Solitaire" by Martin Gardner in a 1983 *Scientific American* column. I first encountered the problem in Doug West and John D'Angelo's text *Mathematical Thinking* where it is known as the "Penny Problem." In my sophomore level discrete mathematics class I use this example to introduce students to partitions of integers, state graphs, and dynamical systems and to draw connections to the ubiquitous triangular numbers. I have also directed two undergraduate research projects on extensions. In this talk I will describe the process of Bulgarian Solitaire in more detail, answer the questions posed, and explain how it is implemented in my classroom.

Mark Ward (ward2@math.upenn.edu) University of Pennsylvania, 209 South 33rd Street, Philadelphia, PA, 19104-6395

The Multiplicity Matching Parameter in Suffix Tree

The multiplicity matching parameter in suffix trees has intricate connections to the Lempel-Ziv '77 data compression algorithm. This parameter can be easily explained to undergraduates, inviting them to explore an interesting application of pattern matching and applied discrete mathematics in a fundamental computer science problem. This connection has been well-received by undergraduates at the regional Indiana MAA meeting. The concepts are readily accessible for undergraduates, although the analysis is non-trivial. As a result, undergraduates are enticed into further investigations, leading to a variety of possible research projects.

Ada Dong (acdong@comcast.net) 23081 Timber Trail, Bingham farms, MI, 48025

Tiny Numbers

Call a number $a - b\sqrt{2}$ with a and b both positive integers *tiny* if it is closer to zero than any number $c - d\sqrt{2}$ such that c and d are positive integers with $c < a$ and $d < b$. It turns out that tiny numbers can be sequenced by a nice general recursive function with closed form solutions.

I encountered the original tiny number problem proposed by Dr. Grabiner in my effort to collect recursively defined structures. I am fascinated by the rich properties of tiny numbers and would like to share the enjoyment.

This work contains two parts: the lecture notes on tiny numbers and a problem set concentrating on proofs of a collection of tiny number properties. This talk will focus on the lecture notes.

Stephen Maurer (smaurer1@swarthmore.edu) Swarthmore College, 206 Benjamin West Ave, Swarthmore, PA, 19081-1421

Typography and Shortest Paths

This is not my nifty example — it is Donald Knuth's! His algorithm in TEX for line breaking in paragraphs is a shortest path algorithm, at heart a very standard algorithm. Yet, as nifty as this application is, it doesn't seem to appear in discrete math texts. Perhaps this is because it is easy to lose the forest for the trees: in the *TEXbook* there is so much discussion of all the things you want to avoid in line breaks that there is no clear statement of the optimization method, let alone the fact that the problem can be represented by a graph.

My only contribution is simplification: examples for classroom presentation that show the powerful and visually pleasing results of the algorithm, and other materials that explain the basic computational idea. Students have been fascinated by this unexpected application domain. Some have gone on to learn the bells and whistles and have written term papers about it, including one paper that won our department math paper award.

This certainly is a good topic to connect discrete math and CS. The solution begins with a discrete math representation (weighted graph) and then one must decide which shortest path algorithm is appropriate. Like all real-world problems, it has various complications and experimental aspects to handle before someone (Knuth!) gets a useful working algorithm.

The speaker will provide the visuals and the references that he gives to students in his algorithmic discrete mathematics course.

SIGMAA on RUME (Research-to-Practice)

Jack Bookman (bookman@math.duke.edu) Duke University, 4421 Whitfield Road, Durham, NC, 27707

Assessing Quantitative Literacy

Quantitative Literacy presents a particular challenge for assessment of student learning. Assessment items must be set in a rich context in which multiple problem solving approaches are possible, where often there is not one "right" answer. On the other hand, the assessment instruments must not take too much time to administer, must include a multitude of problems and situations, and must be designed to allow for reliable scoring. QL assessment instruments must include problems that are not simply schema driven (i.e., students have a well-recognized routine for solving the problem), but also are not so non-routine that students cannot solve them.

I will discuss the development of a pre and post test for assessing the progress made by students in a course designed to improve students QL skills by using quantitative methods to approach problems in public policy. I will discuss the results of the tests and how we've used those results to consider changes in the course.

Warren Koepp (koepp_w@utpb.edu) The University of Texas of the Permian Basin, 4901 East University Blvd, Odessa, TX, 79762

Reading Comprehension and Math Performance

In this study the mathematical reading comprehension level of students in two college mathematics classes was measured via Content Area Reading Inventories (CARIs) based on the course text. The CARIs were administered through an online course management system, were untimed, and preceded classroom coverage of the text material. The CARI data were paired with subsequent assessment measures, showing a significant positive correlation. Implications for instructional practice, including increased emphasis on reading skills throughout the math curriculum, are discussed, with a focus on incorporating web-based strategies.

Lisa Carnell (lcarnell@highpoint.edu) High Point University, 833 Montlieu Avenue, High Point, NC, 27262

Students' Attitudes Toward Statistics

Some students are less than enthusiastic when they enroll in an introductory statistics course. They may perceive the course as being dull, difficult, and not particularly useful to them. While projects have been used in statistics classes to enhance student learning for some time, the evidence of the effect of those projects on students' attitudes toward statistics appears to be primarily anecdotal. In order to gather empirical evidence on the effect of using projects to enhance students' attitudes toward statistics I designed a study in which students in two sections of an introductory statistics course were compared. Each section received the same instruction, assignments, tests, and activities by the same instructor. However, the students in one section of the course completed a student-designed data collection project in which they picked a question of personal interest, collected and analyzed data using techniques learned in the course, wrote a report of the findings, and made a brief presentation to the class. To compare attitudes toward statistics between the two groups, the students in each section completed The Survey of Attitudes Toward Statistics 36, or SATS-36©, on the first day of class and the last day of class. This survey was designed to measure six attitude components: affect (students' feelings about statistics), cognitive competence (students' attitudes about their intellectual knowledge and skills when applied toward statistics), value (students' attitudes about the usefulness, relevance, and worth of statistics in personal and professional life), and difficulty (students' attitudes about the difficulty of statistics as a subject). In this talk I will discuss the results of the survey comparing the two groups on the six attitude components. I will also discuss the implications for instruction which arise from this research regarding the use of a student-designed project in an introductory statistics class.

Kyle Riley (Kyle.Riley@sdsmt.edu) South Dakota School of Mines & Technology, Dept. of Math & Computer Science, 501 East Saint Joseph Street, Rapid City, SD, 57701

The Use of a Lab Section in Trigonometry

A unique feature of our trigonometry course is a regular lab section that meets every week in addition to two meetings per week of a large lecture section. Many of the lab sessions are conducted in a very common recitation format with weekly quizzes and a chance for students to get extra help on homework problems. However, 2-3 of the sessions are spent on an applied lab experience where small groups of students (at most three students to a group) conduct deep investigations of trigonometry in structured applications. The student groups are evaluated via lab reports that are typed and submitted to their lab teaching assistant who grades the assignment according to a rubric. This presentation will provide a couple of the labs used, the grading rubric, discussion of student scores on the labs, and a summary of survey results from the students involved

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Bernadette Baker (bernadette.baker@DRAKE.EDU) Drake University, 2507 University Ave, DesMoines, IA, 50311

Unified Representation of Function

This talk will present the results from a small pilot study using a new approach to teaching the concept of function. Based on a review of the literature and the researchers' experiences with students, the approach was developed to help bridge the gap between the three traditional representations (algebraic, graphical, tabular). In the terminology of action-process-object, the researchers believe that many students face difficulties when moving from an action concept to a process concept because these students have constructed incorrect or ineffective action concepts of function. By helping students develop a more accurate action concept of function, the transition to a process concept may be eased. The initial results from this study are encouraging, but it is still unclear if the increased student ability can be attributed to a deeper understanding of the concept, or simply a result of more efficient techniques. Based on the results from the pilot study, the researchers are modifying the method and plan to use it and conduct further study in the upcoming year. Some examples of the new technique for working with functions will be included.

John Urenko (jbu2@psu.edu) Penn State University, 200 University Drive, Schuylkill Haven, PA, 17972

Using Definitions in Transformation Geometry.

In a recent article in the Monthly B. Edwards and M. Ward, based on their research in undergraduate mathematics education, noted that: "Many students do not use definitions the way mathematicians do, even when the students can correctly state and explain the definitions." This type of behavior is found among students studying transformations of the Cartesian plane. Many are able to state and explain the analytic definitions of geometric objects but do not use the same definitions properly. An initial analysis utilizing APOS Theory accounts for this incongruity in terms of a process vs. object conception of the definitions, indicating the efficaciousness of instructional activities focusing on the coordinated actions of transformations and their inverses

Teaching & Learning Proof in Inquiry-Based Courses: Integrating Research & Practice

Bonnie Gold (bgold@monmouth.edu) Monmouth University, Mathematics Department, West Long Branch, NJ, 07740

A Modified Moore-Method Number Theory Course

In the fall of 2003, I taught our required junior-level number theory course via a modified Moore method. Students in this course have taken our freshman-level Discrete Mathematics course, where they are introduced to logic and proofs, and our Linear Algebra course, where they have had a little more experience with proofs.

