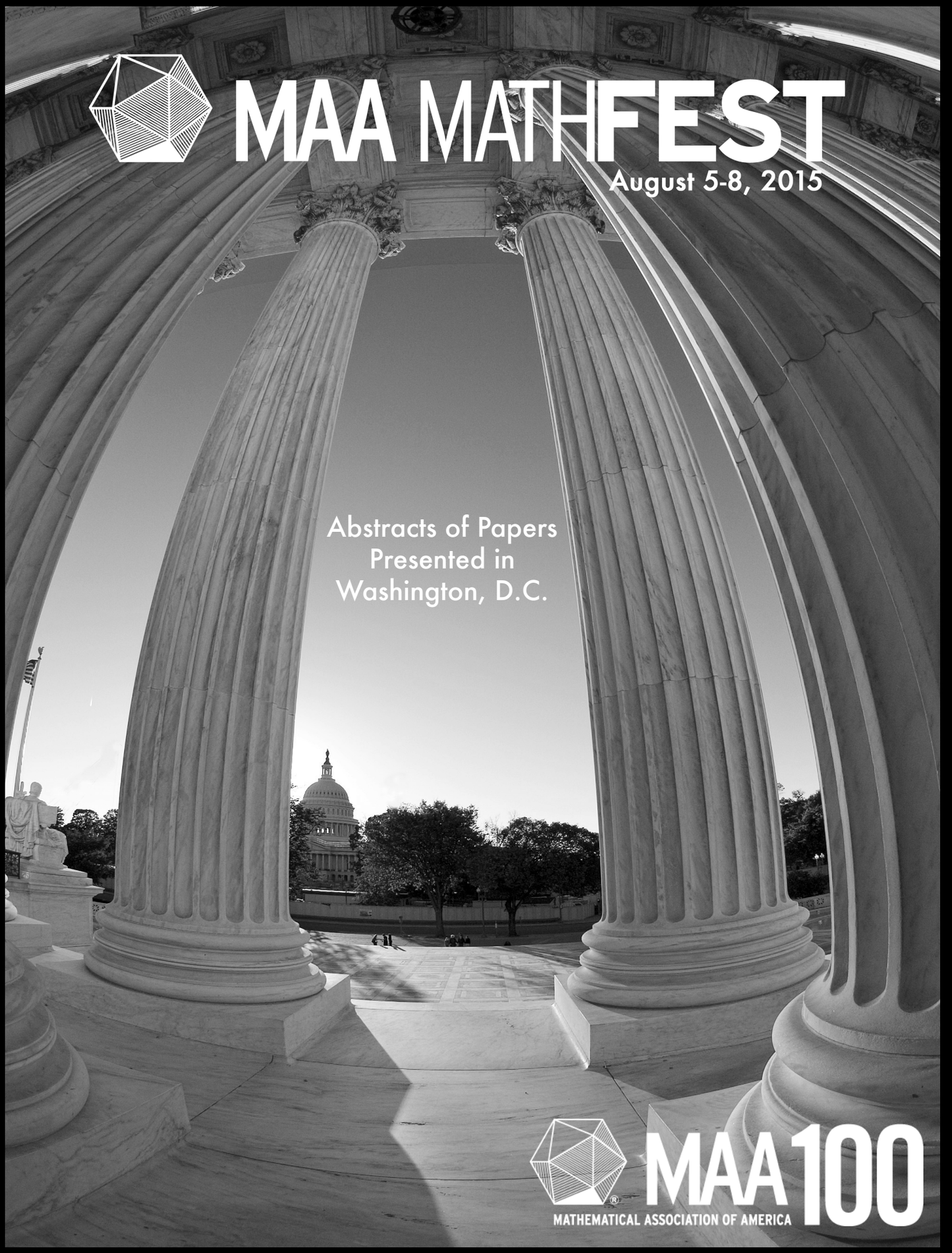

MAA MATHFEST

August 5-8, 2015

Abstracts of Papers
Presented in
Washington, D.C.

MATHEMATICAL ASSOCIATION OF AMERICA

MAA 100

Abstracts of Papers
Presented at
MathFest 2015
Washington, D.C.
August 5 – 8, 2015

Published and Distributed by
The Mathematical Association of America

Contents

Invited Addresses

Earle Raymond Hedrick Lecture Series

Algebra Over Finite Fields

Karen Smith, University of Michigan

Wednesday, August 5, 9:30 AM - 10:20 AM, Salon 2/3

Hedrick Lecture 1

Friday, August 7, 9:30 AM - 10:20 AM, Salon 2/3

Hedrick Lecture 2

Saturday, August 8, 9:30 AM - 10:20 AM, Salon 2/3

Hedrick Lecture 3

MAA Centennial Lectures

Wednesday, August 5, 8:20 AM - 9:20 AM, Salon 2/3

MAA Centennial Lecture 1: Replicators, Transformers, and Robot Swarms: Science Fiction through Geometric Algorithms

Erik Demaine, Massachusetts Institute of Technology

Wednesday, August 5, 10:30 AM - 11:20 AM, Salon 2/3

MAA Centennial Lecture 2: Network Science: From the Online World to Cancer Genomics

Jennifer Chayes, Microsoft Research

Thursday, August 6, 8:30 AM - 9:20 AM, Salon 2/3

MAA Centennial Lecture 3: Mathematics for Art Investigation

Ingrid Daubechies, Duke University

Thursday, August 5, 10:30 AM - 11:20 AM, Salon 2/3

MAA Centennial Lecture 4: The Role and Function of Mathematical Models in Interdisciplinary Mentorship through Research: Lessons from the World of Epidemics

Carlos Castillo-Chavez, Arizona State University

Friday, August 7, 10:30 AM - 11:20 AM, Salon 2/3

MAA Centennial Lecture 5: CSHPM Kenneth O. May Lecture "We Are Evidently on the Verge of Important Steps Forward": The American Mathematical Community, 1915–1950

Karen Parshall, University of Virginia

Saturday, August 8, 10:30 AM - 11:20 AM, Salon 2/3

MAA Centennial Lecture 6: Recent Results Toward the Birch and Swinnerton-Dyer Conjecture

Manjul Bhargava, Princeton University

AMS-MAA Joint Invited Address

Thursday, August 6, 9:30 AM - 10:20 AM, Salon 2/3

The Arithmetic of the Spheres
Jeffrey Lagarias, *University of Michigan*

MAA James R. C. Leitzel Lecture

Saturday, August 8, 8:30 AM - 9:20 AM, Salon 2/3

Calculus at Crisis
David Bressoud, *Macalester College*

AWM-MAA Etta Z. Falconer Lecture

Friday, August 7, 8:30 AM - 9:20 AM, Salon 2/3

"A Multiplicity All At Once": Mathematics for Everyone, Everywhere
Erica Walker, *Columbia University*

MAA Chan Stanek Lecture for Students

Wednesday, August 5, 1:00 PM - 1:50 PM, Salon 2/3

Seventy-Five Years of MAA Mathematics Competitions
Joseph Gallian, *University of Minnesota Duluth*

Pi Mu Epsilon J. Sutherland Frame Lecture

Friday, August 7, 8:00 PM - 8:50 PM, Salon 2/3

G-sharp, A-flat, and the Euclidean Algorithm
Noam Elkies, *Harvard University*

NAM David Harold Blackwell Lecture

Friday, August 7, 1:00 PM - 1:50 PM, Salon 2/3

Mathematics, Mathematicians, Mathematics Education and Equity: Challenges and Opportunities
Terrence Blackman, *The University of Denver*

Alder Awards

Alder Awards

Friday, August 7, 2:00 PM - 3:20 PM, Salon 2/3

Organizer: **Francis Su,** *Harvey Mudd College*

Reality Shifting: Building Mathematical Confidence
Talithia Williams, *Harvey Mudd College*

A Taste of Research
Patrick X. Rault, *Â SUNY Geneseo*

Be Inspirable!
Allison K. Henrich, *Seattle University*

Invited Paper Sessions

MAA Invited Paper Session: Generations of Monthly Gems

Wednesday, August 5, 1:00 PM - 3:50 PM, Salon 1

Organizers: **Scott Chapman,** *Sam Houston State University*
Dan Velleman, *Amherst College*
Bruce Palka, *National Science Foundation*
Roger Horn, *University of Utah*
John Ewing, *Math for America*

The session is designed to help celebrate the MAA's Centennial. With thousands of papers to draw on, 6 speakers will give 25-minute talks on papers chosen from throughout the Monthly's history. Speakers will highlight the significance of these papers and remark on their impact on mathematics and science in general.

1894–1919
Karen Parshall, *University of Virginia*

1920–1939
John Stillwell, *University of San Francisco*

1940–1959
Ron Graham, *University of California at San Diego*

1960–1979
Bob Devaney, *Boston University*

1980–1999
Paul Zorn, *St. Olaf College*

2000–2015
Rebecca Goldin, *George Mason University*

MAA Invited Paper Session: The Non-Traditional "Traditional NSA Mathematician"

Wednesday, August 5, 1:00 PM - 3:45 PM, Delaware B

Organizer: **Carla D. Martin,** *National Security Agency*

The National Security Agency's (NSA) mathematicians create breakthroughs in cryptography and communications security. It is common to associate number theory and discrete mathematics with cryptography. However, problems tackled by NSA mathematicians actually draw upon a much broader variety of fields including statistics, geometry, analysis, topology, graph theory, neuroscience, big data analytics, theoretical computer science, and computational linguistics. As a result, the research community at NSA includes experts in a wide range of mathematics and math-related subjects. The purpose of this session is to highlight both usual and unusual problems applied to national security, with all talks being at the general non-expert level. NSA mathematicians have produced fascinating and significant results over the years, however much of the work is not published. This session is a great opportunity for the MAA community to be exposed to some of NSA's leading mathematicians and learn about the important role mathematics plays in a variety of problems.

The Coming of Enigma
David Perry, *National Security Agency*

Public Key Cryptography: From Abelian Groups to Yellow Padlocks in 30 Minutes Flat

Ben Benoy, *National Security Agency*

Extending Pairwise Element Similarity to Set Similarity Efficiently

Steve Knox, *National Security Agency*

Teaching Computers to See

Christine Edwards, *National Security Agency*

MAA Invited Paper Session: Improving Access to Mathematical Modeling Research

Thursday, August 6, 1:00 PM - 4:20 PM, Delaware B

Organizers: **Carlos Castillo-Chavez,** *Arizona State University*
Carlos Castillo-Garsow, *Eastern Washington University*

Recently with documents such as the Common Core State Standards, there has been an increasing push for mathematical modeling in every classroom. But the picture of mathematical modeling that applied mathematics researchers have is very different from the word problems provided in textbooks for teachers. This session is dedicated to closing the gap between applied mathematics research, mathematics education research, and what goes on in classrooms around the United States. With an eye to creating environment(s) that support students and teachers in mathematical modeling throughout the united states, at all mathematical and economic levels: How can we improve teacher's and students understanding of modeling research, and improve access to the experience of mathematical modeling research to populations that do not typically receive graduate training in the field?

Global Disease Monitoring and Forecasting with Wikipedia

Sara Del Valle, *Los Alamos National Laboratory*

Engaging Students in Applied Mathematics via Experiential Learning through Research

Sherry Towers, *Arizona State University*

Overcoming Epistemic Obstacles to Teaching Mathematical Modeling in Calculus

Patrick Thompson, *Arizona State University*

Mathematical Modeling Experiences in Secondary Schools

Kathleen R. Fowler, *Clarkson University*

Mathematics Education Commentary: At the Interface Between Applied Mathematics and Mathematics Education

Carlos Castillo-Garsow, *Eastern Washington University*

Applied Mathematics Commentary: Math at Top Speed: The Role of Mathematical Modeling in Science and in My Personal Life

Richard Tapia, *Rice University*

MAA Invited Paper Session: Algebraic Structures Motivated by Knot Theory

Friday, August 7, 9:00 AM - 11:20 AM and 1:00 PM - 5:00 PM, Delaware A

Organizers: **Alissa Crans,** *Loyola Marymount University*
Jozef Przytycki, *George Washington University*
Radmila Sazdanovic, *North Carolina State University*

The area of knot theory has been developing rapidly in recent years. Most recent advances rely on the connections between algebra, homological algebra and knot theory. Examples include the Jones polynomial, topological quantum field theories, skein modules of links in 3-manifolds, Khovanov link and Heegard-Floer homologies, homology of distributive structures (i.e. quandles, racks, distributive lattices) and Yang-Baxter operators, as well as categorifications of knot polynomials and other appropriate combinatorial structures. These new developments relate knot theory to other branches of mathematics including number theory, Lie theory, statistical physics, etc, and employ tools far beyond the traditional ones from algebraic topology. These ideas mark the beginning of a new era in knot theory that includes relationships with four-dimensional problems and the creation of new forms of algebraic topology relevant to knot theory. Moreover, knot theory has numerous results and open problems requiring only knowledge of linear algebra, and are therefore accessible to undergraduates. We propose to bring together students and faculty active in these areas to share them with the broader mathematical community and encourage future collaboration and investigation.

Knots and Knot Theory
Lou Kauffman, *University of Illinois at Chicago*

Knot Coloring: A Diagrammatic Approach to Algebraic Invariants
Heather Russell, *Washington College*

Topological Symmetries of Molecules
Erica Flapan, *Pomona College*

An Introduction to Quandles
Alissa Crans, *Loyola Marymount University*

Enhancements of Counting Invariants
Sam Nelson, *Claremont McKenna College*

An Introduction to Quandle Cohomology
J. Scott Carter, *University of South Alabama*

What is Categorification?
Mikhail Khovanov, *Columbia University*

From Jones to Chebyshev: Adventures in Categorification
Radmila Sazdanovic, *North Carolina State University*

MAA Invited Paper Session: Concrete Computations in Algebra and Algebraic Geometry

Friday, August 7, 1:00 PM - 3:20 PM, Delaware B

Organizers: **Sarah Mayes-Tang,** *Quest University*
Karen Smith, *University of Michigan*

This session will bring together researchers in computational or combinatorial algebra and algebraic geometry whose research is concrete and accessible.

Continued Fractions Can Resolve Singularities?!
Robert Walker, *University of Michigan*

The Search for Indecomposable Modules
Courtney Gibbons, *Hamilton College*

The Importance of α
Mike Janssen, *Dordt College*

Pictures of Syzygies
Timothy Clark, *Loyola University*

When Do 10 Points Lie on a Cubic Curve?
Will Traves, *US Naval Academy*

AMS-MAA Invited Paper Session: The Arithmetic of the Spheres

Thursday, August 6, 1:00 PM - 3:50 PM, Delaware A

Organizers: **William Abram,** *Hillsdale College*
Alex Kontorovich, *Rutgers University*
Jeffrey Lagarias, *University of Michigan*

This session deals with topics in number theory, geometry and dynamics related to Farey fractions, circle packings, and dynamical systems where mode locking appears.