However, Number Theory is the first course where they encounter, and must develop, proofs except in carefully limited formats. I broke the class into groups of two to three students, and assigned each group a presentation each week. Presentations usually consisted of one example using the definitions of the week, one theorem they were to prove, or give a counter-example to, fix, and prove, and a third problem of one of these types. Presentations assigned Tuesdays were begun on Thursday and finished the following Tuesday. While I had used this method previously in real analysis at another institution, this was the first time I used it with number theory, and the first time I used it with such a large class (26 students). One problem I had found when I had used this method previously was getting students to listen critically to their colleagues' presentations. I will discuss how I attempted to remedy this, as well as other aspects of how this course worked, in my presentation.

W. Mahavier (wtm@mathnerds.com) Lamar University, PO 10047, Beaumont, TX, 77706

Analysis — The Ultimate Training Ground

We will discuss how we have implemented a single analysis course, with roots in the Moore method, in a series of very distinct course settings. The course has been used as a transitions course to develop proof techniques, in Mathworks (Texas State University San Marcus) to develop bright young minds at the high-school level, as the first of a two-semester, real analysis course for mathematics majors, and as both a pre-service and an in-service training course. We will describe the content, syllabus, grading, and classroom structure of the course, as well as mentoring available to those desiring to implement such a course.

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Approaches to Proof Construction in Number Theory

When presented with a mathematical statement to prove, what do undergraduates do? We followed six students enrolled in an inquiry-based undergraduate number theory course for one semester. During interviews, the students were asked to construct proofs of various number theory statements. The students' strategies for constructing proofs varied depending on context, but in each case they were primarily engaged in making sense of the mathematics, rather than searching for a previously known proof strategy. In this presentation, we will describe their strategies. We claim that the inquiry-based structure of the course facilitated the development of these students' relatively sophisticated approaches to proof.

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Assessment of Student Learning in Abstract Algebra

This paper describes an assessment task used in a first abstract algebra course as part of a university mathematics program assessment. Introductory group theory is typically one of the first proof courses taken by mathematics majors at this university. The primary activity in this classroom is focused on problem solving by students in small groups. As well, students are asked to discuss their attempts and solutions with their peers.

At the end of the term, students were asked to answer some questions in class individually. One of the questions involved a theorem that they had not seen before. Students were expected to write a valid proof and illustrate the theorem with a concrete example.

Several students showed that they were adept at writing abstract proofs, but were not able to provide suitable examples demonstrating the theorem. Preliminary analysis suggested that these students were good at following the form of a proof. Thus, they were able to construct correct proofs, but did not fully understand the ideas involved. It also seemed that students were not focused on the operation-preserving aspect of group homomorphisms. Rather, they were solely concerned with the function aspect, i.e. thinking of homomorphisms as mappings between "structureless" sets instead of groups.

In conclusion, we discuss possible changes to the curriculum to improve students' learning.

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Inquiry-Based Geometry and Abstract Algebra

At Carroll College we combine geometry and abstract algebra into a single senior-level course that is taught using inquiry-based methods. The primary focus of this course is to further develop the students' abilities to write and critique proofs, while introducing them to ideas in algebra and geometry. Students prepare a set of problems for each class period, and then class time is spent having students present and discuss the problems. We have found inquiry-based teaching to be very effective in helping students refine their proof techniques, explore new concepts, and prepare to be independent learners. We will describe how inquiry-based teaching is used in this course, including student reactions to the method.

Luz DeAlba (luz.dealba@drake.edu) Drake University, 2507 University Avenue, Department of Mathematics, Des Moines, IA, 50014

Learning and Assessment of the Mathematical Proofs

Suppose that you give your students the following assignment:

1. Construct a list of 6 triples of consecutive integers, for example $(1, 2, 3)$, make your list as varied as possible.
2. For each triple, (a, b, c), determine all the divisors of the sum $s = a + b + c$.
3. Study the results you obtained in Problem 2, and make a conjecture about divisors of sums of triples of consecutive integers. State your conjecture in the form: "If . . ., then . . ..
4. Prove your conjecture. Show all your steps and do not skip any details. Make sure that your steps are correct. If you use definitions, indicate clearly where, and how you use them. Use complete sentences, good English and correct mathematical terminology.

Would you give the student full credit for the following answers?

1. $(1, 2, 3), (9, 10, 11), (13, 14, 15), (56, 57, 58), (4, 5, 6), (101, 102, 103)$.
2. $(-1, 0, 1) = 0$, divisors $\{\emptyset\}$ (or, divisors = $\mathbb{Z}$).
3. Conjecture: For any series of 3 integers, the sum is equal to three times the middle term.
4. Proof: If $a+b+c = d$, then $b|d$. If a plus $b+c$ equals d, then b divides d. b can't $\frac{d}{0}$, or if $a+b+c = d$, then $3|d$.

My talk concentrates on my efforts to help students participate in and understand the process of creating mathematics. I will describe the format of a no-lecture Mathematics Reasoning course, the project-like assignments, the assessment method that I use, and the students' reactions to these types of activities.

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Surprising Effects of Inquiry-Based Learning

When inquiry-based learning is used in classes before the "transitions" course, there are surprising effects on the students' ability to write proofs. Students who had a Modified Moore Method Calculus III course have better self-evaluation skills and are more able to ask appropriate questions to improve their conceptual understanding than students who enrolled in a lecture-oriented Calculus III course. These groups and this surprising effect of inquiry-based learning will be discussed.

Walker White (wmwhite@udallas.edu) University of Dallas, 1845 East Northgate Drive, Irving, TX, 75062

Teaching the Process of Mathematics

A problem with modern "bridge courses" is that they often try to perform two very different duties: teach students how to write proofs, and provide them with essential mathematical content for later courses. However,

when content is the focus, students tend to learn the tricks and techniques for those particular mathematical objects. Hence, they have difficulty adapting their proof-writing skills to other topics. One way of dealing with this difficulty is to construct a bridge course that focuses on the process of mathematics, and not so much on content.

In this talk, we will examine a discovery learning course for writing proofs. In particular, we will see how this course helps students understand the process of developing a proof. Students learn how to pick apart a hypothesis, and determine how each part is important to the final result. They learn how to evaluate proofs, and how to achieve the same goal through many different approaches. They also learn to question the veracity of a theorem, turning failed proofs into counterexamples, and failed counterexamples into proofs. Finally, they learn to create their own conjectures and evaluate the significance of them.

The course examined in this talk has been taught successfully at the University of Dallas for several decades. At the end of this course, sample materials will be made available, with some discussion on how to adapt them to your course's needs.

Uses of the World-Wide Web that Enrich and Promote Learning

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A Math Gateway Update

The Math Gateway, a portal to online learning materials in undergraduate mathematics, is being constructed with a major NSF grant in the National Science Digital Library (NSDL) program and will be launched by the MAA next fall. The Math Gateway will provide an easy access to materials in many of the most important online collections: MathDL, Math Forum, MERLOT, iLumina, College Board, Virtual Laboratories in Probability and Statistics, CAUSE, Demos with Positive Impact, the National Curve Bank, the Ethnomathematics Digital Library, and the Duke Connected Curriculum Project. In addition, the Gateway will feature a regular Math in the News column and provide many services to the user. The presentation will feature demo versions of Gateway pages.

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An Enriched Course in Geometric Modelling

Over the past few years the speaker has been teaching a course in geometric modelling enhanced by Java applets, interactive course notes, on-line quizzes and most recently a course management system. This talk will overview the course, some of the materials and the speaker's experience with this web-enhanced course.

Calvin Armstrong (carmstrong@appleby.on.ca) Appleby College, 540 Lakeshore Road West, Oakville, ON, L6K 3P1

Assessing with CAS-based web tools

By using a web assessment program with a Computer Algebra System in the background and incorporating other instructional tools such as mathlets and whiteboard videos, we have found students more active and more responsive to doing practice, both required and self-initiated. Providing immediate, full feedback to algorithmically-generated problems which present mathematical skills and knowledge in a variety of contexts has given students more efficient practice and generous revision opportunities whenever and wherever, with all activity being tracked for the instructor's formative evaluation. The CAS is aware of algebraic and numeric equivalences and the student responses can be more open-ended; we aren't limited to multiple choice, which only measure mathematical conclusions rather than process. We have used this and other online tools, structured through the use of a course management system, throughout PreCalculus and AP Calculus at our secondary school and will discuss the evolving pedagogical implications and opportunities, illustrated by online examples.