The Apollonian Structure of Imaginary Quadratic Fields
Katherine Stange, *University of Colorado Boulder*

Circles in the Sand
Lionel Levine, *Cornell University*

Pythagoras Meets Euclid: A Euclidean Algorithm for Pythagorean Triples
Dan Romik, *University of California Davis*

Dynamics of Apollonian Circle Packings
Elena Fuchs, *University of Illinois Urbana-Champaign*

Variations on Apollonian Circle Packing Rules
Steve Butler, *Iowa State University*

Geometry and Number Theory of Integral Sphere Packings
Kei Nakamura, *University of California Davis*

Special Invited Session: The Geometry of Triangles

Saturday, August 8, 1:00 PM - 2:50 PM, Salon 1

Richard Guy and John Conway will share their latest ideas about the geometry of Euclidean triangles.

A Triangle Has Eight Vertices (But Only One Centre)
Richard Guy, *University of Calgary*

New Ideas about the Geometry of Triangles
John Conway, *Princeton University*

Special Session: "Notes of a Native Son": The Legacy of Dr. Abdulalim A. Shabazz (1927–2014)

Saturday, August 8, 1:00 PM - 4:50 PM, Delaware B

Organizers: **Monica Jackson,** *American University*
Talitha M. Washington, *Howard University*

Dr. Abdulalim A. Shabazz was a distinguished mathematician who is credited for mentoring over half of all African-Americans with a doctorate in mathematics. "Notes of a Native Son" is a title of a collection of essays by James Baldwin. This title is fitting for a session honoring the life of Dr. Shabazz for three reasons. First, Dr. Shabazz is native to Washington, DC as he spent many years of his life there. Second, this session will feature various speakers whose careers were directly transformed by Dr. Shabazz's mentorship. Third, this session will also include Dr. Shabazz's peers who will discuss his active role in the mathematical community.

Dr. Abdulalim A. Shabazz – Statistically Significant!
Monica Jackson, *American University*

"In a Beautiful Way": Lessons for Mathematics Education from Dr. Abdulalim Shabazz
Erica Walker, *Teachers College, Columbia University*

Sharing the Impacts of Dr. Abdulalim Shabazz
Talitha M. Washington, *Howard University*

More than Equations
Gwendolyn Irby, *Lockheed Martin*

The Impact of Dr. Abdulalim Shabazz on the Business Community
Shree Taylor, *Delta Decisions of DC*

Dr. Abdulalim A. Shabazz: An Example of a Living Topological Isomorphism
Brett Sims, *Borough of Manhattan Community College*

To STEM or Not STEM
Gelonia Dent, *Medgar Evers College*

"The Teacher and the Mentor: A Combination that Instills Mathematical Greatness"
Ronald Mickens, *Clark Atlanta University*

Themed Contributed Paper Sessions

TCPS 1A - History of Mathematics

Wednesday, August 5, 10:30 AM - 11:55 AM, Washington 4

Organizers: **Maria Zack,** *Point Loma Nazarene University*
Thomas Drucker, *University of Wisconsin*
Robin Wilson, *Open University and Oxford University*
June Barrow-Green, *Open University*
Jean-Pierre Marquis, *University of Montreal*
Sloan Despeaux, *Western Carolina University*
Sponsored by HOM SIGMAA, *POM SIGMAA*

This session welcomes contributions from all areas related to history and philosophy of mathematics. This includes reports on research, survey talks, and issues related to the use of history and philosophy of mathematics in the classroom. The session will also include special sessions on mathematical communities and on the philosophy of mathematics. There will also be a group of talks in honor of Karen Parshall (one of the MAA Centennial lecturers) and also in memory of Jackie Stedall (a well known historian of mathematics who passed away in the early fall).

Ellipsographs: Drawing Ellipses and the Devices in the Smithsonian Collections
Amy Shell-Gellasch, *Montgomery College*

Charter Members of the MAA and the Material Culture of American Mathematics
Peggy A. Kidwell, *Smithsonian Institution*

History of Mathematics in Washington, DC
Florence Fasanelli, *MAA*

TCPS 1B - History of Mathematics

Wednesday, August 5, 10:30 AM - 11:55 AM, Washington 5

Eisenhower, the Binomial Theorem, and the $64,000 Question
Cathleen O'Neil, *Johnson County Community College*

John Horton Conway: Certainly a Piece of History
Siobhan Roberts, *Freelance Writer, Math & Science Journalist, Biographer*

A Pair of Early MAA Presidents = A Pair of Mathematics Historians: Florian Cajori and David Eugene Smith
Eileen Donoghue, *City University of New York/CSI*

TCPS 1C - History and Philosophy of Mathematics

Wednesday, August 5, 1:00 PM - 2:55 PM, Washington 4

Doing Arithmetic in Medieval Europe
Chuck Lindsey, *Florida Gulf Coast University*

Imagination and Reading the Third Dimension in Early Modern Geometry
Travis D. Williams, *University of Rhode Island*

The Arc Rampant in 1673: An Early Episode in the History of Projective Geometry
Christopher Baltus, *SUNY Oswego*

William Brouncker's Rectification of the Semi-Cubical Parabola
Andrew Leahy, *Knox College*

TCPS 1D - History and Philosophy of Mathematics

Wednesday, August 5, 1:30 PM - 3:55 PM, Washington 5

Inspiration for Elementary Mathematics Descriptions from a "Heritage" Reading (in the Sense of Grattan-Guinness) of On the Nonexistent by Gorgias
Ann L. von Mehren, *Arcadia University and University of Houston*

Going to the Source
Thomas Q. Sibley, *St. John's University, College of St. Benedict*

Rope Geometry of Ancient India in the Classroom
Cynthia J. Huffman, *Pittsburg State University*
Scott V. Thuong, *Pittsburg State University*

Getting to the Root of the Problem
Steven J. Tedford, *Misericordia University*

Reenactment of the Calculus Controversy: Newton vs Leibniz
Abraham Ayebo, *North Dakota State University*

TCPS 1E - The Mathematics of Euler

Wednesday, August 5, 3:00 PM - 5:55 PM, Washington 4

Euler's Dissertation on Logic
Sylvio R. Bistafa, *University of São Paulo*

Euler and Phonetics: The Untold Story of the Mathematics of Language
Dominic Klyve, *Central Washington University*
Olivia Hirschey, *Central Washington University*

Leonhard Euler: The Final Decade 1773 to October 1783
Ronald S. Calinger, *Catholic University of America*

Euler's Method for Computing the Movement of a Mortar Bomb
William W. Hackborn, *University of Alberta*

Euler on L'Hôpital's *Analyse*
Robert E. Bradley, *Adelphi University*

Euler's OTHER Constant
Jonathan Martin, *Purdue University*
Andy Martin, *Kentucky State University*

TCPS 1F - Special Session in Memory of Jackie Stedall

Thursday, August 6, 8:30 AM - 11:25 AM, Washington 4

Sylvester's Amphigenous Surface
June Barrow-Green, *The Open University*

Jackie Stedall and the Mathematics of Thomas Harriot
Janet L. Beery, *University of Redlands*

The Construction of Map Projections in the Works of Lambert and Euler
Rosanna Cretney, *The Open University*

Soviet Views of Early (English) Algebra
Christopher Hollings, *University of Oxford*

Bolzano's Measurable Numbers: Are They Real?
Steve Russ, *University of Warwick*
Katerina Trlifajova, *Centre for Theoretical Studies, Prague*

The BSHM, 1971-2015
Robin J. Wilson, *Oxford University, UK*

TCPS 1G - History and Philosophy of Mathematics

Thursday, August 6, 1:00 PM - 2:25 PM, Washington 4

Robert Patterson: American 'Revolutionary' Mathematician
Richard DeCesare, *Southern Connecticut State University*

Lisbon: Mathematics, Engineering and Planning in the Eighteenth Century
Maria Zack, *Point Loma Nazarene University*

Vera on the Foundations of Mathematics
Alejandro R. Garciadiego, *UNAM*

TCPS 1H - History and Philosophy of Mathematics

Thursday, August 6, 1:00 PM - 2:25 PM, Washington 5

Yoshikatsu Sugiura: A Good Japanese friend of Paul Dirac
Michiyo Nakane, *Nihon University Research Institute of Science and Technology*

Ramanujan, Robin, Highly Composite Numbers, and the Riemann Hypothesis
Jonathan Sondow, *Independent Scholar*
Jean-Louis Nicolas, *University of Lyon, France*

A Visit to the Vatican Library
Matthew Haines, *Augsburg College*

TCPS 1J - Special Session on Philosophy of Mathematics

Thursday, August 6, 2:30 PM - 4:55 PM, Washington 4

Mathematical Structuralism and Mathematical Applicability
Elaine Landry, *University of California, Davis*

Designing Mathematics: the Role of Axioms
Jean-Pierre Marquis, *Université de Montréal*

Does the Indispensability Argument Leave Open the Question of the Causal Nature of Mathematical Entities?
Alexandru Manafu, *IHPST Paris*

How Does the Mind Construct/Discover Mathematical Propositions?
Carl Behrens, *Alexandria VA*

What is an Adequate Epistemology for Mathematics?
Jeff Buechner, *Rutgers University-Newark*

TCPS 1K - Special Session on Mathematical Communities

Friday, August 7, 8:00 AM - 10:25 AM, Washington 4

A Partial History of Math Circles
Diana White, *University of Colorado Denver*
Brandy Wiegers, *University of Central Washington*

An American Postulate Theorist: Edward V. Huntington
Janet H. Barnett, *Colorado State University - Pueblo*

Combatting the "Legion of Half-Wits": the Contentious Mathematicians of the Paris Academy of Sciences
Lawrence D'Antonio, *Ramapo College*

The Mathematics in 'Mathematical Instruments': The Case of the Royal Geographical Society, London, in the Mid to Late Nineteenth Century
Jane Wess, *Edinburgh University/Royal Geographical Society-IBG*

Did American Professors Form a Mathematical Community in the Early 19th Century?
Amy Ackerberg-Hastings, *University of Maryland University College*

TCPS 1M - Special Session in Honor of Karen Parshall

Friday, August 7, 2:00 PM - 4:55 PM, Washington 4

Leonard Dickson's Other Doctoral Student from 1928
Della Dumbaugh, *University of Richmond*

Spreading the Wealth: The Ford Foundation and Eugene Northrop's Advancement of Mathematics and Science at Home and Abroad
Patti W. Hunter, *Westmont College*

The Annals of Mathematics: From the Fringes of Civilization to the University of Virginia, 1873-1883
Deborah Kent, *Drake University*

Karen Parshall and a Course on the History of Mathematics in America
David Zitarelli, *Temple University*

Fuzzy Logic and Contemporary American Mathematics: A Cautionary Tale
Joseph W. Dauben, *City University of New York*

American Mathematicians Beyond the Iron Curtain: The US-Soviet Interacademy Exchange Program
Brittany Shields, *University of Pennsylvania*

TCPS 1N - History and Philosophy of Mathematics

Saturday, August 8, 8:30 AM - 11:55 AM, Washington 4

Some Original Sources for Modern Tales of Thales
Michael Molinsky, *University of Maine at Farmington*

A Prehistory of Arithmetic
Patricia Baggett, *New Mexico State University*
Andrzej Ehrenfeucht, *University of Colorado*

Adelard's Euclid and the Arabic Transmission Attributed to al-Ḥajjāj
Gregg De Young, *The American University in Cairo*

Al-Khwarizmi, Anselm, and the Algebra of Atonement
Valerie J. Allen, *John Jay College, CUNY*

Approaches to Computation in Third Millennium Mesopotamia
Duncan J. Melville, *St. Lawrence University*

Famous Mathematicians from Iran but Whom You May Not Know
Samaneh Gholizadeh Hamidi, *Brigham Young University*

The Quest for Digital Preservation: Will Part of Math History Be Gone Forever?
Steve DiDomenico, *Northwestern University Library*
Linda Newman, *University of Cincinnati Libraries*

TCPS 1P - History and Philosophy of Mathematics

Saturday, August 8, 8:30 AM - 11:55 AM, Washington 5

Finding the Roots of a Non-Linear Equation: History and Reliability
Roger Godard, *RMC*

J. D. Forbes and the Development of Curve Plotting
Isobel Falconer, *University of St Andrews*

"Remarkable Similarities": A Dialogue Between De Morgan & Boole
Gavin Hitchcock, *University of Stellenbosch*

Clifford and Sylvester on the Development of Peirce's Matrix Formulation of the Algebra of Relations 1870-1882
Francine F. Abeles, *Kean University*

Polygonal Numbers from Fermat to Cauchy
Susan Martin, *Kentucky Employers' Mutual Insurance*

Orson Pratt: A Self Taught Mathematician on the American Western Frontier
Troy Goodsell, *Brigham Young University-Idaho*

Five Families Around a Well: A New Look at an Ancient Problem
Ezra Brown, *Virginia Tech*

TCPS 1Q - Special Session in Memory of Ivor Grattan-Guinness

Saturday, August 8, 1:00 PM - 3:25 PM, Washington 4

Ivor Grattan-Guinness (1941–2014) and his Contributions to the History of Analysis, Set Theory, and Applied Mathematics
Joseph W. Dauben, *City University of New York*

Grattan-Guiness's Work on Classical Mechanics
Roger Cooke, *University of Vermont*

Ivor Grattan-Guinness's Legacy to History and Philosophy of Logic
John W. Dawson, *Penn State York*

"Another Big Book": I Grattan-Guinness as Editor and Organizer
Albert C. Lewis, *Educational Advancement Foundation*

"Same Time Next Week?": Ivor Grattan-Guinness as a Ph.D. Advisor
Adrian Rice, *Randolph-Macon College*

TCPS 1R - History of Mathematics

Saturday, August 8, 3:30 PM - 5:25 PM, Washington 4

Humanistic Reflections on Mathematics Magazine Problem 1951 and a Solution
Joel Haack, *University of Northern Iowa*
Timothy Hall, *PGI Consulting*

The Interplay of "Hard" and "Soft" Analysis in the History of Summabiliy Theory: Preliminary Report
Alexander F. Kleiner, *Drake University*

The Life and Letters of William Burnside
Howard Emmens, *BSHM*

Prehistory of the Outer Automorphism of S_6
James Parson, *Hood College*

TCPS 2A - The Contributions of Women to Mathematics: 100 Years and Counting

Friday, August 7, 1:00 PM - 3:55 PM, Washington 2

Organizers: **Alissa S. Crans,** *Loyola Marymount University*
Jacqueline Jensen-Vallin, *Lamar University*
Maura Mast, *University of Massachusetts Boston*
Sponsored by The Association for Women in Mathematics (AWM)

In celebration of the 100th anniversary of the MAA, the AWM sponsors this session to acknowledge and recognize the contributions, achievements, and progress of women mathematicians over the past 100 years. This century has seen great mathematical achievements by women, the most recent and most public being Maryan Mirzakhani winning the Fields Medal. To honor this and other advances in mathematics by women, this session welcomes talks about mathematics done by women and historical or biographical presentations celebrating women in mathematics.

One of the Most Significant Women in Matrix Theory — Olga Taussky-Todd
Sandra Fital-Akelbek, *Weber State University*

Pie Charts, Pearson, and the Prussian Army: Celebrating Florence Nightingale and FN David
Samuel Luke Tunstall, *Appalachian State University*

American Women Mathematics PhDs of the 1940s and 1950s
Margaret Murray, *University of Iowa*

African American Women Mathematicians
Darlene Butler, *Arkansas State University-Beebe*

Making Her Mark on a Century of Turmoil and Triumph: A Tribute to Polish and Polish-American Women in Mathematics
Emelie Kenney, *Siena College*

A Well-Kept Secret: Women in Mathematics Education
Jacqueline Dewar, *Loyola Marymount University*

Interesting Women in the Missouri MAA Section
Leon Hall, *Missouri S&T*

Life and Research of Vasanti Bhat-Nayak
Pallavi Jayawant, *Bates College*

Iran and Women in Mathematics
Sahar M. Kashan, *DuPont Manual Highschool*
Fariba Nowrouzi-Kashan, *Kentucky State University*

TCPS 2B - The Contributions of Women to Mathematics: 100 Years and Counting

Saturday, August 8, 1:00 PM - 3:15 PM, Washington 2

Teaching Students about Women and Mathematics: A Dialogue between Two Course Designers
Sarah J. Greenwald, *Appalachian State University*
Jacqueline Dewar, *Loyola Marymount University*

Gender and the Pursuit of Mathematics: An Examination of the Participation Gap in Math Careers
Kevin T. Maritato, *Suffolk County Community College*

Positive Female Role Models in Mathematics: The Importance, Influence, and Impact of Their Contributions in Attracting Females to Mathematics
Joan E. DeBello, *St. John's University*

The Daughters of Hypatia: A Mathematical Dance Concert Celebrating Women Mathematicians
Karl Schaffer, *De Anza College*

Application of Knot Theory: Using Knots to Unravel Biochemistry Mysteries
Candice Renee Price, *United States Military Academy, West Point*

Dessin D'Enfants and Shabat Polynomials
Alejandra Alvarado, *Eastern Illinois University*

An Introduction to Interval Exchange Transformations
Kelly B. Yancey, *University of Maryland*

TCPS 3 - Math Circle Problems Involving the Number 100 in Honor of the MAA's 100th Anniversary

Friday, August 7, 8:30 AM - 11:05 AM, Washington 6

Organizers: **Katherine Morrison,** *University of Northern Colorado*
Philip B. Yasskin, *Texas A&M University*
Paul Zeitz, *University of San Francisco*
Sponsored by SIGMAA MCST

A mathematics circle is an enrichment activity for K-12 students or their teachers, which brings them into direct contact with mathematics professionals, fostering a passion and excitement for deep mathematics in the participants. It is usually a weekly or monthly activity, but it can also be an intensive summer experience. Circles provide rich open-ended problems that enable students or their teachers to strengthen their problem-solving skills and deepen their appreciation for and excitement about mathematics. In honor of the MAA's 100th anniversary, we especially encourage talks that address a problem or topic involving the number 100 that was successful at your math circle.

Coordinating a State-Wide Math Contest

Abraham S. Mantell, *Nassau Community College*

Abbot and Costello Numbers

Mary Garner, *Gateway Community Math Center*
Virginia Watson, *Gateway Community Math Center*

Exploring the 100 (and 1) Spaces of Prime Climb in a Math Teachers' Circle

Jialing Dai, *University of the Pacific*
Christopher Goff, *University of the Pacific*
Sara Malec, *Hood College*
Dennis Parker, *University of the Pacific*

Growing Math Circles for the Next 100 Years

Brandy Wiegers, *Central Washington University/ National Association of Math Circles*
Diana White, *University of Colorado, Denver / National Association of Math Circles*

100 Problems Involving the Number 100

James Tanton, *MAA*

The Cell Phone Dropping Problem

Japheth Wood, *Bard College*
Philip B. Yasskin, *Texas A&M University*

From 100s in a Number to 100 Squares on a 10x10 Checker Board (Or Are There More?)

Victoria Kofman, *Quality Engineering Education, Inc.*

Spinout, The Brain, Gray Code, and 100

George McNulty, *University of South Carolina*
Nieves McNulty, *Columbia College*
Douglas B. Meade, *University of South Carolina*

TCPS 4 - Undergraduate Research Activities in Mathematical and Computational Biology

Friday, August 7, 1:20 PM - 4:15 PM, Washington 5

Organizers: **Timothy D. Comar,** *Benedictine University*
Sponsored by BIO SIGMAA

This session is dedicated to aspects of undergraduate research in mathematical and computational biology. First and foremost, this session would like to highlight research results of projects that either were conducted by undergraduates or were collaborations between undergraduates and their faculty mentors. Of particular interest are those collaborations that involve students and faculty from both mathematics and biology. Secondly, as many institutions have started undergraduate research programs in this area, frequently with the help of initial external funding, the session is interested in the process and logistics of starting a program and maintaining a program even after the initial funding expires. Important issues include faculty development and interdisciplinary collaboration, student preparation and selection, the structure of research programs, the acquisition of resources to support the program, and the subsequent achievements of students who participate in undergraduate research in mathematical and computational biology.

Building a Math-Bio Research Program at a Primarily Undergraduate Institution
Zachary Abernathy, *Winthrop University*

Ten Years of Math/Bio Research Collaboration with Undergraduates
Jeffrey L. Poet, *Missouri Western State University*
Laurie J. Heyer, *Davidson College*
Todd T. Eckdahl, *Missouri Western State University*
A. M. Campbell, *Davidson College*

Modeling Delay in Axon Circuit
Mikhail Shvartsman, *University of St Thomas*
Pavel Bělík, *Augsburg College*

The Dynamics of Pulse Vaccination Models
Timothy D. Comar, *Benedictine University*

Simulating and Animating the Spatial Dynamics of Interacting Species Living on a Torus-shaped Universe
Boyan Kostadinov, *City Tech, CUNY*

Leaf Hydraulic Conductance: Modeling Geometry
Frank Lynch, *EWU*

Cancer Classification of Gene Expression Data by Top Scoring Pairs, Consensus Clustering and Support Vector Machines
Andrea E. Ekey, *Howard University*
Louise A. Raphael, *Howard University*
Ahmed Tadde, *Howard University*

Integrating Mathematics and Biology Through Mathematical Modeling
Debra Mimbs, *Lee University*

Classification: A Fundamental Tool in Biology and Mathematics
Atabong T. Agendia, *Madonna University Nigeria*

TCPS 5A - Recreational Mathematics: New Problems and New Solutions

Friday, August 7, 1:00 PM - 4:55 PM, Washington 1

Organizers: **Paul R. Coe,** *Dominican University*
Sara Quinn, *Dominican University*
Kristen Schemmerhorn, *Concordia University Chicago*

As with all mathematics, recreational mathematics continues to expand through the solution of new problems and the development of novel solutions to old problems. For the purposes of this session, the definition of recreational mathematics will be a broad one. The primary guideline used to determine the suitability of a paper will be the understandability of the mathematics. Papers submitted to this session should be accessible to undergraduate students. Novel applications as well as new approaches to old problems are welcome. Examples of use of the material in the undergraduate classroom are encouraged.

Elvis Lives: An Exploration of Greedy and Global Path Optimization in a Game of Fetch
Steve J. Bacinski, *Davenport University*
Mark J. Panaggio, *Rose-Hulman Institute of Technology*
Timothy J. Pennings, *Davenport University*

Logarithms are Hot Stuff and a New Rating Scale for Chili Peppers
Eric Landquist, *Kutztown University*

Turning Infinity Inside Out: A Seamstress's Conundrum
Ellie Baker, *Freelance*

Geometric Modeling of Hexagonal Joints: Carving Mathematics Out of Wood
James Sochacki, *James Madison University*
Anthony Tongen, *James Madison University*

A Trouble-some Simulation
Geoffrey Dietz, *Gannon University*

An Analyzable (Though Seldom Winnable) Card Solitaire
Leon Harkleroad, *Bates College*

Penney's Game and Roulette
Robert W. Vallin, *Lamar University*

Multi-Opponent James Functions
Christopher N. B. Hammond, *Connecticut College*
Warren P. Johnson, *Connecticut College*

Sylver Coinage - An Algebraist's Investigation
Jeremy Thompson, *USAF Academy*

Winning Moves in Fibonacci Nim
Cody Allen, *San Diego State University*
Vadim Ponomarenko, *San Diego State University*

The n-Queens Problem with Forbidden Placements
Doug Chatham, *Morehead State University*

A New Approach to Chinese Chess Knight's Tour Using Gauss' Area Formula
Matthew Mak, *ACS Independent*
Suling Lee, *ACS Independent*

TCPS 5B - Recreational Mathematics: New Problems and New Solutions

Saturday, August 8, 1:00 PM - 3:15 PM, Washington 1

Cracking the SafeCracker 40 Puzzle
Brittany Shelton, *Albright College*
Tyler VanBlargan, *Albright College*

Nonclassical Logic Puzzles
Jason Rosenhouse, *James Madison University*

The Mathematics of Triphos, A World without Subtraction
Brian Hollenbeck, *Emporia State University*

Counting with Fractals and the Mysterious Triangles of Behrends and Humble
Michael A. Jones, *Mathematical Reviews*
Lon Mitchell, *Mathematical Reviews*
Brittany Shelton, *Albright College*

Cover the Spot' and Homothetic Covering of Convex Bodies
Muhammad A. Khan, *University of Calgary*

Dissecting and Coloring Polygons Using Power Series
Alison G. Schuetz, *Hood College*
Gwyneth R. Whieldon, *Hood College*

Exploring Two Fascinating Integer Sequences
Jay L. Schiffman, *Rowan University*

TCPS 6A - Mathematics and Art

Wednesday, August 5, 1:00 PM - 4:55 PM, Maryland A

Organizers: **Sandra Fital-Akelbek,** *Weber State University*
Mahmud Akelbek, *Weber State University*

Mathematics and art have a long historical relationship throughout the centuries. Ancient Egyptians and Greeks incorporated several mathematical relationships into their lives and art. In this session we encourage talks and presentations that connect mathematics and art. We would like to see a broad range of art: visual art, decorative art and performing art. The emphasis will be on college level mathematics that connects math and art in problems and projects that can enrich mathematics teaching. Puzzles, games and other activities that relate math and art are also encouraged.

A Kaleidoscopic Journey
Jeff Johannes, *SUNY Geneseo*

Artistic Patterns on Triply Periodic Polyhedra
Douglas Dunham, *University of Minnesota - Duluth*

Maps of Strange Worlds: Beyond the Four-Color Theorem
Susan Goldstine, *St. Mary's College of Maryland*

Virtual Bumblebees
James P. Howard, *University of Maryland University College*

Surprises from Iterating Discontinuous Functions
Brian Heinold, *Mount St. Mary's University*

The Many Lessons in Fractals
Lisa A. Oberbroeckling, *Loyola University Maryland*

Parametric Equations at the Circus: Trochoids and Poi Flowers
Eleanor Farrington, *Massachusetts Maritime Academy*

Modeling the Mathematical: Man Ray, Equational Mimesis, and Kinesthetic Learning
Steve Zides, *Wofford College*

Pythagoras to Secor: Generalized Keyboards and the Miracle Temperament
Anil Venkatesh, *Ferris State University*

Mathematics and Poetry: The Sweetest Noise
Randall E. Cone, *Salisbury University*

Differential Equations in Music, Dance, and the Visual Arts
Lorelei Koss, *Dickinson College*

Counting with Your Toes!
Julian Chan, *Weber State*

TCPS 6B - Mathematics and Art

Thursday, August 6, 8:50 AM - 11:25 AM, Maryland A

Geometry in Paintings: Where Two Dimensional Becomes Three Dimensional
Blair Lewis, *Weber State University*

Geometric Islamic Star Patterns of Carved Mamluk Domes
Lynn Bodner, *Monmouth University*

Geometry in 18th Century Japan: Exploring and Creating Sangaku
David Clark, *Randoph-Macon College*

Randomness and Structure in Computer-generated Art and Design
Vincent J. Matsko, *University of San Francisco*

"iFlakes": Interactive Line Designs for iOS
James E. Mihalisin, *JedMDesigns*

Ten Years of Student Art in a Math Class
Bryan Clair, *Saint Louis University*

Art of Teaching Mathematics
Radmila Sazdanovic, *North Carolina State University*
Andrew Cooper, *North Carolina State University*

Math = Art (or: How to Enhance Threaded Discussions)
Debra M. Kean, *DeVry University*

TCPS 7 - Financial Mathematics

Wednesday, August 5, 1:00 PM - 2:35 PM, Washington 6

Organizers: **Richard Stephens,** *Columbus State University*
Alin Stancu, *Columbus State University*

Financial Mathematics encompasses all the mathematical and statistical tools, theories and techniques involved in the applied areas usually described as Quantitative Finance, Computational Finance, and Financial Engineering. Research in these areas of financial market modeling include derivatives pricing, risk-and-portfolio management and the theory of interest. Such works have resulted in Nobel Prizes in 1990 and 1997. This session welcomes presentations on any aspect of Financial Mathematics, including the history of this topic, the teaching of this topic, new applications or items of purely academic interest.

Remaining Questions on Approximating The Rate of Interest For an Annuity
Richard Stephens, *Columbus State University*

Insurance and Financial Investment Strategy Under a Stochastic Process Model
Wanwan Huang, *Roosevelt University*

Social Security Benefit: Now or Later?
Amanda Mummert, *Washington & Jefferson College*
Katie Linthicum, *Washington & Jefferson College*
Kadie Clancy, *Washington & Jefferson College*

An Undergraduate Research Experience in Financial Mathematics
Jeong-Mi Yoon, *UH-Downtown*

Actuarial Present Value: Calculations for Two Parametric Models
Veera Holdai, *Salisbury Universiry*
Barbara Wainwright, *Salisbury Universiry*

TCPS 8 - Mathematics in Video Games

Saturday, August 8, 3:00 PM - 4:55 PM, Washington 3

Organizer: **Heidi Hulsizer,** *Hampden-Sydney College*

Video games are a part of popular culture and they show up everywhere and in different forms: computer or console, online or offline, on phones or other mobile devices. There are many applications of mathematics in the gameplay and creation of games that are popular today. This session seeks presentations that share some of the mathematical applications that appear in recent games. Presenters are encouraged to show college-level mathematics that might appear in a range of courses. This session will be of interest to gamers and instructors looking for innovative examples to use in their classes.