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Combining On-line & Classroom Teaching in Algebra

A recent analysis of three years of data revealed that the single best predictor of retention of UW-Stout first-year students into the second year was taking and passing a math class during their first semester of college. Substantial fractions of our undergraduate population are students who have delayed their entry into college by a year or more since graduating high school or are members of other underrepresented subgroups whose math skills and preparation are often their biggest obstacle to collegiate success. These students place into one of two classes, a 2-credit remedial algebra course or a 4-credit intermediate algebra course which serves as a prerequisite to the general education requirement. Failure and withdrawal rates in these two courses have averaged a combined 29% (remedial) and 27% (intermediate). Our new math course is a unique format that combines the best elements of on-line learning and traditional classroom teachings in a way that takes full advantage of the UW-Stout Laptop Initiative. We have been able to equip a Math Teaching and Learning Center (Math TLC) dedicated exclusively to employing this hybrid on-line/classroom approach in these two courses. Our new math course structure requires daily submission of on-line homework assignments, with immediate feedback and the opportunity to re-work problems until they are mastered. The students now have the availability of on-line question-by-question tutorial help as well as in-person instruction. Our results thus far are very encouraging, failure and withdrawal rates dropped to 16% (remedial) and 18% (intermediate) after our first semester. This talk will focus on the new course structure, the advantages and disadvantages, and demonstrate the software package MyMathLab by Pearson-Prentice Hall.

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Evaluation Instruments for Internet-Based Courses

Courses based on the Internet offer new possibilities for evaluation, before, during, and after a course. This report will explore evaluation techniques that utilize the Internet in their design and implementation, and in analysis and presentation of the results.

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Integrating MathML and SVG in Moodle and Elsewhere

Although most students nowadays own or have access to computers and use them extensively in writing term papers and to communicate with their instructors by email, there are still serious obstacles when it comes to communicating mathematical formulas and diagrams online. As a result, many students still prefer to write mathematics and make drawings by hand, since this is easier than using an "equation editor" and drawing program. Computer algebra systems provide some support, but they tend to be expensive and hide the mathematical details that students are supposed to learn.

To address these problems, we have developed two open-source web browser scripts, ASCIIMathML [2] and ASCIIsvg [3], that make it easy for students to write mathematical formulas on webpages and to generate graphs of functions and labeled diagrams. Both scripts work with Internet Explorer and Firefox/Mozilla on Windows, Macs and Linux. They use well established web standards, namely MathML and SVG (scalable vector graphics), and at the same time hide technicalities from the user. The formula syntax is an extension of graphing calculator syntax that is familiar to most students. For example

$$\frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

is typed as '(-b+-sqrt(b2-4ac))/(2a)',

$$\frac{d}{dx}(f(x)) = \lim_{h \to 0} \frac{f(x+h) - f(x)}{h}$$

is typed as 'd/dx(f(x))=lim_(h-¿0)(f(x+h)-f(x))/h', and plotting a sine curve is as simple as typing plot(sin(x)). If it is preferred, LaTeX syntax can also be used. With the support of a Personalized Education Teaching

Grant from Chapman University, these scripts have been integrated into the free online learning environment Moodle [1]. They are also used on interactive webpages, and other users have added them to many blogs and wikis.

In this talk we show how our students use Moodle, enhanced with these tools, to write solutions, proofs and projects online. The online discussion forums have been used for a discovery style course in real analysis, and students' ability to type readable mathematics in emails has improved. We conclude with a description of how our system is used for an online calculus assessment test.

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Kyle Siegrist (siegrist@math.uah.edu) Mathematics Department, University of Alabama in Huntsville, Huntsville, AL, 35899

New Directions for JOMA

This talk will be a discussion of some new directions and areas of emphasis for *The Journal of Online Mathematics and Its Applications*, now in its fifth year of publication. Possible changes include a somewhat broader mission statement, and increased support for MathML and other web standards.

David Smith (das@math.duke.edu) Duke University, Department of Mathematics, Durham, NC, 27708

New Features in MathDL

The Mathematical Sciences Digital Library (MathDL) will feature two new components this summer. MAA Reviews, the online successor to Telegraphic Reviews, is being edited by Fernando Gouvêa. This component will feature reviews of new books and other learning materials in mathematics. It will also maintain a regularly updated Basic Library List. Classroom Capsules, edited by Wayne Roberts, will bring together the best of 111 years of the short classroom materials from the MAA print publications. It can be easily searched by topic, author, and student level. The presentation will feature sample pages from both publications.

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Online Quizzing Using WebCT

An online quiz component to the calculus courses has been used as an optional component of the calculus courses, with a flexible grade weighting system used for grade calculation. A description of the online quiz process is provided, along with student results and reactions to the online quizzing process.

Introduction For the past several years, I have been using an online quiz component for my Calculus I and Calculus II classes. This article is to report on how I implement the online quizzing scheme and how the online quizzing has been received by students and colleagues.

The quiz questions have been hand input to WebCT. Due to WebCT not being very mathematically friendly, this has been a time consuming process, with many of the questions needing to be written with HTML by hand. The publishers testing software can be used in conjunction with WebCT, but this limits the number of different questions one has available for each topic.

The online quizzes consist only of multiple-choice questions and can be repeated up to three times, anytime during the term up until the final exam is administered. The highest score the student receives is recorded as the score for the quiz. For Calculus II, each quiz consists of five or six questions, with there being at least five different versions of each question. Actual quizzes are generated randomly by WebCT, with each quiz question being randomly selected from the five possible choices and the multiple-choice answers being randomly shuffled.

As the online quiz questions are hand entered into the WebCT, errors in the questions are virtually unavoidable. To compensate for the possibility of a student getting an erroneous question, I implement bonus points for any student who discovers a question which is erroneous. The student will get credit for the points the question was worth, plus and extra 3 points are added to the quiz for the student reporting the error. This process has lead over a few semesters to a database of questions with few if any errors.

In my implementation, I use the online quizzing as an optional component of course, with a flexible grade weighting scheme being used. Students can have the online quizzes contribute to their final grade calculation or can opt out, depending on the grade weighting scheme they have chosen. The flexible grade weighting system being used for grade calculation has been positively received by the students. Students can choose the components of the course they wish to perform, within bounds set at the beginning of the course. Hence, no student is obligated to do aspects of the course which they do not want to participate in.

Each term I have used online quizzes as an optional component of a flexible grade weighting system, roughly 30 percent of the students have used the online quizzes in the final computation of their course grades. This compares with the student rate of participation in the carefully graded homework of roughly 40 percent.

The use of multiple-choice questions is for instructor convenience. Once the semester begins, I do not have to do any work on grading the quizzes, as everything is automated. At the end of the term, I go online and record the scores for the students who wish to have the online quizzing component used in the computation of their final grade. The option exists in WebCt to have written answers, but they must be hand graded by the instructor.

The first efforts I had with the online quizzing were with my requiring that all students participate in the online quizzes. Some students rebelled, as they did not like spending hours at a time on the computer or felt they did not learn anything from the online quizzing. It is partially in reaction to these reasonable concerns that I moved to the flexible grade weighting system, with the online quizzes being an optional component of the course.

As a measure of the effectiveness of the online quizzes with respect to student learning, I consider the final exam scores for each class. For my most recent three calculus sections, where I implemented the online quizzes as a component of a flexible grade weighting system, the average final exam score average over all the sections was 78.7 percent. The average for the final exam of the students who completed the online quizzes and chose to include the online quizzes as a component of their final grade was 83.2 percent. These numbers are based on a limited number of 35 students with 11 choosing to complete the online quiz component. More data needs to be collected before any conclusions can be drawn.

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Online Technology in a Liberal Arts Math Class

At West Virginia University, many of the calculus and below courses are taught in large lecture sections (200 students). These courses are managed by a group of faculty members within the math department, called the Institute for Math Learning. This talk will detail the experiences of the speaker as course coordinator for the Liberal Arts Math course in the 2004-2005 academic year. We will discuss the positive and negative aspects of using Web CT Vista as a course management tool, for all student quizzes, labs, and exams. We will anecdotally note the impact of making detailed PowerPoint lectures available to students online before class. We will also briefly touch on our experiences using Personal Response System questions (also available online before class), in an effort to engage students during lectures. Finally, we will share results of a survey on each of these course components, given to students in the spring 2005 semester.

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The Classroom-Free Web-Only Course Environment

This is a kind of "report from the trenches" of my personal experience teaching Statistics over the last three years using the eCollege platform.

I shall try to assess the emerging positive and negative features of this environment.

James Rolf (jim.rolf@usafa.af.mil) United States Air Force Academy, 2354 Fairchild Hall, Suite 6D124, CO, 80840

Using CalcTool to Teach Calculus

CalcTool consists of two suites of (free) java applets that can be used to teach differential and integral calculus. I demonstrate the utility of CalcTool applets for discovery learning, visualizing certain concepts, and as a calculational tool.