Using Turn Based Games to Introduce Modeling and Optimization
Glenn Berman, *Dakota State University*

Mathematics of Ingress
Kimberly Anne Roth, *Juniata College*
Erika Ward, *Jacksonville University*

Quaternions in Action
Susan H. Marshall, *Monmouth University*

Mathematics of Fez
Raena King, *Christian Brothers University*

A Math Course for Game Programming Majors
Scott Stevens, *Champlain College*

Extracting Mathematical Pedagogy from Video Games
Aaron M. Montgomery, *Baldwin Wallace University*

TCPS 9 - What Can a Mathematician Do with a 3D Printer?

Saturday, August 8, 1:00 PM - 4:55 PM, Virginia B

Organizers: **Edward Aboufadel,** *Grand Valley State University*
Laura Taalman, *James Madison University*

This session is dedicated to the intersection of 3D printing and mathematics: the creation of objects through the application of college-level mathematics or research-level mathematics, or the incorporation of 3D printing into the teaching of mathematics. In terms of the creation of objects on a 3D printer, of particular interest are those works that answer the question, "What can a mathematician do with a 3D printer?" This may include fractal images, knots, smooth manifolds, polyhedra, and demonstrations of theoretic or historical constructs. For teaching, of particular interest is the incorporation of 3D printing into college-level courses like geometry, topology, or multivariable calculus.

3D Printed Catalan Wireframes: Designing with Mathematica, MeshLab, and TopMod
Laura Taalman, *James Madison University*

I Can Touch the Math!
Lila F. Roberts, *Clayton State University*

3-D Printing and Triply-Periodic Minimal Surfaces
Rebekah Durig, *Southern Illinois University*
Oneal Summers, *Southern Illinois University*
Gregory Budzban, *Southern Illinois University*

Printing Fractals: Experiences with Julia Sets and Diffusion-Limited Aggregates
Mark J. Stock, *Independent Artist*

Teaching Mathematical Art: Coordinating Design and 3D Printing
Christopher R. H. Hanusa, *Queens College, CUNY*

Exploring Visualizations: An Overview of a Seminar in 3D Modeling and Printing
Nicholas J. Owad, *University of Nebraska - Lincoln*

How You Too Can Join the 3D Printing Craze!
Lewis Ludwig, *Denison University*

Cy: A 3D-Printed Robot for Calculus Teaching
Jason H. Cantarella, *University of Georgia*

A Voluminous Vessel
Brenda Edmonds, *Johnson County Community College*
Cathleen O'Neil, *Johnson County Community College*
Rob Grondahl, *Johnson County Community College*

Goblet Design in Calculus II
Scott Dunn, *University of South Carolina*
Douglas B. Meade, *University of South Carolina*
Philip B. Yasskin, *Texas A&M University*

Topology, Calculus and 3D Visualization

Elizabeth Denne, *Washington & Lee University*

3D Printing Projects for Multivariate Calculus and College Geometry

Edward Aboufadel, *Grand Valley State University*

TCPS 10 - The Scholarship of Teaching and Learning in Collegiate Mathematics

Wednesday, August 5, 1:00 PM - 5:35 PM, Washington 2

Organizers: **Russell E. Goodman,** *Central College*
Jessie Hamm, *Winthrop University*
Jackie Dewar, *Loyola Marymount University*
Curt Bennett, *Loyola Marymount University*

In the Scholarship of Teaching and Learning (SoTL), faculty bring disciplinary knowledge to bear on questions of teaching and learning and systematically gather evidence to support their conclusions. Scholarly work in this area includes investigations of the effectiveness of pedagogical methods, assignments, or technology, as well as probes of student understanding. The goals of this session are to: (1) feature scholarly work focused on the teaching of postsecondary mathematics, (2) provide a venue for teaching mathematicians to make public their scholarly investigations into teaching/learning and (3) highlight evidence-based arguments for the value of teaching innovations or in support of new insights into student learning. Appropriate for this session are preliminary or final reports of post-secondary classroom-based investigations of teaching methods, student learning difficulties, curricular assessment, or insights into student (mis-)understandings. Abstract submissions should have a clearly stated question that was (or is) under investigation and should give some indication of the type of evidence that has been (or is being) gathered and will be presented. For example, papers might reference the following types of evidence: student work, participation or retention data, pre/post-tests, interviews, surveys, think-alouds, etc.

Comparing Oral and Traditional Assessments in Math Content Courses for Pre-Service Elementary Teachers

Daniel Visscher, *University of Michigan*
Nina White, *University of Michigan*

Assessing the Effects of Interactive Technology on Concept Retention in Precalculus

Doug Ensley, *Shippensburg University*
Lea Adams, *Shippensburg University*
Barbara Kaskosz, *University of Rhode Island*

Curing the High DFW Rate in First Year Calculus

Adam Childers, *Roanoke College*
Jan Minton, *Roanoke College*
Hannah Robbins, *Roanoke College*
Kristin Emrich, *Roanoke College*
David Taylor, *Roanoke College*

Increasing Student Success in the Calculus Sequence

Mary Shepherd, *Northwest Missouri State University*

Investigating Student Learning Gains from Content Videos in a Flipped Calculus I Course

John (Zig) Siegfried, *James Madison University*
Cassie Williams, *James Madison University*

Does Calculus Help with Algebra?

Cory Johnson, *California State University, San Bernardino*

Introducing Technology to a Vector Calculus Course

Tyler Kloefkorn, *University of Arizona*

Engaged Learning Through Writing: A Faculty Development Project

Mary E. Pilgrim, *Colorado State University*
Sue Doe, *Colorado State University*
Hilary Freeman, *Colorado State University*
Kate Kiefer, *Colorado State University*

From Scratch to Proof: Preliminary Report

Margaret L. Morrow, *SUNY Plattsburgh*

SoTLE: Assessing the Effectiveness of Moodle Glossaries

Jill E. Thomley, *Appalachian State University*
Sarah J. Greenwald, *Appalachian State University*

The Emporium Teaching Model and Its Effect on Students' Conceptions of Mathematics, Metacognitive Awareness and Course Performance

Yevgeniya Rivers, *University of New Haven*
Joshua Goss, *University of New Haven*

Student Beliefs on Math Ability and Sense of Belonging to a Math Community

Frank Hassebrock, *Denison University*
Lewis Ludwig, *Denison University*

Assessing the Cognitive Levels of Exam Problems in Mathematics: A Comparison Across Years

Sandra M. Merchant, *University of British Columbia*
Wesley Maciejewski, *University of Auckland*

Development of Students' Bayesian Reasoning Skill

Frank Wang, *LaGuardia Community College, CUNY*

TCPS 11A - Cultivating Critical Thinking through Active Learning in Mathematics

Thursday, August 6, 8:30 AM - 11:25 AM, Washington 1

Organizers: **David Taylor,** *Roanoke College*
Robert Allen, *University of Wisconsin*
Lorena Bociu, *North Carolina State University*

Critical thinking is self-directed, self-disciplined, self-monitored, and self-corrective thinking. It entails effective communication and problem solving abilities. "We think critically when we have at least one problem to solve. One is not doing good critical thinking, therefore, if one is not solving any problems." (Richard Paul, Think Magazine, 1992). Mathematics is solving problems. The session will focus on the role of active learning in mathematics, and how a teacher can use it to cultivate critical thinking. We invite instructors to share their experiences and provide useful tips and tricks on implementing active learning strategies and overcoming obstacles to active learning in general. Examples and ideas can come from any type of course, from undergraduate non-major service courses and early-major mathematics courses to late-major and even graduate-level classes. Speakers are encouraged to include assessment data on the effectiveness of their active learning strategies or empirical feedback from students and/or faculty about their strategies.

Teaching Elements of Effective Thinking Through Mathematics

Michael Starbird, *The University of Texas at Austin*

Fostering Critical Thinking in a Liberal Arts Mathematics Course through Graph Theory
Elizabeth S. Wolf, *Saint Mary's College*

Creative, Critical and Correct: Achieving Common Objectives in an Introductory Proofs Course
Kayla B. Dwelle, *Ouachita Baptist University*

Active Learning in Linear Algebra Through Preview and In-class Activities
Feryal Alayont, *Grand Valley State University*
Steven Schlicker, *Grand Valley State University*

RAMScholars: Increasing Student Engagement in Learning Calculus Through PBL, Oral Assessments, and Writing
Jessica Gehrtz, *Colorado State University*
Mary E. Pilgrim, *Colorado State University*

Beginning an Emerging Scholar's Program in Calculus II
Jacqueline Jensen-Vallin, *Lamar University*

Wonders of 11 Stars: Mathematical Cultivations through Paper Folding
Duk-Hyung Lee, *Asbury University*

Teaching Validity and Soundness of Arguments Using the Board Game 'The Resistance'
Derek Thompson, *Taylor University*

Puzzles + Games = Mathematical Thinking
Edmund A. Lamagna, *University of Rhode Island*

TCPS 11B - Cultivating Critical Thinking through Active Learning in Mathematics

Thursday, August 6, 1:00 PM - 5:15 PM, Washington 1

Using Projects to Enrich and Expand in the Classroom
Meghan De Witt, *St Thomas Aquinas College*

Using Learning Logs to Cultivate Critical thinking Skills
Roger Wolbert, *University at Buffalo*

Linked Math and English in an Active Learning Classroom
Victor Piercey, *Ferris State University*

Active Learning through Formative Assessments
Maggie McHugh, *La Crosse School District*
Jennifer Kosiak, *University of Wisconsin-La Crosse*

Making Problem Asking the Students to Make Up Problem
Noriko Tanaka, *Toyota-nishi High School (Japan)*

Teaching with Your Mouth Shut - Inquiry Based Learning in Upper Level Mathematics Courses
Shay Fuchs, *University of Toronto Mississauga*

Student Centered Learning of Number Theory for Reluctant Mathematics Majors
Daniel R. Shifflet, *Clarion University of Pennsylvania*

Putting the "Real" Back in Real Analysis
Justin Wright, *Plymouth State University*

Discussing Mathematical Creativity at the Undergraduate Level

Houssein El Turkey, *University of New Haven*
Gulden Karakok, *University of Northern Colorado*
Milos Savic, *University of Oklahoma*
Gail Tang, *University of La Verne*
Emilie Naccarato, *University of Northern Colorado*

Mathematics Applied Through Programming, Modeling, and Games

Leslie Jones, *University of Tampa*
Britney Hopkins, *University of Central Oklahoma*

Blended Delivery and Asynchronous Active-Learning Strategies in Developmental Math: a Case Study

Filippo Posta, *Grand Canyon University*

Achieving a Successful Active Learning Environment in an Online Math/Stat Undergraduate Course

Christy S. Langley, *University of Louisiana at Lafayette*
Julie Roy, *University of Louisiana at Lafayette*

Synchronous Active Learning in Online and Hybrid Environments

Carolyn Johns, *The Ohio State University*

TCPS 12 - Improving Undergraduate Math Writing

Wednesday, August 5, 1:00 PM - 5:15 PM, Virginia A

Organizers: **Kerry M. Luse,** *Trinity Washington University*
Sita Ramamurti, *Trinity Washington University*

From the simplest modeling equations to the most complex proofs, students often lack the writing abilities to properly communicate their solutions. In order to help students achieve coherent arguments that are both logical and sequential, math-writing skills need to be developed. Students in introductory math classes must be able to find the solution to a problem by writing down all the necessary steps and reasons for each step leading up to the answer. Students in advanced math classes must be able to delineate hypothesis from conclusion in proving statements and be able to use the definitions, assumptions, and related results accurately in justifying their proofs. In this session, we invite participants to share useful approaches to teaching students not only how to reason critically, but also to communicate in writing in a way that fully demonstrates conceptual understanding. We encourage instructors that actively practice mathematical writing across all levels of the curriculum to share best practices for student writing objectives. We are interested in hearing about specific problems and/or projects, as well as the assessment tools for these projects, which have been used to address the issue of writing mathematics.

Creating and Assessing Writing Prompts in Calculus and Below

Carolyn Johns, *The Ohio State University*

I Need Some Focus! Helping Calculus Students Navigate Mathematical Writing

David Clark, *Grand Valley State University*

Student Engagement and Learning through Reading and Writing in Differential Equations

Michael C. Barg, *Niagara University*

Using Writing in Introductory Statistics to Enhance Understanding

Tonya Adkins, *Johnson & Wales University*

Writing with Critical Thinking and Values for Effective Problem Solving

Jacci White, *Saint Leo University*
Monika Kiss, *Saint Leo University*
Brian Camp, *Saint Leo University*

Definitions as Proof Blueprints
Andrew Cooper, *North Carolina State University*

Product and Process: Writing Portfolios and Feedback in Introduction to Proof Techniques
May Mei, *Denison University*

Revised Writing Across the Math Major
Jacqueline Anderson, *Bridgewater State University*

Typesetting Homework in LaTeX: Best Practices that Support Teaching and Learning in Post-Calculus
James Quinlan, *University of New England*

Revising for Clarity
Jeffrey Clark, *Elon University*

Why Induction Is Like Ice Cream: Writing About Analogies in Discrete Mathematics Courses
Joshua Holden, *Rose-Hulman Institute of Technology*

Emphasizing Mathematical Writing in On-line Courses
Byungik Kahng, *University of North Texas at Dallas*

Teaching Mathematical Proof Writing Skills in a General Education Course: Graph Theory Algorithms and Color-Coding
Robin L. Blankenship, *Morehead State University*

TCPS 13 - Successful STEM Programs for Elementary Education Majors

Thursday, August 6, 1:00 PM - 3:15 PM, Washington 2

Organizers: **Timothy W. Flood,** *Pittsburg State University*
Karla Childs, *Pittsburg State University*
Aaron Flood, *Missouri University of Science and Technology*

As president Obama stated regarding STEM, "We need to make this a priority to train an army of new teachers in these subject areas." In response to this need, many institutions have developed programs that provide STEM certification or other credentialing for pre-service elementary education majors. This session solicits presentations regarding programs that have been developed to provide this type of credentialing. As mathematics plays a significant role in these programs, the mathematical aspects of these programs should be highlighted. Presentations about programs under development are also encouraged.

Lecturing Left on the Cutting Room Floor: A Video Project for Pre-service Teachers
Matthew D. Zawodniak, *University of Georgia*

Examining the Features and Outcomes of a STEM-Focused Elementary Teacher Preparation Program
Temple A. Walkowiak, *North Carolina State University*
Valerie N. Faulkner, *North Carolina State University*
Paola Sztajn, *North Carolina State University*

Calculus for Pre-Service Elementary Teachers
Alina N. Duca, *North Carolina State University*
Karen Keene, *North Carolina State University*

Graduate Certificate in STEM Education
Cynthia Orona, *University of Arkansas*

An Overview of a Successful Mathematics Minor in Elementary Math Teaching at PUC

Diana Underwood, *Purdue University Calumet*
Catherine Murphy, *Purdue University Calumet*

The Pennsylvania Math Initiative: The First Three Years

Andrew Baxter, *Penn State University, University Park*
Fran Arbaugh, *Penn State University, University Park*
George Andrews, *Penn State University, University Park*

Reflections on Twenty Years of Wheelock College's Math/Science Majors for Prospective Elementary Teachers

Debra K. Borkovitz, *Wheelock College*

TCPS 14 - Projects, Applications and Demonstrations to Enhance a Numerical Analysis or Computational Mathematics Course

Saturday, August 8, 1:00 PM - 2:35 PM, Washington 3

Organizer: **Kyle Riley,** *South Dakota School of Mines & Technology*

Computational mathematics is an important subject that is either an independent course or a component across multiple courses. This session seeks to gather ideas and further the scholarly discussion regarding the delivery of a course in: numerical analysis, numerical methods, modeling, and the use of Computer Algebra Systems to solve problems. All applicable ideas are welcome, but we would like to encourage presentations in areas like:

- New techniques for presenting numerical methods to an undergraduate audience
- New resources or tools that can be incorporated into a course
- Applications that illustrate the power of computational mathematics
- Contemporary research that is accessible to undergraduate students
- Assessment tools that could be used in this type of course

The Everyday Examples in Engineering (E3) Program in a Scientific Computing Course

Mike Nicholas, *Colorado School of Mines*

Project-Based Numerical Mathematics and Computation Course at Augsburg College

Pavel Bělík, *Augsburg College*

A Project-Based Numerical Analysis Course

G. Daniel Callon, *Franklin College*

A Novel Newton's Method Project

James Sochacki, *James Madison University*

Assessing Student Motivation in a Numerical Methods Class

Kyle Riley, *South Dakota School of Mines & Technology*

TCPS 15 - Democratizing Access to Authentic Mathematical Activity

Friday, August 7, 1:20 PM - 3:35 PM, Maryland A

Organizers: **Catherine Buell,** *Fitchburg State University*
Steven Greenstein, *Montclair State University*
Zahava Wilstein, *Berry College*

Essential to the learning of mathematics is that students engage in "authentic" mathematical activity, or what mathematicians would recognize as "doing math." However, too often deficit explanations (i.e., students' lack of background knowledge, lack of math ability, lack of motivation) have been used to deny students access to authentic experiences. This session is a vehicle to promote a more equitable orientation to the learning of mathematics for all students in a range of learning situations (not just the "top" kids in ideal situations). We invite talks illustrating viable, evidence-based strategies that promote access to authentic mathematical activity through inquiry that honors the diversity of students' mathematical knowledge. Topics may include 1) innovative, equity- and inquiry-oriented methods of teaching and learning in remedial, developmental, or introductory courses and courses for non-majors; 2) lessons that allow students to use mathematics to address important equity and social justice issues in their communities; and 3) programs that provide students with opportunities to engage in the kinds of authentic mathematical activities and research projects that embrace the knowledge and experiences they bring to school.

Mathematics and Social Justice: Perspectives and Resources for the College Classroom
Gizem Karaali, *Pomona College*
Lily Khadjavi, *Loyola Marymount University Los Angeles*

Opening a Gateway to Mathematical Inquiry
Brian Katz, *Augustana College*

Seeding Mathematical Interest in Inner-City Latino Students
Alessandra Pantano, *University of California, Irvine*
Li-Sheng Tseng, *University of California, Irvine*
Andres Forero, *University of California, Irvine*

Documenting Instantaneous and Cumulative Change
Monelle Joline Gomez, *The Ohio State University*
Azita Manouchehri, *The Ohio State University*
Xiangquan Yao, *The Ohio State University*

What Evidence Do You Have? Data-Based Investigations into Contemporary Race Relations in a General Education Math Class
Victor Piercey, *Ferris State University*

Mathematical Modeling for Elementary Mathematics Teachers
Elizabeth A. Burroughs, *Montana State University*

Undergraduate Research, Outreach and Student Activities for a "Fair" Mathematical Experience
Emek Kose, *St. Mary's College of Maryland*

TCPS 16 - Curriculum Development to Support First Year General Education Mathematics Students

Wednesday, August 5, 1:00 PM - 3:35 PM, Washington 3

Organizers: **Donna Flint,** *South Dakota State University*
Charles Bingen, *University of Wisconsin Eau Claire*

A common focus of university administration is student retention and graduation. First year mathematics courses- remedial and general education- have relatively high drop/fail/withdraw rates, which place them under scrutiny by administration. In this

session, we would like to hear what you have been doing to improve pass rates and student persistence in first year courses with traditionally high DFW rates. We hope to focus on department efforts (rather than specific classroom approaches) to support students in these first year Mathematics courses. Presentations could include complete multi-section redesign, restructure of curriculum, efforts to standardize. We would like to hear about successful, in progress, and unsuccessful efforts. Presentations with a description of the initiative along with data supporting the success or failure are encouraged.

Redesigning a Liberal Arts Math Course for Student Performance

Crystal Lorch, *Ball State University*
John Lorch, *Ball State University*

Design and Implementation of a Quantitative Literacy Course at a Large Research Institution

Vince Melfi, *Michigan State University*
Dave Bramer, *Michigan State University*
Jeff Craig, *Michigan State University*
Richard A. Edwards, *Michigan State University*
Andrew Krause, *Michigan State University*
Amanda Lorenz, *Michigan State University*

Just Enough Algebra – Or How Teaching Interesting, Useful Algebra in Applied Contexts Incorporating Active Learning Led to Higher Student Engagement and Success

Suzanne I. Dorée, *Augsburg College*

System-wide Co-requisite Pedagogical Approaches for Learning Support Mathematics Students

Minsu Kim, *University of North Georgia*

Eliminating Pre-Foundational and Comprehensively Redesigning First Year General Education Mathematics Courses at Trinity Washington University

Kent Kraft, *Trinity Washington University*

Reorganization and Innovation in First Year General Education Mathematics Courses

Grace E. Cook, *Bloomfield College*
Michael Schiro, *Bloomfield College*
Kevin Kline, *Bloomfield College*

Alternative Pathway for General Education Mathematics Students

Rachel M. Bates, *Redlands Community College*

Building Learning Communities for Students and Instructors in Introductory and Intermediate Algebra

Janet Nichols, *Colorado State University - Pueblo*

TCPS 17 - Curriculum and Course Development to Support First Year STEM Students

Friday, August 7, 1:00 PM - 2:55 PM, Washington 3

Organizers: **Donna Flint,** *South Dakota State University*
Dan Kemp, *South Dakota State University*
Charles Bingen, *University of Wisconsin Eau Claire*

Poor retention in the STEM fields is often tied to students' initial difficulties and/or lack of motivation in mathematics courses early in their academic career. In this session, we would like to hear about efforts to help struggling students in first year mathematics courses for STEM students or to help motivate students in these courses. We are particularly interested in departmental efforts, rather than specific classroom teaching activities. We would like to hear about successful, in progress, and unsuccessful efforts. Presentations with a description of the initiative along with data supporting the success or failure are encouraged.

Supporting Students in Health Sciences

Magdalena Luca, *MCPHS University*

A Watershed Year in STEM Education at Sonoma State University

Martha Shott, *Sonoma State University*

FastTrack: A Collaborative Effort to Support STEM students

Jennifer Kosiak, *University of Wisconsin-La Crosse*
James Sobota, *University of Wisconsin-La Crosse*
Robert Hoar, *University of Wisconsin-La Crosse*
Maggie McHugh, *La Crosse School District*

Summer Curriculum for Selected Incoming Freshmen and Transfer STEM Students

Amanda L. Hattaway, *Wentworth Institute of Technology*
Kathleen Grace Kennedy, *Wentworth Institute of Technology*
Emma Smith Zbarsky, *Wentworth Institute of Technology*

Implementing Learning Labs as Instructional Support for Freshman Calculus

K. Grace Kennedy, *Wentworth Institute of Technology*
Emma Smith Zbarsky, *Wentworth Institute of Technology*
Amanda Hattaway, *Wentworth Institute of Technology*
Joan Giblin, *Wentworth Institute of Technology*

Thinking On Your Feet Does No Harm

Paul N. Runnion, *Missouri S&T*

TCPS 18 - Using Modeling for Teaching Differential Equations: Before, During, After

Saturday, August 8, 1:00 PM - 4:35 PM, Virginia A

Organizers: **Brian Winkel,** *US Military Academy*
Karen Bliss, *Quinnipiac University*
Jessica Libertini, *Virginia Military Institute*
Nakeya Williams, *US Military Academy*

Often modeling is associated with differential equations courses as a motivator for learning and as a way of showing how mathematics is applied in other disciplines such as physics, biology, and economics. Modeling can be used (1) as a way of leading up to the mathematics being taught, (2) during the instruction on the mathematics and techniques, and/or (3) after the mathematics has been taught. These three times — before, during, or after — for using modeling have the potential to support students and motivate their learning. We invite colleagues who use modeling, especially with real data, to share their experiences with special attention paid to the timing of the modeling activities with respect to associated differential equations concepts and techniques. This session is sponsored by SIMIODE - Systemic Initiative for Modeling Investigations and Opportunities with Differential Equations and presenters will be invited to submit their modeling scenarios for peer-reviewed publication at www.simiode.org.

Modeling from Calculus to Numerical Analysis (and Everything in Between)

Meagan C. Herald, *Virginia Military Institute*

Coloring Inside the Lines: My Experiences Adding Modeling to an Existing DE Curriculum Without Sacrificing Content

Jessica M. Libertini, *Virginia Military Institute*

Using Real Data to Study the Heat Equation
Kimberly Spayd, *Gettysburg College*

Using Differential Equations to Analyze the Energy Future
James Case, *SIAM*

Validating Groundwater Flow Models
Michael A. Karls, *Ball State University*

Predator-Prey Modeling
Hubert Noussi Kamdem, *Roger Williams University*

Modeling Duck-Gull-Human Interactions in California
Christopher Brown, *California Lutheran University*

Two Differential Equations Projects to Help Students Apply and Synthesize Mathematics
Michelle Ghrist, *United States Air Force Academy*

Inquiry-Based Learning in ODE Classes: Stable or Unstable?
Randall E. Cone, *Salisbury University*

Modeling in an Inquiry-Oriented Differential Equations Course
Karen A. Keene, *North Carolina State University*
William Hall, *North Carolina State University*

Day One Modeling Discussions
Benjamin Galluzzo, *Shippensburg University*

TCPS 19A - Innovative Approaches in the Calculus Sequence

Friday, August 7, 1:00 PM - 3:35 PM, Washington 6

Organizers: **Aaron Wangberg,** *Winona State University*
Brian Fisher, *Lubbock Christian University*
Jason Samuels, *City University of New York*

There has been a significant amount of investigation into the flaws of traditional calculus courses and possible improvements, from the Calculus Reform movement beginning in the late 1980s to the recent MAA study finding significant attrition during the calculus sequence. This session shines a spotlight on recent efforts from instructors to make a productive change. In this session, we ask instructors to share creative ideas for instruction from the calculus sequence. We are interested in general approaches and/or specific activities that a) help students engage in the mathematics of calculus in innovative ways and/or b) promote group work and conversation about the mathematical content. Submitted abstracts should include a description of the approach/activity, how it meets these objectives, and observed strengths and weaknesses compared with the traditional approach. We encourage presentations in which the audience can experience the innovative teaching and learning.

Calculus for Life Sciences: A Two-Semester Calculus Sequence for Biology and Health Science Majors
Anthony DeLegge, *Benedictine University*

Resequencing Calculus I & II
Charlotte Knotts-Zides, *Wofford College*

Rethinking the Sequence of the Content of Calculus I for Deeper Conceptual Understanding
Jose A. Jimenez, *Penn State Hazleton*

Multivariable Calculus Reordered and Rethought
Robert Sachs, *George Mason University*

An Innovative, Three-Dimensional Approach to Multivariable Calculus Instruction
Jason Samuels, *City University of New York*
Aaron Wangberg, *Winona State University*
Brian Fisher, *Lubbock Christian University*

Exploring Multivariable Calculus Concepts in Context through Physical Surfaces
Dale Buske, *St. Cloud State University*

Inquiry Based Instructional Supplement (IBIS) for Calculus Sequence
Karmen T. Yu, *Montclair State University*
Justin Seventko, *Montclair State University*
Trina Wooten, *Montclair State University*

An Instructor's Perspective of Flipping Calculus: The Pros and Cons
Caleb Adams, *Radford University*

TCPS 19B - Innovative Approaches in the Calculus Sequence

Saturday, August 8, 1:00 PM - 3:35 PM, Washington 6

Teaching Calculus Using Movies and Television Shows
Elana Reiser, *St. Joseph's College*

Beyond Computation: A Team-Based Learning Approach to the Limit Definition of the Derivative
Carly J. A. Briggs, *University at Albany*

Elements of the Successful Calculus Computer Lab Assignment
Stepan Paul, *California Polytechnic State University*

Creating Online Problems that Develop Mathematical Strategies and Reduce Student Frustration
Geoffrey Cox, *Virginia Military Institute*

Where is the Differential in Differential Calculus?
Eugene Boman, *Penn State, Harrisburg Campus*
Robert Rogers, *SUNY, Fredonia*

Five Things The Calculus Texts Leave Out and What We Can Do About It
Meighan Dillon, *Kennesaw State University*

A Small Adjustment to the Definition of the Limit of a Function
Andy Martin, *Kentucky State University*

Finite Topological Spaces as a Pedagogical Tool for Teaching Concepts in Calculus
Daniel C. Cheshire, *Texas State University*

Students' Perceptions of and Expectations for Videos in a Flipped Calculus Course
Fei Xue, *University of Hartford*
Larissa Schroeder, *University of Hartford*
Jean McGivney-Burelle, *University of Hartford*

TCPS 20 - Evidence-Based Approaches to the Mathematical Preparation of Secondary Teachers

Wednesday, August 5, 1:00 PM - 1:55 PM, Washington 1

Organizers: **Laurie O. Cavey,** *Boise State University*
Scott A. Courtney, *Kent State University*

The mathematical preparation of secondary teachers has received substantial attention by mathematicians and mathematics teacher educators for many years, but how do university instructors and program coordinators know their efforts are making a difference? While the program evaluation process, which can include accreditation reports (e.g., CAEP) and teacher candidate surveys, encourages faculty to seriously consider this question, it is tempting to focus program evaluation on outcomes such as: graduation rates, teacher placement rates, and scores on teacher licensure exams or performance-based teacher assessments (e.g., edTPA). In this session, we invite mathematics content and methods instructors and program coordinators to share ways they gather and analyze data for the purpose of making decisions about their programs. Presentations should focus on one or two program goals directly linked to the mathematical preparation of secondary teachers. Examples include: How do you know that teachers can promote mathematical thinking and learning in ways consistent with the Common Core Standards for Mathematics (NGA Center & CCSSO, 2010)? How is your program addressing the recommendations in the Mathematical Education of Teachers II document (CBMS, 2012)? How does your program work with mentor teachers to develop candidates' use of formative assessment?