Carolyn Warren (cwarren@olemiss.edu) The University of Mississippi, 120 Evergreen Dr., Senatobia, MS, 38668

Using Web-Based Software in Your Teaching Team

This presentation will describe the different instructional software that The University of Mississippi has piloted in their College Algebra course over the past four years and the results on a standard final exam given for each pilot course. Results from students using the software were also compared to the results of students taking the same exam before instructional technology was implemented. The conclusion is that effective use of instructional software that has a mastery level focus can significantly improve the level of student performance based on a standard College Algebra Exam. Results from an Elementary Statistics course using the same format will be discussed briefly to show that the results can be generalized to other courses.

General Contributed Paper Session

Jonathan Hodge (hodgejo@gvsu.edu) Grand Valley State University, Department of Mathematics, Allendale, MI, 49504

A Course on the Mathematics of Voting & Elections

In this talk, I will discuss my experiences designing and teaching a discovery-based, general education course on the mathematics of voting and elections. Together we'll explore both the benefits and the challenges of teaching such a course to non-mathematics majors.

Danrun Huang (dhuang@stcloudstate.edu) Saint Cloud State University, Department of Mathematics, St. Cloud State University, St. Cloud, MN, 56301-4498

A Fun Approach in Proving Fibonacci Identities

We all know bees are smart; they make honey and can spell really well, too. In this talk, we show how honeybees can prove a lot of Fibonacci identities, ranging from those seen in many texts of discrete mathematics to those more complicated or sophisticated.

Vince Matsko (matskvi@quincy.edu) Quincy University, 1800 College Ave., Quincy, IL, 62301

A High School Course on Polyhedra

Learn how a course on the theory and construction of polyhedra and geodesic domes is being offered to seniors at Quincy High School. See how students constructed a zonohedron with 2040 CDs on an aluminum frame nine feet in diameter.

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Linda Becerra (becerral@uhd.edu) University of Houston-Downtown, 1 Main St., Houston, TX, 77002

A Self-contained Short Course in Statistics

In 2002 we were asked to develop and present a 1- day short course in statistics for a group of individuals affiliated with the Beijing International Airport. The group was in the United States taking several short

courses to assist them in the continuing development of the Beijing Airport operations. The group took a series of about 15 short courses in areas ranging from accounting to statistics. This paper describes the development and presentation of the statistics short course.

This course consisted of a survey of a number of different statistical tools and procedures which were then used to illustrate how statistics can be used both in the planning and development of management objectives, with an emphasis on examples and applications applied to international airport activities.The standard EXCEL Data Analysis library with inexpensive add-on programs was used throughout the course.

It should be noted that the paradigm introduced by this paper can be used as the framework to develop similar short courses in statistics relating to other areas of interest, or to develop case studies which utilize inexpensive statistical software.

Note: The Peoples' Republic of China was subsequently awarded the 2008 Summer Olympic Games to be staged in Beijing.

Laura Taalman (taal@math.jmu.edu) James Madison University, Department of Mathematics and Statistics, 127 Burruss Hall, MSC 7803, Harrisonburg, VA, 22807

An Exact Sequence of Weighted Nash Complexes

Given a three-dimensional complex algebraic variety with isolated singular point and a sufficiently fine complete resolution of the singularity, we can make a careful choice of hyperplane that allows us to construct an exact sequence of weighted Nash complexes.

Mike Pinter (pinterm@mail.belmont.edu) Belmont University, 1900 Belmont Blvd, , Nashville, TN, 37212

An Integrated Math and Philosophy of Science Course

Analytics, a course within the Honors program at Belmont University, integrates mathematics, logic, and some philosophy of science; problem-solving serves as an overall theme, with particular emphasis on problems from discrete mathematics that are explored by students using discovery-based methods. The course also features laboratory work, small group work, and extensive reading and writing. During the course, students are engaged in a variety of cooperative and interactive learning activities, especially during the weekly two-hour "lab" times. In my presentation, I will focus primarily on the discrete mathematics portion of the course and some strategies I use. I will also address my efforts at assessment within the course, including the use of writing assignments and student portfolios. Students have generally enjoyed the attempt to integrate knowledge from what they previously perceived as diverse areas.

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Applied Projects in Linear Algebra

Linear Algebra has many applications. Unfortunately, in many instances, there is not enough class time during the semester to devote to these interesting applications. In this talk, I give three out-of-class projects that I've used to show how linear algebra can be a very useful tool. The applications we discuss are population distribution and Markov Chains, differential equations, and surprising applications to other areas of mathematics. I will also show how computer software is used to enhance these projects and how it exposes the students to aspects of computer programming.

Sarah Greenwald (greenwaldsj@appstate.edu) Appalachian State University, 121 Bodenheimer Drive, 326 Walker Hall, MATH, ASU, Boone, NC, 28608

Ben Franklin's Codicil — Financial Mathematics

In honor of the 300th anniversary of the birthday of Benjamin Franklin, a short course on magic squares and recreational mathematics will be presented at MathFest. Here we discuss how we have used another legacy of Benjamin Franklin in the liberal arts mathematics classroom. In 1785 Charles-Joseph Mathon de la Cour wrote a parody mocking the spirit of American optimism with Fortunate Richard leaving a small sum of money in his will to be used only after it had collected interest for 500 years. Franklin, who was 79 years old

at the time, thanked him for a great idea and left a bequest of 1000 pounds each to Boston and Philadelphia on the condition that it be placed in a fund that would gather interest over a period of 200 years. A related Excel lab and writing project examine what actually happened to Benjamin Franklin's money, and combine financial mathematics with the disciplines of history, economics, political science, ethics, and philosophy. We will discuss student reactions, problems that were encountered, and suggestions for improvement and successful implementation.

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Blast Sound Propagation over Complex Terrain

A ray-tracing method for predicting sound pressure levels at medium to large distances from an explosive source is developed which takes into account the effects of weather and complex terrain on sound propagation. The model uses two-dimensional piecewise-linear terrain profiles and assumes a stratified atmosphere as an alternative to computationally intensive three-dimensional terrain and weather models. Comparisons are made between model predictions and numerical results for the Split-Step Padé method as well as measured sound pressure levels from actual field data.

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Leah Chenault (leahjun1781@aol.com) Texas Tech University, MS 1042, Mathematics and Statistics, Lubbock, TX, 79409

College Math in High School: Why Not?

An intervention by college mathematics faculty in K–12 teaching is described. College level mathematics lessons were presented to high school Algebra II and Geometry classes. The purpose was to examine if the new material would lead to an improvement in algebra and geometry skills. Topics introduced to the students included complex variables, complex functions and transformations of the complex plane. Student interest in mathematics as well as their algebra and geometry skills were tested both before and after the introduction of the college level mathematics. There was no significant increase in student interest. From the results of the pre-test and post-test, the students' algebra and geometry skills did improve. Detailed analysis of the pre and post-intervention problem solutions show particular errors in mathematical reasoning that can be addressed in future studies.

Fabio Santos (fabio.santos@uc.edu) University of Cincinnati, 9555 Plainfield Rd, Cincinnati, OH, 45236

Computer Simulations for Teaching Statistics

Although simulation methods in statistics are valuable research tools, they can also be useful for teaching. In this talk we provide examples of Monte Carlo and bootstrapping simulation methods that can be used to introduce students to fundamental statistics concepts. We will demonstrate how these computer-simulation techniques can be used in the classroom to describe sampling variability, sampling distributions of various statistics, and the central limit theorem. We will also highlight their use to improve students' statistical understanding of hypothesis testing. In particular, we will show several examples of Monte Carlo and bootstrapping simulation activities designed to investigate the relationships among statistical power, effect size, sample size, level of significance, and Type II errors.

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Alison Setyadi (alison.setyadi@dartmouth.edu) Dartmouth College, 6188 Bradley Hall, Hanover, NH, 03755

Conquering Calculus Consternation

The Math 1/ Math 2 program was initiated at Dartmouth College in the 1980's by Dwight Lahr to accommodate students who would normally struggle in the introductory calculus course. Over the years the program has

evolved and has recently adopted some innovative methods for aiding the students. In particular, weekly meetings with all the instructors, tutors and a college dean created a support network that contributed to the success of record numbers of students especially minority students. In this talk, we will present the system currently used in the Math 1/ Math 2 program. Furthermore we will propose simple ways of implementing such a system in an inexpensive and efficient manner.

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Discovering Binomial Identities with PascalGT

PascalGT is a software package for drawing "PascGalois triangles" — triangular arrays generated by two elements in a group using the familiar Pascal's triangle generating rule. For example, the usual Pascal's triangle is a PascGalois triangle for the additive group $\mathbb{Z}$ with both generators equal to 1. In this talk, I will describe exercises which use *PascalGT* to help students "discover" certain binomial identities which hold when the binomial coefficients are interpreted as elements in the cyclic group $\mathbb{Z}_p$ of integers modulo a prime integer p.