Lesson Study: A Capstone Experience to Address the Recommendations of the MET II Document

Connie Yarema, *Abilene Christian University*
David Hendricks, *Abilene Christian University*

Focusing on Mathematical Arguments

AnnaMarie Conner, *University of Georgia*
Laura Singletary, *Lee University*

Investing the Preparation of Teachers of Mathematics: The Influence of Content Knowledge on Novice Teaching

Allyson Hallman-Thrasher, *Ohio University*
Jeff Connor, *Ohio University*
Derek J. Sturgill, *Ohio University*

TCPS 21 - Show Me Geometry: Geometry Software and Tablet Demonstrations

Wednesday, August 5, 1:00 PM - 2:55 PM, Virginia C

Organizer: **Sarah L. Mabrouk,** *Framingham State University*

This session invites presenters to share demonstrations, using geometry software or tablet applications, which help students to understand aspects of undergraduate geometry. These demonstrations should be suitable for Euclidean and non-Euclidean geometry courses as well as for courses frequently referred to as "modern" or "higher" geometry but not those related to differential geometry or (low-level) graduate courses. Presenters must perform the full demonstration (or a key portion of it) and discuss the aspects of the demonstration that help students to understand an associated theorem. Information regarding prerequisite topics and related areas with which students have difficulty should be discussed as should problems, if any, experienced in using the software or tablet application. Presenters are invited to discuss how they have modified the demonstration over time as well as to share information about software or tablet explorations performed with students that have helped students understand the associated theorem. Abstracts should include the name of the software or application, the platform (computer or tablet), and the associated theorem as well as a brief description of the demonstration. Presenters must provide their own laptop or tablet.

Investigation of Geometric Theorems Using Geometer's Sketchpad

Nora Strasser, *Friends University*

Using a Dynamic Software Program to Develop Geometric Constructions

Laura Singletary, *Lee University*

The Poincaré Disk Model in GeoGebra

Martha Byrne, *Earlham College*

GeoGebra and Hyperbolic Geometry

Violeta Vasilevska, *Utah Valley University*

Math on a Sphere: an Interactive Programming System for Spherical Geometry

Michael Eisenberg, *University of Colorado*
Hilary Peddicord, *National Oceanic and Atmospheric Administration*
Sherry Hsi, *Lawrence Hall of Science, Berkeley*

Active Exploration of Desargues' Theorem and Projective Geometry

Michael Hvidsten, *Gustavus Adolphus College*

General Contributed Paper Sessions

Algebra and Linear Algebra

Wednesday, August 5, 1:00 PM - 3:40 PM, Virginia B

Organizers: **Aliza Steurer,** *Dominican University*
Holly Zullo, *Westminster College*

Linear Algebra and Forensics
Donna Beers, *Simmons College*
Catherine Crawford, *Elmhurst College*

New Algorithms for Solving a System of Linear Equations
Michael F. Zimmer, *Teradata, Inc*

New Canonical Forms for Matrices Over a Principal Ideal Domain
Peter M. Joyce, *CCBC*

On the Structure of Generalized Symmetric Spaces of the Special Linear and General Linear Groups of Degree 2 Over Finite Fields
Jennifer Schaefer, *Dickinson College*

The Index of a Numerical Semigroup in Four Generators
Bernadette Boyle, *Sacred Heart University*

The Space of Biorders on Some Solvable Groups
Kelli Karcher, *Virginia Polytechnic Institute and State University*

Polynomials, Discriminants, and Root Counting in Number Fields
Chad Awtrey, *Elon University*

Can this Polynomial be Factored?
Gary Brookfield, *California State University, Los Angeles*

Valuation Derived from Graded Ring and Module and Krull Dimension Properties
Mohammad Hassan Anjom Shoa, *University of Birjand*
Mohammad Hossein Hosseinie, *University of Birjand*

Analysis and Other

Friday, August 7, 8:30 AM - 11:10 AM, Salon 1, Balcony B

Green's Functions for Right Focal Boundary Value Problems in Nabla Fractional Calculus
Julia St. Goar, *University of Nebraska-Lincoln*

Periodic Behavior of Nonlinear 2nd Order Discrete Dynamical Systems
Dan Maroncelli, *Concordia University St. Paul*
Jesus Rodriguez, *North Carolina State University*

The Existence of Positive Solutions to an Even Order Differential Equation with Right Focal Boundary Conditions
Kristi Karber, *University of Central Oklahoma*
Britney Hopkins, *University of Central Oklahoma*

Algebra, Analysis, and Geometry in the Solution of the Basel Problem
C. L. Frenzen, *Naval Postgraduate School*

Elementary Approach to End Compactifications
Malgorzata A. Marciniak, *CUNY*

Composition of Formal Laurent Series
Xiao-Xiong Gan, *Morgan State University*

An Example for Green's Theorem with Discontinuous Partial Derivatives
Adam Coffman, *Indiana-Purdue Fort Wayne*
Yuan Zhang, *Indiana-Purdue Fort Wayne*

Equivalence of Some Picard-type Iterations for a General Class of Operators in Normed Linear Spaces
Hudson Akewe, *University of Lagos*

Operator Diagonalizations of Multiplier Sequences
Robert Bates, *University of Hawaii at Manoa*

Non-Linear Operators Satisfying Orthogonality Properties
William Feldman, *University of Arkansas*

A Survey of Best Monotone Theorems in Graph Theory
Michael Yatauro, *Penn State Brandywine*
Douglas Bauer, *Stevens Institute of Technology*
Hajo J. Broersma, *University of Twente*
Nathan Kahl, *Seton Hall University*
Aori Nevo, *Stevens Institute of Technology*
Edward Schmeichel, *San Jose State University*
Douglas R. Woodall, *University of Nottingham*

Applied Mathematics

Thursday, August 6, 1:00 PM - 4:55 PM, Washington 3

A New Directed Interval Arithmetic
Sijie Liu, *University of Alabama*

An Alternative Way of Calculating Area of Closed Regions in Parabolas
Yavuz Sidal, *Işıklar Air Force High School*

Iteratively Regularized Gauss-Newton Method for Applied Inverse Problems
Leslie Meadows, *GSU - Dept. of Mathematics and Statistics*

On the Equilibrium Configurations of Flexible Fibers in a Flow
Bogdan Nita, *Montclair State University*

Master Stability Functions for Synchronized Identical Systems with Linear Delay-Coupling

Stanley R. Huddy, *Fairleigh Dickinson University*

Initial Condition and Stability of Differential Equations

Hassan K. Mansour, *El Centro College*
Mike Panahi, *El Centro College*
Dale Pearson, *El Centro College*

A Seventh Order Block Integrator for Solving Stiff Systems

Blessing I. Akinnukawe, *University of Lagos, Lagos, Nigeria*
Solomon A. Okunuga, *University of Lagos, Lagos, Nigeria*

Mathematical Modeling of Continuous and Intermittent Androgen Deprivation Therapy for Advanced Prostate Cancer

Alacia M. Voth, *Sam Houston State University*
John G. Alford, *Sam Houston State University*
Edward W. Swim, *Sam Houston State University*

Development and Implementation of a Pharmacokinetic Model as the Target Equation for a PID Control System

George W. Carpenter, *Louisiana Tech University*
E. A. Sherer, *Louisiana Tech University*
D. P. O'Neal, *Louisiana Tech University*
I. B. Magana, *Louisiana Tech University*
P. Adhikari, *Louisiana Tech University*
Holly Grigsby, *Louisiana Tech University*
Katie Evans, *Louisiana Tech University*

A Numerical Solution to Boundary Value Problems and Volterra Integrals

Hamid Semiyari, *James Madison University*

Identification Problem for Klein-Gordon Equation

Qinghua Luo, *Marian University*

Reduced Basis Method for Solving the Hyperspectral Diffuse Optical Tomography Model

Rachel Grotheer, *Clemson University*
Thilo Strauss, *Clemson University*
Taufiquar Khan, *Clemson University*

Where Is the Hypergeometric Distribution Used (Besides Card Games)?

Luis F. Moreno, *SUNY Broome Community College*

Temporal Network Dynamics

Haley A. Yaple, *Carthage College*

A New Way to Measure Competitive Balance Across Sports Leagues

Tyler Skorczewski, *Cornell College*
Jake Lehman, *Cornell College*
Brian Cristion, *Cornell College*
Jordan Wolfe, *Cornell College*

Counting Mutations and Anti-Chains in Binary Trees and Motzkin Trees

Lifoma Salaam, *Howard University*

Geometry

Thursday, August 6, 1:00 PM - 4:40 PM, Salon 1, Balcony B

Exploring Mathematical Ideas through Origami
Arsalan Wares, *Valdosta State University*

The Right Pascal's Triangle
Yaping Liu, *Pittsburg State University*

Generalizing the Law of Cosines
Lee N. Collins, *County College of Morris*
Tom Osler, *Rowan University*

Perfect Heptagons and 13-Sided Triskaidecagons
Genghmun Eng

How to Add Guards to an Art Gallery
T. S. Michael, *United States Naval Academy*
Val Pinciu, *Southern Connecticut State University*

New Perspectives on Polygonal Area
Owen D. Byer, *Eastern Mennonite University*

Area Bounds of Covers of Unit Arcs
Libin Mou, *Bradley University*

What Isn't an Ellipse?
Alex Meadows, *St. Mary's College of Maryland*
Casey Douglas, *St. Mary's College of Maryland*

The Bounding Problem for Infra-Solvmanifolds
Scott V. Thuong, *Pittsburg State University*

Nested Sequences of Triangles in Non-Euclidean Spaces
Andrew Lazowski, *Sacred Heart University*

Excursions in Combinatorial Taxicab Geometry
John Best, *Summit University of Pennsylvania*

Inequalities in Spherical Geometry: Ancient and Modern
Marshall Whittlesey, *California State University San Marcos*

Angle-of-Parallelism Spectra in Non-Homogeneous Geometries
J. Mealy, *Austin College*
Malin Pappas, *Austin College*

A New Theorem Concerning Isopivotal Cubics, Could it be the 'Swiss Army Knife' of Geometry?
Ivan Zelich, *Anglican Church Grammar School*

Plane Geometry Construction of Gravity Field Mechanical Energy Curves
Alexander L. Garron, *Sand Box Geometry LLC*

Graph Theory

Thursday, August 6, 8:30 AM - 11:25 AM, Washington 3

Social Implications of the Königsberg Bridge Problem
Paul J. Janiczek, *Virginia Military Institute*

Coprime and Prime Labelings of Graphs
Jonelle Hook, *Mount St. Mary's University*

Propagation Time on Directed Graphs
Nathan Warnberg, *University of Wisconsin-La Crosse*

Counting Loops and Paths: The Monoid of a Directed Graph
James Hamblin, *Shippensburg University*
Lance Bryant, *Shippensburg University*

The Isoperimetric Constant of a Paley Graph
Anthony Shaheen, *CSU Los Angeles*

Two Intersection Sets and Paley Graphs
Liz Lane-Harvard, *University of Central Oklahoma*

Generating Combinatorial Identities via Walk Counting
Nathan Moyer, *Whitworth Univesity*

Book Thickness of Zero-Divisor Graphs of Commutative Rings
Shannon Overbay, *Gonzaga University*

DI-Pathological Conjectures and Results
John Asplund, *Dalton State College*
Joe Chaffee
James Hammer, *Ceder Crest College*

On Decomposing Regular Graphs and Multigraphs into Forests
Saad El-Zanati, *Illinois State University*
Sabrina Allen, *Illinois State University*
Maggie Kopp, *Illinois State University*
Mike Plantholt, *Illinois State University*
Shailesh Tipnis, *Illinois State University*

On the Number of Hills Among Generalized Dyck Paths
Jiillian McLeod, *U.S. Coast Guard Academy*
Naiomi Cameron, *Lewis & Clark College*

History or Philosophy of Mathematics

Thursday, August 6, 9:15 AM - 11:25 AM, Salon 1, Balcony A

More of 1915: Why is Mathematics Continually Deemed So Essential to Science?
G. Arthur Mihram, *Princeton, NJ*
Danielle Mihram, *University of Southern California*

The Derivative Productions of Classical Heat Analyses
Shigeru Masuda, *Kyoto University*

Romance in Many Dimensions
Tereza Bartlova, *Charles University in Prague*

An Animation of the Maya Tzolkin Calendar
Megan R. Rehm, *Millersville University of Pennsylvania*
Cynthia E. Taylor, *Millersville University of Pennsylvania*
Ximena Catepillan, *Millersville University of Pennsylvania*

On Mathematical Reasoning and the Decision Problem
Linda Becerra, *University of Houston-Downtown*
Ron Barnes, *University of Houston-Downtown*

The Sources Jeremiah Day Used in his 1823 Algebra Book
Lokendra Paudel, *New Mexico State University*

History of Mathematics - The Illinois Connection
Herbert Kasube, *Bradley University*

Mathematics, Baseball and Shakespeare: What Do They Have in Common?
Charlie Smith, *Park University*

Interdisciplinary Topics in Mathematics and Modeling or Applications

Friday, August 7, 1:00 PM - 4:25 PM, Maryland B

Experiences Teaching an Honors Seminar on Sports Analytics
Russell E. Goodman, *Central College*

Tapestries In the Teaching Of Mathematics
Hari N. Upadhyaya, *Scholars Home Academy*

The Importance of "Navigating Ambiguity through Context" for Students in Quantitative Sciences
Aminul Huq, *University of Minnesota Rochester*
Marcia D. Nichols, *University of Minnesota Rochester*
Bijaya Aryal, *University of Minnesota Rochester*

Unique Algebraic Structure to Connect Nanoscale Instance from Mesoscale Material Behavior
Vikash Mishra, *University of Arkansas*
Craig Mclean, *University of Arkansas*

Counting Melodies with Fibonacci Polynomials
Kurt Ludwick, *Salisbury University*