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Election 2004 and Alternative Voting Methods in Chemung County, New York

One of the drawbacks of much of the research done on alternative methods of voting is a lack of data with respect to actual elections. To help remedy this, the author and the Elmira College Mathematics Seminar class conducted a poll of registered voters in Chemung County, New York to determine how various voting methods might have affected the results of the 2004 Presidential Election. This article presents the results of the election according to this poll for Plurality Voting, Instant Run-off Voting, Approval Voting, the Borda Count and the Condorcet Method. Speculations about national results are made assuming that the data from this poll can be extrapolated.

Mohamed Allali (allali@chapman.edu) Chapman University, One University Drive, Math and CS Dept, Orange, CA, 92866

Enhancement of Images: A Project in Linear Algebra

Many realistic and interesting applications have already been incorporated into a standard Linear Algebra course. However, Digital Image Processing tools have not been used extensively in Linear Algebra. In this talk, I will show how the simple concept of linear enhancement of images can make it more visual and interesting for instructors and students.

Anne Edlin (edlin@lasalle.edu) La Salle University, 1900 West Olney Avenue, Philadelphia, PA, 19141

Exploration, Conjecture and Proof

Students often get frustrated with the minutiae of proof writing and start to forget why they love mathematics. I assign group explorations of some of the greatest problems in mathematics such as Goldbach's Conjecture and Fermat's Last Theorem. These problems are not identified by name and are often incorrectly stated. Students have an opportunity to be the mathematician and apply their new found knowledge to create a conjecture and then try to prove it. During this process I am able to see how well they can relate what they have studied to some very challenging scenarios.

John Maceli (Maceli@Ithaca.edu) Ithaca College, Department of Mathematics, Williams Hall, Ithaca, NY, 14850

Fairness, The Talmud, and Pascal

Topics of fairness make terrific subject matter for a contemporary mathematics course. We will illustrate a few problems related to fairness and equity. In particular, we will discuss a bankruptcy problem arising in

The Talmud and show a connection with the solution of this problem and Pascal's solution of the "Problem of Points."

David Ewing (ewing@cmsu1.cmsu.edu) Central Missouri State University, Dept. of Math & Computer Science, WCM 117, Warrensburg, MO, 64093-5045

Geometry on a HubCap

What geometry can exist on the surface of a 'Hubcap,' a 'Donut,' 'Saddle' or a chocolate 'Kiss'? Your undergraduate course in Geometry can be taught more effectively by having your students create their own geometries on these surfaces. In this inquiry-based approach, students become more effective in posing theorems and writing proofs as they create definitions, formulate postulates, state and verify hypotheses concerning properties and relationships occurring within 'their' geometry.

Doreen De Leon (doreendl@csufresno.edu) California State University, Fresno, 3150 W. Fir Ave., #127, Fresno, CA, 93711

Getting Students Warmed Up to Mathematics

Applied Analysis at California State University, Fresno is a semester long course focusing on the solution of differential equations. Its major audience is engineering majors. The average exam scores for the students in the two sections of this course in the Fall 2004 semester indicated poor student comprehension. Since students found the problem-solving sessions held periodically during the semester to be helpful, a natural next step toward improving student comprehension in the Spring 2005 semester seemed to be the addition of warm-up problems to be given at the beginning of many of the lectures. The impact on student exam scores seemed to be positive because the average exam scores in each section improved by approximately ten full percentage points from the Fall 2004 semester.

Student response to the use of warm-up problems was enthusiastic. On a mid-semester survey designed to obtain student feedback on all aspects of the course, three of the five questions were targeted towards the warm-up problems. On a scale of one (very poor) to five (excellent), the average rating of the students of the effectiveness of the warm-up problems was 4.5, with a standard deviation of 0.66, in one section and 4.4, with a standard deviation of 0.82, in the other section.

Fred Worth (worthf@hsu.edu) Henderson State University, Box 7783, Arkadelphia, AR, 71999

Great (but lesser known) Theorems

We will look at some intriguing but less well known theorems, one coming from dynamical systems and two coming from algebra.

Jeff Johannes (johannes@member.ams.org) SUNY Geneseo, 1 College Circle, Geneseo, NY, 14454-1213

Greatest Hits of Mathematics

For the past two years I have begun every single class session by playing a song that has a connection (at times extremely tenuous) to the content of the day. I will share a mix of as many songs as I can during this time.

Scott Greenleaf (sgreenleaf@une.edu) University of New England, 11 Hills Beach Road, Biddeford, ME, 04005

Group Action Decompositions for Symmetric Tensors

For $G = SO(2m, 2n)$, $m \leq n$, impose the standard ordering on the roots relative to the standard compact Cartan subgroup. Let $\mathfrak{u} \cap \mathfrak{p}$ be the span of the root vectors for the positive noncompact roots, and let L be the compact subgroup built from the compact Cartan subgroup of G and from all linear combinations of compact simple roots. The decomposition of the symmetric algebra $S(\mathfrak{u} \cap \mathfrak{p})$ under L plays a role in cohomological induction. The cases $m = 1$ and $m = 2$ were studied in works of W. Schmid and of B. Gross and N. Wallach. This talk will focus on the decomposition for general m.

Sandra Richardson (richardson@math.lamar.edu) Lamar University, PO Box 10047, Beaumont, TX, 77710

Implementing Thought Revealing Mathematics Tasks

Much of the reform in mathematics education advocates collaborative learning and approaches that require students to explain their mathematical ideas. This session will introduce a framework for creating and implementing thought-revealing mathematical activities called model-eliciting activities (Lesh, Hoover, Hole, Kelly, and Post, 2000).

Model-eliciting activities are open-ended mathematics problems that require collaborative student groups to make sense of their existing mathematical knowledge and understandings to formulate a generalizable mathematical model that is applicable to both the given problem and similar problems. In addition to implementing model-eliciting activities in middle school, high school, and university mathematics courses, they can also be used in university mathematics education methods courses for middle school and high school pre-service teachers. In such methods courses, pre-service teachers are afforded the opportunity to discuss the mathematical issues that arise as students engage in model-eliciting activities, consider the sorts of knowledge and skills needed to teach corresponding concepts, and make attempts at creating such problems as instructional material.

Haohao Wang (hwang@semo.edu) Southeast Missouri State University, Math Department MS6700, Cape Girarduea, MO, 63701

Implicit Equation of Certain Parametric Surfaces

This paper will show that the use of syzygies provides method for finding the implicit equation of certain type of parametric surfaces.

Abdulmajeed Abdurrahman (ababdu@ship.edu) Shippensburg University, 1871 Old Main Drive, Shippensburg, PA, 17257

Infinite Sums in String Field Theory

In this paper we present some of the crucial infinite sums needed to further understand the connection between Witten's String Field Theory (WSFT) and the Comma Theory. Special cases of these sums have been encountered before in the work of D. Gross et al. These sums constitute the foundation for inverting the infinite dimensional change of representation matrices appearing in the comma approach to WSFT. In particular the generalization of the sums encountered would be essential when considering the problem of the interaction vertex for more than three strings and may simplify the construction of the conformal operator connecting the Comma Theory and WSFT. Many techniques in evaluating infinite sums would also be presented and discussed in this paper.

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Lessons Learned in Creating Girls' Math Clubs

Math clubs for girls were designed to increase interest and enthusiasm for scientific reasoning and mathematical activities among preadolescent and adolescent girls. The clubs are hosted by a college level mathematics department and several local middle schools. These represent a diverse range of schools including one which is 97 percent Hispanic, several public schools and one private school. A major feature of the program is to have successful young women facilitate the clubs and these include a science education graduate student, mathematics graduate students, a senior engineering student and several pre-service education students. Ongoing activities include math games, hands-on science, interest surveys, and consultation with teachers on curricular issues. In order to maintain a successful club it is essential to understand the school and social calendar of the students, to provide activities that draw the girls together, to have activities that produce tangible results,

and to model mathematics as a creative endeavor. Feedback from the students suggests that they enjoy the games and gain increased confidence in problem solving, even though they find "regular" mathematics to be difficult and boring. A formal study of the efficacy of the math clubs is underway. Questions posed relate to the attitude and confidence of the girls as well as to teacher attitudes. The state test scores will also be examined to determine if club participation results in enhanced performance.

Janet Nichols (janet.nichols@colostate-pueblo.edu) Colorado State University-Pueblo, 2200 Bonforte Blvd, Pueblo, CO, 81212

Lessons Taught and Lessons Learned

Colorado State University - Pueblo now requires an elementary statistics course and a sequence of three courses for pre-service elementary education students. Lessons learned about attitudes of students towards mathematics, competency with algorithms, and problem solving abilities will be discussed. Group activities will be shared. Assessment activities including a geometry dictionary and measurement manual will be presented.

Richard McIntosh (mcintosh@math.uregina.ca) University of Regina, Math Dept., Regina, Saskatchewan, Canada, SK, S4S 0A2

Lucas Sequences and Probable Prime Testing

A brief introduction to Lucas sequences and the concept of pseudoperiod modulo primes will be presented. The following theorem will be proved: Let $n = (2^p + 1)/3$, where p is an odd prime. A necessary condition for the primality of n is $S_{p-1} \equiv -34 \pmod{2^p + 1}$, where $S_0 = 6$ and $S_{k+1} = S_k^2 - 2$. I discovered that n is a probable prime when $p = 42737$, 83339 and 95369.