Roots of Polynomials with Generalized Fibonacci Coefficients
Ron Taylor, *Berry College*
Eric McDowell, *Berry College*
Jill Cochran, *Berry College*

The Use of Mathematics in Ecology, Evolution and Behavior
Pablo Duran, *The University of Texas at Austin*

A Model for Soil-Plant-Surface Water Relationships in Arid Flat Environments

Bonni Dichone, *Gonzaga University*
David Wollkind, *Washington State University*
Richard Cangelosi, *Gonzaga University*

Pattern Formation in the Developing Visual Cortex - The Joint Development of CO Blobs and Ocular Dominance Stripes

Andrew M. Oster, *Eastern Washington University*
Paul C. Bressloff, *University of Utah*

A Mathematical Model with Asymptomatic Individuals for Malaria in the Amazon Region

Ana L. Vivas-Barber, *Norfolk State University, VA, USA*
Eun Chang, *Norfolk State University,VA,USA*
Sunmi Lee, *Kyung Hee University, Yongin, Korea*

Bifurcations, Chaos and Fractal Dimensions in Population Models

Tarini K. Dutta, *Gauhati University*

Tomographic Image Processing

Shylee Ezroni, *Wentworth Institute Of Technology*
Ely Biggs, *Wentworth Institute Of Technology*
Jack Reff, *Wentworth Institute Of Technology*

Understanding the Role of Voltage Dependent Electrical Coupling in a Neuronal Network

Christina L. Mouser, *William Paterson University*
Amitabha Bose, *New Jersey Institute of Technology*
Farzan Nadim, *New Jersey Institute of Technology*

Timing of Action Potential in Auditory Neuron System

Anh T. Vo, *Creighton University*

Mathematics and Technology

Saturday, August 8, 8:45 AM - 11:25 AM, Salon 1, Balcony A

Introducing the Pi-Base: An Interactive Encyclopedia of Topological Spaces

Austin Mohr, *Nebraska Wesleyan University*

Cutting Edge Information Technology Applied to the NIST Digital Library of Mathematical Functions

Bonita V. Saunders, *National Institute of Standards and Technology*

Audio, Documents, and Screens, Oh My! Free and Easy Online Collaboration

Tamara Eyster, *Kaplan University*
Lea Rosenberry, *Kaplan University*

Exploration of Best “Flipped” Practices

Gulden Karakok, *University of Northern Colorado*
Emilie Naccarato, *University of Northern Colorado*
Spencer Bagley, *University of Northern Colorado*

Increase Student Engagement by Using Clickers and Smart Phones
Myungchul Kim, *Suffolk County Community College*

Maplets for Calculus, Rating, Grading and Evaluation
Philip B. Yasskin, *Texas A&M University*
Douglas B. Meade, *University of South Carolina*

Enhancing Student Learning Experience through Maple
Marcela Chiorescu, *Georgia College*
Darin Mohr, *Georgia College*
Brandon Samples, *Georgia College*

Updating the WeBWorK Open Problem Library
John W. Jones, *Arizona State University*
Jeff Holt, *University of Virginia*

Online Homework Can Provide Desirable Difficulties for Learning Mathematics
Dick Lane, *University of Montana*

Improving Students' Learning by Integrating Effective Learning and Teaching Strategies and Instructional Learning Management Systems
Jack Narayan, *SUNY Oswego and WebAssign*

Mentoring and Outreach

Thursday, August 6, 8:15 AM - 11:10 AM, Maryland B

What's It Like to Be Editor-in-Chief of the Notices of the American Mathematical Society?
Frank Morgan, *Williams College*

Upper Elementary Outreach Mobius Bands and Polyhedra
Beth Schaubroeck, *United States Air Force Academy*

"Energizing" Students
Elizabeth Yanik, *Emporia State University*

Girls in Science: Over 15 Years of STEM Outreach for Middle School Girls
Susan Kelly, *University of Wisconsin - La Crosse*

Expanding Your Horizons at James Madison University: Math and Science Outreach to Middle and High School Girls
Katie S. Quertermous, *James Madison University*
Elizabeth Arnold, *James Madison University*

Rural STEM Model
Elizabeth Mauch, *Bloomsburg University*

How to Hook Pre-Service Teachers on Professional Development
Pari Ford, *University of Nebraska at Kearney*
Amy Nebesniak, *University of Nebraska at Kearney*

Impact of 2015 National Math Festival on Undergraduate Mathematics Students

Alice E. Petillo, *Marymount University*
Nicole Ferree, *Marymount University*

Increasing Diversity in the Classrooms: A Path towards Inclusion in Mathematics

Li-Sheng Tseng, *University of California, Irvine*
Alessandra Pantano, *University of California, Irvine*

Native American-based Mathematics Materials for Undergraduate Courses

Charles P. Funkhouser, *California State University Fullerton*
Miles R. Pfahl, *Turtle Mountain Community College*
Harriet Edwards, *California State University Fullerton*

Creating a Meaningful Undergraduate Research Project

Brandon Samples, *Georgia College & State University*

Supporting the Success of Women Faculty through an NSF ADVANCE Grant: Looking Back, Moving Forward

Jenna Carpenter, *Louisiana Tech University*
D. P. O'Neal, *Louisiana Tech University*

Number Theory and Logic or Foundations

Saturday, August 8, 1:00 PM - 4:55 PM, Salon 1, Balcony B

Bijections between Hyper m-ary Partitions

Timothy B. Flowers, *Indiana University of Pennsylvania*
Shannon R. Lockard, *Bridgewater State University*

The Graphic Nature of Gaussian Periods

Stephan R. Garcia, *Pomona College*

The Composite Two-Step

Ryan Stuffelbeam, *Transylvania University*

The Periods of Fibonacci Sequences mod m

Marc Renault, *Shippensburg University*

10,000 Ways to Count a Truncated Tetrahedron

Jeremy Newton, *Lee University*
Debra Mimbs, *Lee University*

Jacobsthal Sequence in Ternary Represented Modified Collatz Sequences

Ji Young Choi, *Shippensburg University of PA*

Schinzel's Hypothesis H

Elijah M. Allen

Infinitude of Primes

Sam Northshield, *SUNY Plattsburgh*

Using Binomial Coefficients to Prove Oppermann's Conjecture

William R. Oscarson, *Cornell*

Topics in $\tau_{(n)}$-Number Theory

Reyes M. Ortiz-Albino, *University of Puerto Rico-Mayaguez*

The Digital Binomial Theorem

Hieu D. Nguyen, *Rowan University*

A Bad But Fruitful Way To Count N Choose K

Steven Edwards, *Kennesaw State University*
William Griffiths, *Kennesaw State University*

Number of solutions to $a^x + b^y = c^z$

Reese Scott
Robert Styer, *Villanova University*

Beal's Conjecture vs. "Positive Zero", Fight

Angela Moore, *Yale University*

Near-Isosceles Pythagorean Triples

Frederick Chichester

Using Strong Notions of Reducibility to Distinguish Complete Sets

Brooke Andersen, *Assumption College*

Probability or Statistics

Friday, August 7, 9:15 AM - 11:25 AM, Maryland B

An Exploration into Grouped Current Status Data

Lucia C. Petito, *UC Berkeley*
Nicholas P. Jewell, *UC Berkeley*

Using the Mathematical Sciences to Protect Data

Paul Massell, *U.S. Census Bureau*

Stability — A New Way to compare Statistical Measures: Theory and Applications for Assessing Learner Achievement and Teaching Effectiveness

David DiMarco, *Neumann University*
Ryan Savitz, *Neumann University*
Fred Savitz, *Neumann University*

Lefty-Righty Experiment: A Group Project for An Individual Grade

Tuyetdong Phan-Yamada, *Glendale Community College*
Walter M. Yamada, *III, Children's Hospital Los Angeles*

Statistics and Japan: Bringing Themes into Elementary Statistics Courses

Pat Kiihne, *Illinois College*

Analyzing Distributions by Visualization in a Probability and Statistics Class

Jason Molitierno, *Sacred Heart University*

Inverting an Introductory Statistics Course

Gertrud L. Kraut, *Southern Virginia University*

Probability and Possibilities: A Promising Pedagogy

Deborah J. Gougeon, *University of Scranton*

Using Conway's Napkin Problem in an Introductory Probability Class

Shenglan Yuan, *LaGuardia Community College, CUNY*

Teaching or Learning Advanced Mathematics

Friday, August 7, 1:00 PM - 3:10 PM, Salon 1, Balcony B

Teaching Quantifiers via Map Coloring
John McSweeney, *Rose-Hulman Institute of Technology*

Teaching Linear Independence with Process Oriented Guided Inquiry Learning (POGIL)
Kseniya Fuhrman, *Milwaukee School of Engineering*
Cynthia Farthing, *University of Iowa*

Four Stages in Teaching Linear Algebra: From Diagnosis, Connection, Deepening to Application
Wen-Haw Chen, *Department of Applied Mathematics, Tunghai University*

Visualizing the Actions of Abelian Groups
Jennifer F. Vasquez, *The University of Scranton*

Where Can We Use Abstract Algebra?
Fariba Nowrouzi-Kashan, *Kentucky Sytate University*

Exterior Algebra in the Undergraduate Curriculum
Boyd Coan, *Norfolk State University*

Writing Projects in Combinatorics and Graph Theory
Mahmud Akelbek, *Weber State University*

Empowering Undergraduate Students through Project-Oriented Independent Studies
Zhewei Dai, *Alma College*

Rekindling Critical Thinking: Heeding Major Errors in Typical "Transition to Proof" Textbooks
Raymond T. Boute, *Ghent University*

Teaching or Learning Calculus

Thursday, August 6, 9:15 AM - 11:25 AM, Salon 1, Balcony B

Warmup Problems: How to Help Students Learn, Avoid Grading Homework, and Make All Your Dreams Come True
Ryan Higginbottom, *Washington & Jefferson College*

The New Mathways Project's STEM Prep Curriculum: Learning Outcomes & Example Lessons
Frank Savina, *Charles A Dana Center, University of Texas, Austin*
Stuart Boersma, *Central Washington University*

High Impact Practices at UHD: Calculus I Teaching Circle
Ronald Barnes, *UH-Downtown*
Sergiy Koshkin, *UH-Downtown*
Jeong-Mi Yoon, *UH-Downtown*
Ryan Pepper, *UH-Downtown*
Plamen Simeonov, *UH-Downtown*
Timothy Redl, *UH-Downtown*
Volodymyr Hrynkiv, *UH-Downtown*
Arati Pati, *UH-Downtown*

A Surprisingly Simple Integral
Alan Levine, *Franklin and Marshall College*

Integration By the Wrong Parts
William Kronholm, *Whittier College*

Integrating Ideas: A Calculus II Project
Jonathan Hulgan, *Oxford College of Emory University*

Reflections on Using Mastery-Based Testing in a Calculus II Course
Alyssa Armstrong, *Wittenberg University*

The Effects of Assignment Timing on Student Learning
Emma Smith Zbarsky, *Wentworth Institute of Technology*

Integrating First-year Physics and Mathematics through Project-based Learning
Randall Crist, *Creighton University*
Gintaras Duda, *Creighton University*

Teaching or Learning Developmental Mathematics and Assessment

Friday, August 7, 9:15 AM - 11:25 AM, Salon 1, Balcony A

Conceptual Learning in Mathematics Upper Secondary Education: The International Baccalaureate
Neil Hendry, *International Baccalaureate*

Developmental Mathematics Remediation through an Online Summer Bridge Program
James Sobota, *University of Wisconsin-La Crosse*
Jennifer Kosiak, *University of Wisconsin-La Crosse*
Maggie McHugh, *La Crosse School District*
Robert Hoar, *University of Wisconsin-La Crosse*
Robert Allen, *University of Wisconsin-La Crosse*

For Developmental Students, a Different Way of Working with Fractions, Solving Linear Equations, Obtaining the Equation of a Straight Line and Rigorously Defining Real Numbers
Maria T. Alzugaray, *Suffolk County Community College*

Dividing Process in Base-10 Number System: Reversed Dividing Process for 1/X
Nick H. Huang, *Howard Consulting*

What Should be the Content of a Developmental Algebra Class?
Carlos Nicolas, *Ferrum College*

A Critical Reflection on the Development and Promotion of Constructivist-Learning Environment in Mathematics at the Intermediate Phase in South Africa
Lateef N. Najeem, *University of South Africa*

One Student's Journey on the Road to Sense-Making in Algebra
Janet St.Clair, *Alabama State University*

The University of Illinois Math Placement Program: A Retrospection on 8 Years and 75,000+ Students
Alison Reddy, *Univeristy of Illinois*

An Assessment of Student-Centered Learning Across Multi-Sections of 'Large' College Algebra Classrooms: An On-Going Study
Perry Y.C. Lee, *Kutztown University of Pennsylvania*
Padraig McLoughlin, *Kutztown University of Pennsylvania*

Teaching or Learning Introductory Mathematics, Part A

Wednesday, August 5, 1:00 PM - 2:55 PM, Maryland B

Exploring Probability Using The Settlers of Catan
Jathan Austin, *Salisbury University*
Susanna Molitoris-Miller, *Kennesaw State University*

Estimating the Number of Extraterrestrial Civilizations in a Statistics Class
Alexander G. Atwood, *Suffolk County Community College*

Elementary Statistics using Facebook
Krishna Kaphle, *University of Maine at Fort Kent*

Experiences and Experiments in Implementing a Flipped Classroom Design in an Introductory Statistics Course
William J. Heuett, *Marymount University*

Integrating Worked Examples into a Flipped College Algebra Classroom
Tyrone Washington, *Millersville University*

Collins Math Magic Number Blocks and the Wobble-Square Method of Multiplication
Dennis G. Collins, *UPR-Mayaguez*
Glenn H. Collins

Promoting Student Understanding of Properties of Logarithms
Erin R. Moss, *Millersville University of Pennsylvania*

Applications of R to Introductory and Intermediate Statistics
Leon Kaganovskiy, *Touro College Brooklyn Campus*

Teaching or Learning Introductory Mathematics, Part B

Thursday, August 6, 1:00 PM - 4:40 PM, Maryland B

"Reverse Engineering" to Strengthen Critical Thinking for Pre-Service Teachers
J. Lyn Miller, *Slippery Rock University*

An Algebra Course for Pre-Service Middle Level Teachers
Dorothee J. Blum, *Millersville University*

Graduate Student Session

Great Talks for a General Audience: Coached Presentations by Graduate Students, Part A

Saturday, August 8, 1:00 PM - 5:00 PM, Virginia C

Organizers: **James Freeman,** *Cornell College*
Rachel Schwell, *Central Connecticut State University*
Aliza Steurer, *Dominican University*

Presenters in this session must be graduate students. While many graduate students will be asked to give a lecture to a general audience, which includes undergraduates and non-mathematicians as part of a job interview, most students do not have experience talking to a non-research audience. This session gives graduate students the opportunity to give a 20-minute talk aimed at an undergraduate audience, which has been exposed to calculus and some linear algebra. Both the talks and abstracts should be designed to excite a wide range of undergraduates about mathematics. All participants in this session will receive private feedback on their presentations from an established faculty member and an undergraduate student. Time permitting, a discussion of effective techniques for delivering great general-audience talks will occur at the end of the session.