Melanie Butler (mbutler@math.wvu.edu) West Virginia University, Department of Mathematics, PO Box 6310, Morgantown, WV, 26506-6310

Math Enrichment for Middle School Students

This talk will discuss the second year of the Math Saturday Series, a math enrichment program for middle school students. This outreach effort is sponsored by the Mathematics Department and the Institute for Math Learning at West Virginia University. Examples of topics and technology used with the students will be discussed. Future directions for the program will also be considered.

David Quesada (dquesada@stu.edu) St. Thomas University, 16401 NW 37 Avenue, Miami Gardens, FL, 33054

Modeling An Asthma Attack: The Immune Response

Asthma is a respiratory disorder resulting from a combined response of the immune system to environmental agents (allergens) and the expression of different genes (complex trait disorders). Asthma episodes are characterized at least by an increase in levels of Immunoglobulin E (IgE) and by the bronchial hyperresponsiveness (BHR). A coarse-graining approach has been adopted for developing a mathematical model for T-helper cells differentiations, including cell competition and a hierarchical organization. The cell competition has been modeled via the Lotka-Volterra model, and it was applied to T_{h1} and T_{h2} cells, while the hierarchical model controls the levels of cytokines secreted by each one of the T cells.

Shishen Xie (xies@uhd.edu) University of Houston-Downtown, 1 Main Street, Houston, TX, 77002

Modified Decomposition Method for Solving DE

The decomposition technique, first introduced by Adomian, has been used to solve nonlinear differential equations, algebraic equations and boundary-value problems. The scheme assumes an infinite series solution $u = \sum_{n=0}^{\infty} u_n$, where the terms u_n are recursively determined.

A modified version of the technique will be presented to solve four equations of importance in mathematical physics and engineering.

1. A nonlinear wave equation, the KdV equation, that arises in the modelling of shallow water waves;
2. A hyperbolic conservative system that models shocks;

3. Another nonlinear wave equation, the Klein-Gordon equation, which is an important model in quantum mechanics; and
4. The H-equation due to Chandrasekhar which arises in the study of radiative transfer.

The solution obtained by the modified technique approximates the exact solution with a high degree of accuracy using only a few terms of the iterative scheme.

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Richard Brazier (rab27@psu.edu) Penn State University, College Place, Du Bois, PA, 15801

Mom! There's a Hypocycloid in my Closet!

We will explore the calculus of closet doors. Specifically, we ask, "How much floor space is saved by using a bi-fold door on your closet rather than an ordinary door?" We will give a parameterization of the area swept out as a bi-fold door opens (or closes) and show that this represents a 70% space savings over an ordinary door. Interestingly, the hypocycloid arises naturally in the parameterization. We will also consider generalizations to n-fold doors. We didn't find any monsters in the closet.

Paul McCreary (pmccrear@xula.edu) Xavier University of Louisiana, Department of Mathematics, One Drexel Drive, New Orleans, LA, 70125

Navigating 3D Models; Mathematical and Biological

An interactive computer graphics application combines five classic examples of hyperbolic 3-space isometries, together with a model of the active protein in gila monster venom, exendin-4. The provocative hyperbolic shapes and protein configurations provide an ideal context for discussions with and between undergraduates across the natural and physical science disciplines. In each of the hyperbolic examples, animated action on select curves and surfaces infers the action on the entire space. "Flying" through the molecular model makes functional groups stand out in a most distinctive manner.

At Xavier University of Louisiana, we use this 3D computer application in an interdisciplinary seminar for undergraduates who concurrently conduct research projects in biochemistry or mathematics. It provides a 3D context in which undergraduates and faculty members can communicate across their respective disciplines.

To see this application in action, download the following two files and click on the entry.exe file.

http://webusers.xula.edu/pmccrear/entry.exe

http://webusers.xula.edu/pmccrear/glut32.dll

Unfortunately, the application described above operates only on PC's. However, an earlier version operates on Mac's, but without the molecular model.

http://webusers.xula.edu/pmccrear/test.app

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Newton's Greatest 'Blunder'

It is well known that Albert Einstein's greatest 'blunder' was his introduction of a cosmological constant term in the theory of general relativity to explain a static universe, a belief that was later dismissed by Hubble's discovery of an expanding universe. However, less well known is the same blunder made by Isaac Newton over 300 years ago, who introduced essentially the same cosmological constant in his theory of gravitation to explain lunar precession. As the use of this cosmological constant has recently become fashionable again among physicists, I revisit Newton's blunder and discuss in particular his theorem on revolving orbits and calculation of orbital precession as published in the Principia to demonstrate how his mathematical ideas are still useful to us.

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Non-Archimedean Topologies as Boolean Rings

A Topology T on a set X is said to be non-Archimedean Topology if it has a basis B such that if u and v are two members of B, then either u and v have no element in common or u is a subset of v or v is a

subset of u. In this paper, we investigate two operations that make this topology to become a Boolean ring. Maximal ideals of such ring and ultrafilters in T as a non-Archimedean topology will be investigated. Finally these relations have been characterized.

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On the 'alternating Euler constant' $\ln(4/\pi)$

We give (non-rational) series for $\ln\frac{4}{\pi}$ and Euler's constant γ which exhibit $\ln\frac{4}{\pi}$ as an alternating analog of γ. (See the author's note "Double integrals for Euler's constant and $\ln\frac{4}{\pi}\ldots$" in the Jan., 2005, *Amer. Math. Monthly*.) Then we "sketch" a geometric proof of a rational series for $\ln\frac{4}{\pi}$ analogous to Vacca's series for γ. We discuss generalizations and accelerations of both series.

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Pattern Breakers In Elementary Number Theory

Number Theory is a mathematical discipline that is very amenable to formulating conjectures via the analysis of patterns. In some cases these patterns aid in resolving the conjectures and establishing neat theorems. To cite a very fundamental example, empirical evidence suggests every fifteenth Fibonacci Number starting with the fifteenth is divisible by ten. This conjecture is indeed true and readily substantiated via The Principle of Mathematical Induction. Similarly observing the periodicity of the Lucas Sequence correctly suggests that no member of this sequence is divisible by either five or ten. On the other hand, numerous observations via patterns do not lead to fruitful results and eventually break down. In this paper, we will observe patterns seemingly suggesting certain number theoretic behavior only to alas break down often after a large number of cases. Examples will be taken from prime generating polynomials, abundant numbers, the linear function $f(n) = 945 + 630n$ where n is a whole number, prime races, and the Euler Phi Function. Please join us to witness number theory and the CAS (Compute Algebra Systems) Mathematica and The TI-89 in achieving these dynamic pattern breakers.

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Cristina Torres (cristina.torres@att.net) University of Texas at El Paso, 10428 Byway, El Paso, TX, 79935

Predicting Exam Performance from Concept Map Terms

This study used student concept maps on function to determine whether concepts predict performance on exam questions relating to function. Seventy-five students from two sections of College Algebra completed concept maps on function during the fall 2003 semester. Students completing the second map and the first exam and/or the fourth map and the final exam were considered in the analysis. Students were given a concept score based on the number of relevant concepts present on their maps and a test score based on a rubric score of one to six. Correlations were run on concept and test scores as a whole, by class section, and by type of exam. Initial findings indicate that there may be a relation between the presence of relevant concepts on the maps and the success of the students on the function related questions.

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Prime Number Theorem with Littlewood Oscillations

A new method is developed for deriving the prime number theorem including Littlewood oscillations. Sets of δ-functions are used to model the Eratosthenes' sieve process, giving rise to recursive functions for the prime density $\rho_S(N)$ (smoothed, local, average fraction of primes near N) and the divisibility density $\rho_D(N)$ (fraction of integers not divisible by any prime up to N, where those integers then determine new primes in the interval $X = \{N, N^2\}$). Since $\rho_D(N)$ is a point estimate, one can ask which $X = \{N, N^2\}$ best

gives $\rho_S(X) \equiv \rho_D(N)$. Here $\rho_S(X = N) = \rho_D(N)$ is linear, $\rho_S(X = N^2) = \rho_D(N)$ is quadratic, and $\rho_S(X = N^\Lambda) = \rho_D(N)$ or $\rho_S(X) = \rho_D(X^{1/\Lambda})$ would be a general model. We then derive

$$\mathbf{1}\frac{d\rho_D(Q)}{dQ} + \rho_D(Q) \cdot \frac{\rho_D(Q^{1/\Lambda})}{Q} + \mathcal{O}\left(\frac{1}{Q^2}\right) \equiv 0 \tag{4}$$

as a fundamental equation for $\rho_D(Q)$, where the above "$\mathbf{1}$" expresses a symmetry that there must be exactly one new prime within every $Q = \{P_{k-1} + \epsilon, P_k + \epsilon\}$ interval. Ignoring the $\mathcal{O}(1/Q^2)$ term, this equation has a fundamental solution of $\rho_D(Q) = \mathbf{1}/\{\Lambda \ln Q\}$ and $\rho_S(Q) = \mathbf{1}/\ln Q$, giving the prime number theorem (PNT). Let $Z(Q)$ be the first correction to the PNT:

$$\rho_D(Q) = \frac{\mathbf{1}}{[1 + Z(Q)]\Lambda \ln Q}. \tag{5}$$

For $Z(Q) \ll 1$, it gives

$$\frac{dZ(Q)}{dQ} + \frac{Z(Q^{1/\Lambda})}{Q \ln Q} \approx 0, \tag{6}$$

which has a solution

$$Z(Q) = \sum_{m=0}^{\infty} \frac{A_m}{(\ln Q)^{\beta m}} \tag{7}$$

with a side constraint $\beta_m \equiv \Lambda^{\beta m}$. This $Z(Q)$ function gives terms that exceed the von Koch monotonic correction to the PNT, which required the Riemann hypothesis and was of $\mathcal{O}(Q^{1/2} \ln Q)$. If $0 < \Lambda \leq e^{1/e} \approx 1.44466786\ldots$, then β_m is real, but at larger Λ, an infinity of complex β_m values are allowed, and a β_m closed form can be derived. Mertens' theorem sets $\Lambda = \Lambda_F \equiv e^{\gamma_0} \approx 1.781072418\ldots$ for the prime number system, where γ_0 is Euler's constant, and the resulting Littlewood oscillations are relatively small, giving corrections to the PNT that are all nearly periodic in $\{\ln \ln(Q)\}$.

Bronislaw Czarnocha (broni@mindspring.com)
Vrunda Prabhu Brown University, City University of New York

Proof of the Existence of a Limit using Moore Method in Freshman Calculus

This report describes the design of instruction from the Teaching Experiment in Freshman calculus*. The design of the teaching experiment incorporates successes of known (first generation) calculus reform approaches and addresses documented student challenges in understanding the concept of the limit. Classroom inquiry within the Zone of Proximal Development (ZPD) (Vygotsky, 1986) guides students from their intuitive, spontaneous understanding to "scientific" concepts of the limit through the elimination of their misconceptions via mathematical essay writing and guided problem solving initiated by Moore Discovery method.

The Moore method, in conjunction with the guidance, within students' ZPD allows them to tackle the concept of lub (glb), and to use it in proofs of existence/non-existence of the limit of a sequence. This approach aims at (1) eliminating standard student misconceptions of the limit (Cornu, 1990, Serpinska,1987) and (2) at anchoring student grasp of the concept in the integration of formal rigor with intuitive understanding. The excerpts from student mathematical essays will illustrate the successes of the approach.

Support provided by NSF-Research on Learning in Education grant #0126141. Introducing Indivisibles into Calculus Instruction

Xiao-Xiong Gan (gxiaoxio@morgan.edu)
Karen Adams Morgan State University, Department of Mathematics, Baltimore, MD, 21251

Proving Minkowski's Inequality as a Tool for Student Research

Many undergraduate curriculums in mathematics now include some form of a research project. However, even the savviest students often remain at a loss on exactly how to proceed, many fresh graduate students have some problems too. Instructors are faced with trying to identify an area of student research that is sufficiently complex so that there is little or no existing results already produced and at the same time trying to insure

that the student has the tools necessary to proceed as independently as possible. Most students end up relying heavily on their advisors, but there is help available.

In his article, "But How Do I Do Mathematical Research?" Suzuki (*Focus,* 2004) suggest s that by first categorizing mathematical research students may find it easier to plan and navigate their own research.

There are different types of Minkowski's Inequality (MI). There are different kinds of proofs for MI. We introduce the Mathematical Inductive proof of MI in the discrete context and explain why and how our work can help the undergraduate or graduate student to do research.

(Karen Adams is a graduate student and Dr. Xiao-Xiong Gan is the advisor)

Jay Abramson (abramson@math.la.asu.edu) Arizona State University, Dept. of Mathematics and Statistics PO Box 871804 College of Liberal Arts and Sciences, Tempe, AZ, 85287-1804

Quantitative Literacy in a College Math curriculum

The talk will discuss methods to facilitate the student's acquisition of quantitative literacy in a freshman level College Mathematics curriculum. The goal is to empower the student to be critical, understand and take charge of our their conclusions when faced with the numbers they are confronted with daily. Some of the activities presented will have evolved from scenarios as seen in CNN.com or Time magazine. Others have been designed to simply capture the student's imagination or motivate them to think mathematically. Vocabulary is stressed, literacy is mandated. Mathematics is like any other language and the student needs to be taught how to be fluent. We live in a world punctuated with numbers, thus the goal of the talk is teach the student how to be numerate, critical in their view of the numbers that confront them and confident in their ability to interpret, react and enjoy the understanding of the meanings behind the numbers.

Colm Mulcahy (colm@spelman.edu) Spelman College, 350 Spelman Lane, PO Box 953, Atlanta, GA, 30314

Questionable Mathematics With a Shuffled Deck

We'll show how to use a card principle dating back to the late 1950's to establish a little known result about primes, and discover the ϕ (the golden ratio), e, and π embedded in a shuffled deck of cards.

Robert Fontenot (fontenot@whitman.edu) Whitman College, Department of Mathematics, Walla Walla, WA, 99362

Several Problems in Linear Algebra

I will present statements and solutions of several interesting, nonroutine problems that I use for homework assignments or for class discussion in a first course in linear algebra. Along with the problems themselves, I will give background information on the problems and/or the context in which the problems arise naturally.

Roxana Costinescu (roxana.costinescu@millersville.edu) Millersville University, PO Box 1002, Millersville, PA, 17551

Solving Geometry Problems through Inquiry

From personal experience I know that a geometry class is as important in teaching formal proofs as the typical "Introduction to Proof" class that most mathematics majors are required to take. Moreover, practice has shown me that an inquiry-based approach is more efficient in teaching students how to solve even more subtle problems. In this talk I will describe my experiences of guiding my students through the solution of a challenging construction problem through inquiry and use of the dynamic software Geometer's Sketchpad. In doing so I will address the problems the students and I faced, as well as the outcome of our efforts.

Susan Pustejovsky (susan.pustejovsky@alverno.edu) Alverno College, 3400 S. 43rd Street, PO. Box 343922, Milwaukee, WI, 53234-3922

Teachers in Trigonometry — What's Important?

Preservice Elementary teachers who want to minor in mathematics have Trigonometry in their program at Alverno College. Because this course serves a number of different groups of students, I've had to think hard

about what is most important for them to learn. I've developed this course with an explicit focus on helping students deepen their knowledge of proportional thinking, practice working with fractions and ratios in flexible ways, and grow in ability to create useful representations of geometric problem situations. It seems these are good things to emphasize for all students in this class.

David Ewing (ewing@cmsu1.cmsu.edu) Central Missouri State University, Dept. of Math & Computer Science, WCM 117, MO, 64093-5045

Teaching Algebra & Calculus via GSP

Although know for its effective ability to teach geometry with technology, Geometer's SketchPad (GSP) can also be used to teach algebra and calculus. Several lessons teaching algebra and calculus concepts will be demonstrated. Teaching pedagogy with respect to this use of technology will be presented and its effectiveness discussed.

Sarah Mabrouk (smabrouk@frc.mass.edu) Framingham State College

Teaching an Online Course — A First Experience

With online courses becoming a popular alternative for college students as well as a convenient option for working students, colleges and universities are eager to offer them. In this presentation, I will discuss my first experience teaching an online *Introduction to Statistics* course. I will discuss both my reaction and student reaction to online communication, online discussions using discussion boards, the virtual classroom, and IM, online assignments, online quizzes, and online presentations as well as some frustrations experienced in teaching an online course and perceived differences between the online environment and the regular class environment.

Ilhan Izmirli (ii6336a@american.edu) American University, Department of Mathematics & Statistics, 4400 Massachusetts Avenue, Washington, DC, 20016-8068

Teaching Introductory Mathematics through Music

In this paper I will discuss a teaching technique I employed in some introductory level mathematics classes and its impact on students' understanding of basic concepts. Relevant statistics and some excerpts from the hand-outs used in these classes will also be presented.

Joel Lucero-Bryan (jlb@nmsu.edu) New Mexico State University, P.O. Box 30001 Dept. 3MB, Las Cruces, NM, 88003

Teaching via Projects Based on Historical Sources

We discuss recent NSF funded grant work of an interdepartmental team at New Mexico State University concerning non traditional instruction which introduces a primary historical source in discrete mathematics. This approach provides an alternative to traditional methods of instruction, which often offer only passing mention of the motivating problems and original work which eventually found resolution in modern mathematical concepts. This approach allows students to hone their verbal and deductive skills through reading, answering key questions, and studying the original works of great minds in history. The students are given the opportunity to react to the original source in much the same way as the contemporaries of the historical masterpiece, explore the development of key and ground-breaking ideas, and rediscover the conceptual roots common to discrete mathematics. In particular, we shall present a project based on Georg Cantor's *Contributions to the Founding of the Theory of Transfinite Numbers* (translated from German). This project was implemented in a sophomore level discrete mathematics course and time permitting we shall present student solutions and reactions to the original source project.

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Donald Beken (beken@uncp.edu) University of North Carolina at Pembroke, Pembroke, NC, 28372

The Eigenvalue Implication Problem

Let A and B be two real matrices of order n. We assume there is some relationship between A and B. The general problem is to show: if A has eigenvalue c, then B has eigenvalue d. Some results are already

known for certain relationships. We consider a relationship of the form: $A = X + Y$ and $B = XY$. We present results for many cases where X and Y are of the types: nilpotent, idempotent, involution or imaginary. EXAMPLE: let E be idempotent ($E^2 = E$) and let J be imaginary ($J^2 = -I$). We show that if $E + J$ has eigenvalue c, then EJ has eigenvalue $d = c^2 - c + 1$.

Lisa Townsley (ltownsley@ben.edu) Benedictine University, 5700 College Rd, Lisle, IL, 60532

The New CLEP Exam for Precalculus Credit

Lisa Townsley is one of the 8 college faculty members who created the new CLEP Exam in Precalculus. She will present an overview of the College Level Examination Program (CLEP), the precalculus exam content, the validation process, and guidelines on how you might use the exam results for credit or placement at your institution.

John Starrett (jstarret@nmt.edu) New Mexico Institute of Mining and Technology, 801 Leroy Place, Socorro, NM, 87801

The Pendulum Weaves All Knots and Links

The behavior of a chaotic dynamical system is determined by its strange attractor, an infinitely folded manifold along which the system state evolves. The strange attractor is organized by a skeleton consisting of an uncountably infinite set of unstable periodic orbits, along with their local stable and unstable manifolds. These orbits are topological knots, and the set is an infinite link; the embedding of an infinite number of knots in three space. The types of knots and links supported by the system may be determined by collapsing the attractor along its local stable manifolds to form a template, a branched two manifold with boundary that supports the same set of knots and links as the original attractor. We show that the strange attractor of a chaotic, vertically forced physical pendulum can be collapsed to a template that supports all knots and links. Thus, one of the simplest and most well known dynamical systems is capable of the most complex behavior possible.

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The q-Standard Polynomials

The Amitsur-Levitzki theorem asserts that $M_n(k)$ satisfies the standard polynomial of degree $2n$. (Here, k is a field and $M_n(k)$ is the algebra of $n \times n$ matrices over k). In this talk we study some of the properties of the family of polynomials in the variable q that arise as coefficients of evaluations of the standard polynomials in basis elements of the quantum plane $k_q[x, y]$.

Ji Young Choi (jychoi@ship.edu) Shippensburg University, Dept of Math, Shippensburg, PA, 17257

The t-Pebbling Number for Cycles

For a positive integer t, the t-pebbling number of a given graph is the number of pebbles which can move t pebbles to any specified vertex in any distribution by the pebbling movement. In this talk, the t-pebbling number for Cycles is presented.

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Lemuel Myers (lem.myers@usafa.af.mil) United States Air Force Academy, 2354 Fairchild Drive, Suite 6D124, CO, 80840

The Tablet PC in the Mathematics Classroom

We illustrate the use of the Tablet PC, along with networking software, in the mathematics classroom. We describe pedagogical successes and failures, along with the realities of implementing both hardware and software. Finally, we present a comparison of student engagement data from both a tablet and non-tablet sections of an Engineering Mathematics course.

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Tic-Tac-Toe on the Integer Lattice

Almost everyone has played 3×3 tic-tac-toe and knows that it is a draw game. (But, can we prove it's a draw game?) However, what if we play on a bigger board and have to occupy more than 3 points in a row? What can we say then? We'll consider tic-tac-toe on an infinite board (the integer lattice) and allow winning lines to have slopes other than vertical, horizontal, and slopes -1 and 1. Then we'll give a strategy that allows the second player to stop all winning lines of a certain length. (What's more, we'll prove that our strategy works.)

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Using History to Teach Mathematics with Examples

The history of mathematics can substantially humanize the teaching of mathematics. This talk will explore three ways of using history in the classroom. Patterns on Pascal's Triangle will be used as an example to make historical connections to several mathematical topics including Fibonacci numbers, Binomial expansions involving positive integer and negative integer powers, Catalan numbers, triangular numbers, square numbers, and powers of eleven and two. This talk will offer reasons to make the history of mathematics a part of classroom instruction by presenting a richer historical curriculum.

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Using Linguistics Problems to Teach Math Modeling

I will discuss a module developed for a mathematical modeling course at the advanced undergraduate level, based on a problem in historical linguistics. Linguist Anthony Kroch published a study of several syntactic changes, and mathematically tested the hypothesis that such changes follow a logistic sigmoid, and that the rate constants for related changes are the same despite variation in the time offset constant. Kroch's paper serves as the basis for the module. Lectures explained the origin of the sigmoid as the solution to a differential equation, and covered many different methods of fitting a sigmoid to data. The problem set guides students through Kroch's analysis. It exposes difficulties that arise when using least-squares methods to fit curves to this data, and leads students to understand why the maximum likelihood fit used in Kroch's paper is better. A computer is required for the maximum likelihood calculations. Students found the problem set challenging and fun. I will explain the module in detail, and give some insights gained from looking at students' performance.

Reference

1. Anthony Kroch. Reflexes of Grammar in Patterns of Language Change. *Language Variation and Change,* 1989.

Eberth Alarcon (alarcoeg@uwec.edu) University of Wisconsin-Eau Claire, 1404 Park Avenue, Eau Claire, WI, 54701

Using the Hypercube to Introduce New Techniques

This presentation will focus on two discovery activities involving the hypercube which the author has used to introduce interesting concepts into his upper-level discrete mathematics courses. In the first activity, students learn to compute the number of edges of Q_n by deriving a recursive formula and then introducing generating function techniques to solve it. The second activity involves a proof which introduces the idea of creating your own notation and leads to a discussion of what is important in a notational system.

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Visualizing the n-Dimensional Permutahedron

The n-dimensional permutahedron Π_n is the convex hull of the $(n+1)!$ points $(x_1, x_2, x_3, ..., x_{n+1})$, whose coordinates are the $(n+1)!$ permutations of $\{1, 2, 3, ..., n+1\}$. We first concentrate on Π_3, which is embedded in 4-dimensional space, determining which points are connected by edges and which points form what types of faces. Then we show that the generalization to higher dimensions, though not difficult, does involve a few surprises. This is joint work with Carolyn Yackel, Todd Lee, and Howard Iseri arising from an MAA PREP Workshop.

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Which Ballparks are Homer Friendly?

When Mark [McGwire] hit his 62nd homerun in 1999 to break Roger Maris' single season homerun record, the ball was a low line drive down the left field line. This ball would not have cleared the "Green Monster" in left field at Fenway Park in Boston because the wall is 37.17 feet high. In this paper we use a Halley's Gunnery law to determine the minimum initial velocity needed to hit a homerun, assuming ballistic motion. This formula is then applied to the fences in each major league ballpark in left, left-center, center, right-center and right fields to produce an average initial velocity for each ballpark. This is a theoretical measure of the difficulty of hitting homeruns. We then use statistics on homeruns hit at home and away to produce a statistical measure of the difficulty of hitting homeruns in each ballpark. These numbers are then compared.

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Widening the Audience for Discrete Mathematics

Although Discrete Mathematics has traditionally been a course for Computer Science majors, students from many different disciplines can benefit from learning this material. How can a course in discrete mathematics appeal to a wide audience, while retaining the rigor and coverage necessary for the study of Computer Science? I suggest two answers: 1) the course should be organized around the different types of thinking used in discrete mathematics, and 2) topics should be motivated whenever possible by applications to other disciplines.

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Women in Mathematics: A New Course

This past spring was the inaugural semester of a new course I designed entitled Women in Mathematics. It is a General Education course accessible to any student who has had at least two years of high school algebra. In this talk, I will discuss the content of the course as well as the various teaching strategies used including Blackboard, group activities and group projects.

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Word Problems and Quantitative Literacy

Even though special Quantitative Literacy (QL) programs are currently being developed and utilized in several colleges and universities, most schools still depend on traditional mathematics courses to reach their quantitative literacy goals. This paper is a case study of how a traditional mathematics course sequence intended for students majoring in social and life sciences may be modified and adapted to at least partially fulfill the need in case a stand-alone QL program is not yet developed. The course sequence in discussion covers the traditional content of a first-year calculus sequence along with a clear and intentional emphasis on word problems.