Histomorphometry-Based Modeling and Simulation of Multiple Myeloma Bone Disease
Catherine Patterson, *University of Iowa*

Mathematical Modeling of Kidney Function
Julia Walk, *University of Iowa*

A computational Model for depression and cognitive function
Pengcheng Xiao, *University of Texas at Arlington*
Jianzhong Su, *University of Texas at Arlington*

Classifying Tangles
Christine Caples, *University of Iowa*

Knot Theory through Quandles
Indu Rasika Hamudra, *University of South Florida*
Mohamed Elhamdadi, *University of South Florida*

Loops and Operads: An Introduction
Jason Lucas, *Purdue University*

What is an Orderable Group?
Kelli Karcher, *Virginia Tech*

Great Talks for a General Audience: Coached Presentations by Graduate Students, Part B

Saturday, August 8, 1:00 PM - 5:00 PM, Maryland C

Polynomials: An Exploration
Joshua Cape, *Johns Hopkins University*

Demystifying Matrix Multiplication
Erin Griesenauer, *University of Iowa*

Hopf Algebras: Linear Algebra in Action
Kevin Gerstle, *University of Iowa*

The Marriage of Two Series: An Exciting Approach to Obtaining Definite Integral Solutions
James Rosado, *Rowan University*
Tom Osler, *Rowan University*

A simple way to ruin bacteria's social life – mixing and chemotaxis
Xiaoqian Xu, *University of Wisconsin-Madison*
Alexander Kiselev, *Rice University*

Mixing Times for Sorry! Game
Serena Yuan, *New York University*

Ironing Out the Wrinkles in a Black Hole Horizon
Brian Allen, *University of Tennessee*

Great Talks for a General Audience: Coached Presentations by Graduate Students, Part C

Saturday, August 8, 1:00 PM - 5:00 PM, Salon 1 Salon 1, Balcony A

Can You Reconstruct a Tiger from Its Stripes? The Mathematical Reconstruction of a Medical Image
Rachel Grotheer, *Clemson University*

Could Topology Provide Insight into Huntington's Disease?
Leyda Almodovar Velazquez, *University of Iowa*

Tiling the Bathroom Floor: An Exercise in Counting
Ranjan Rohatgi, *Indiana University*

Realizing Reality on the Drawing Board
Natalie Hobson, *University of Georgia*

Spider Graphs
Zoey Guo, *Northwestern University*

Coloring your World: An Introduction to Ramsey Numbers
Kendra Pleasant, *Howard University*

Fourier, Duality, and the Uncertainty Principle
Zhengqing Chen, *Clarkson University*

PosterFest 2015

A Poster Session of Scholarship by Early Career Mathematicians and Graduate Students

Friday, August 7, 3:30 PM - 5:00 PM, Exhibit Hall A

Organizers: **Doug Ensley,** *Shippensburg University*
Jenny McNulty, *University of Montana*
MAA Committee on Early Career Mathematicians
Project NExT
Young Mathematicians Network

This poster session will allow early career mathematicians, including untenured faculty and graduate students, to present and discuss their scholarly activities with other attendees in an informal atmosphere.

Valuation Derived from Graded Ring and Module and Krull Dimension Properties
Mohammad Hassan Anjom Shoa, *University of Birjand*
Mohammad Hossein Hosseinie, *University of Birjand*

GPS Positioning Algorithm, its Errors and Solutions
Mohammed Abdi, *Benedict College*
Hohite A. Fetene, *Benedict College*

Group-Based Learning in the TILE Environment
Catherine Patterson, *University of Iowa*
Kevin Gerstle, *University of Iowa*

The Effect of Technology-Enhanced Lessons in the Math Classroom
Elly Couch, *University of North Alabama*

Comparing Methods of Sparse Discriminant Analysis Applied to fMRI Data
Maria Puhl, *University of Tulsa*
William Coberly, *University of Tuls*

Studying Habits in Developmental Math: What Can Be Learned from Analysis of Assignments Data
Filippo Posta, *Grand Canyon University*

Pythagoras to Secor: Generalized Keyboards and the Miracle Temperament
Anil Venkatesh, *Ferris State University*

Integrating Oral Presentations in Mathematics Content Courses for Pre-service Teachers
Sayonita Ghosh Hajra, *University of Utah*
Abeer Hasan, *Humboldt State University*

A Visualization of Quillen Stratification with Applications in Restricted Lie Algebras
Harry Warner, *University of Southern California*

The Bitcoin Protocol: A Detailed Look
Andrew Sward, *Augustana College*

How Do You Measure Primality?

Christopher O'Neill, *Texals A&M University*
Roberto Pelayo, *University of Hawaii at Hilo*

The Marriage of Two Series: An Exciting Approach to Obtaining Definite Integral Solutions.

James Rosado, *Rowan University*
Tom Osler, *Rowan University*

Incorporating Maple Software Projects of Graphic Design in College-Level Mathematics Learning

Lina Wu, *Borough of Manhattan Community College*

Bats, Ecology and Public Health

Julia Martin, *SUNY Oswego*

Heat and Mass Transfer in an Electrically Conducting Micropolar Fluid with Thermal Radiation and Heat Generation

Louis Effiong, *Abia State Polytechnic, Aba, Nigeria*
Jonathan Imumolen Oahimire, *University of Port Harcourt, Port Harcourt, Nigeria*
James U. Okafor, *Abia State Polytechnic, Aba, Nigeria*

Outcomes Assessment Using Item Response Theory

Jordan Neus, *Suffolk County Community College*
Maria Alzugaray, *Suffolk County Community College*

Modeling the Effect of Biofilm Development within Plant Diseases

Matthew Donahue, *University of Tulsa*
Nick Cogan, *Florida State University*
Leonardo De La Fuente, *Auburn University*

Classification of Complete 3-nets

Jeremiah Bartz, *Francis Marion University*

A Function-field Analogue of Conway's Topograph

Martha Wijaya, *Dartmouth College*

An Assessment of the Challenges of STEM Women Faculty in an Urban Predominatly Undergraduate University

Dawn Archey, *University of Detroit Mercy*
Xiaohui Zhong, *University of Detroit Mercy*
Linda Slowik, *University of Detroit Mercy*
Pamela Zarkowski, *University of Detroit Mercy*
Kathleen Zimmerman-Oster, *University of Detroit Mercy*
Ryan Todoroff, *University of Detroit Mercy*

Identifying Codes in the Cartesian Product of a Path and a Complete Graph

Jason Hedetniemi, *Clemson University*

(0,2)-Deformations and the Hilbert Scheme

Benjamin Gaines, *Iona College*

The Effects of Long-range Coupling on Neural Activity in the Crayfish Swimmeret System

Lucy Spardy, *The Ohio State University*

Timothy Lewis, *University of California, Davis*
Brian Mulloney, *University of California, Davis*

Modeling Biphasic Sleep in Preschool Children

Nora Stack, *Colorado School of Mines*
Monique LeBourgeois, *University of Colorado Boulder*
Cecilia Diniz Behn, *Colorado School of Mines*

Project based Learning in Numerical Analysis via Creation of a Phase Diagram and Evolving the Time Dependent Schrodinger Equation

Barry Husowitz, *Wentworth Institute of Technology*

A Density Functional Study of Foams and Micro Emulsions

Barry Husowitz, *Wentworth Institute of Technology*

Differential Equations Concept Inventory

William Hall, *North Carolina State University*
Karen Keene, *North Carolina State University*

Reflections on a Flipped Classroom: Small Tweaks with Big Effects

Justin Dunmyre, *Frostburg State University*

Computing New Ramsey-Theoretic Quantities

Kellen Myers, *Farmingdale State College*

Interdisciplinary Teaching: The Mathematical Component of Ecology of Homelessness

Yanping Ma, *Loyola Marymount University*

The Impact of Student-Selected Projects on Operations Research Education — An Initial Report

Bradley Paynter, *University of Central Oklahoma*

Students' Understanding of Exponential and Logarithmic Functions

Rrita Zejnullahi, *Eastern Michigan University*

Two Strategy Dispersal on Predator-Prey Systems

Jose Valenzuela, *Arizona State University*
Komi Messan, *Arizona State University*

Highlights from AWM Student Chapters

Wednesday, August 5, 3:30 PM - 5:00 PM, Marriott Foyer

Organizers: **Alissa Crans,** *Loyola Marymount University*
Jacqueline Jensen-Vallin, *Lamar University*
Maura Mast, *University of Massachusetts*
Association for Women in Mathematics

AWMUTA: A Group Engaged In Outreach
Julie Sutton, *The University of Texas - Arlington*
Theresa A. Jorgensen, *The University of Texas - Arlington*

Engaging Students in Mathematics through AWM at Georgia College
Emily Baum, *Georgia College and State University*
Kirsten Morris, *Georgia College and State University*

JMU's AWM Adventures!
Victoria Kelley, *James Madison University*
Katie Sipes, *James Madison University*

Clemson Student Chapter of Association for Women in Mathematics
Rachel Grotheer, *Clemson University*
Sarah Anderson, *Clemson University*
Amy Grady, *Clemson University*
Fiona Knoll, *Clemson University*

Society for Women in Mathematics at Mines
Rebecca Swanson, *Colorado School of Mines*
Debra Carney, *Colorado School of Mines*

AWM at Clarkson University
Katie Fowler, *Clarkson University*
Leah Granger, *Clarkson University*

Boston University AWM Student Chapter
Emma Previato, *Boston University*

Abstracts Alphabetized by Author's Last Name

A

Abdi, Mohammed *Benedict College*

Hohite A. Fetene, *Benedict College*

GPS Positioning Algorithm, its Errors and Solutions

PosterFest 2015: A Poster Session of Scholarship by Early Career Mathematicians and Graduate Students

The Global Positioning System is a space-centered satellite which consists of 24 basic satellites carrying atomic clocks navigation system that are responsible for delivering location and time information prudently, anywhere on Earth. If three satellites are available, then three spheres are known whose intersection consists of two points. One is the location of the receiver and the other is far away from the surface of the earth which can be ignored. As a result, the problem is to solve the three sphere equations. One major problem is that the receiver clock is not perfectly in sync with the satellite clock. The only way to fix this error is by adding one more. We define d to be the difference between the coordinated time on the (four) satellite clocks and the earth-constrained receiver clock. Two further problems arise when GPS is deployed. One is the conditioning of the system of equations and another is the transmission speed of the signals, which is not precisely the speed of light (c). Because the signals may encounter blockage by different hindrances on earth before reaching the receiver, this is referred to as multipath interference. To be more accurate, we increased the number of satellites from four to eight in our calculation. Our goal was to solve the least squares system of eight equations in four unknown variables (x,y,z,d) using Gauss-Newton iteration method. We used two types of satellites such as tightly and loosely bunched. Results indicated that system becomes ill-conditioned when satellites are bunched closely in the sky. Future research involves working with two or more receivers to compute difference of position instead of absolute position. Errors that are shared by the receivers will be cancelled when we form the differences.

Abeles, Francine *Kean University*

Clifford and Sylvester on the Development of Peirce's Matrix Formulation of the Algebra of Relations 1870–1882

Themed Contributed Paper Sessions: TCPS 1P - History and Philosophy of Mathematics

This paper focuses on Charles Sanders Peirce's relational algebra during the period when he and James Joseph Sylvester were publishing articles and giving courses at The Johns Hopkins University. More specifically, the representation of the algebra of relations in matrix form emerged during this period and we shall take a close look at this development.

Abernathy, Zachary *Winthrop University*

Building a Math-Bio Research Program at a Primarily Undergraduate Institution

Themed Contributed Paper Sessions: TCPS 4 - Undergraduate Research Activities in Mathematical and Computational Biology

Winthrop University is a public comprehensive university serving approximately 5000 undergraduate and 1000 graduate students. Over the past several years, the math department at Winthrop has made significant efforts to enhance the culture of undergraduate research on the part of its students and faculty, particularly through the development of interdisciplinary research opportunities. We will discuss our department's progression through internally-funded summer research programs to the 1-year NSF/NSA-funded NREUP grant received in 2013 to the current 3-year NSF-funded REU grant for 2014-2016. Our main goal will be to share the various logistics of each research program (timeline, selecting appropriate projects, recruiting students, weekly schedule, expected outcomes, etc.) as well as to offer tips for grant proposals and other lessons learned along the way.

Aboufadel, Edward *Grand Valley State University*

3D Printing Projects for Multivariate Calculus and College Geometry
Themed Contributed Paper Sessions: TCPS 9 - What Can a Mathematician Do with a 3D Printer?

Multivariate Calculus and College Geometry are two courses which have natural ways to introduce undergraduates to 3D printing. In this talk, we will describe projects that can be assigned in these courses, where students will design and print 3D objects. The objects are designed in Mathematica and make use of planar and other multivariate functions, trigonometry, polyhedra, and more.

Ackerberg-Hastings, Amy *University of Maryland University College*

Did American Professors Form a Mathematical Community in the Early 19th Century?
Themed Contributed Paper Sessions: TCPS 1K - Special Session on Mathematical Communities

This talk will reflect on the nature of mathematical communities as a historiographical construct and then apply a working definition to a case study from the United States, ca 1790-1840. College professors of mathematics and natural philosophy taught arithmetic, algebra, geometry, and sometimes calculus; trained tutors and other mentees; compiled series of textbooks; read European publications; and wrote about natural phenomena. Surviving correspondence indicates men such as Jeremiah Day, John Farrar, and Charles Davies were personally acquainted. However, Americans during this time period did not contribute original research or demonstrate any inclinations toward collaboration. The paper thus considers the necessary and sufficient conditions for labeling contemporaries as a community.

Adams, Caleb *Radford University*

An Instructor's Perspective of Flipping Calculus: The Pros and Cons
Themed Contributed Paper Sessions: TCPS 19A - Innovative Approaches in the Calculus Sequence

Within the United States, there exists concern about the small numbers of STEM majors and the rate of attrition of students within STEM majors, especially for under-represented minorities. Improving the classroom experience with unique learning opportunities through student-centered instructional practices has been studied and reported as an effective means to influence retention and graduation rates of students in STEM fields. The project presented serves as an initial study examining how the implementation of the flipped classroom approach in Calculus influenced students' math achievement and attitudes about math and learning. Additionally presented is a personal review of the process, including the pros and cons of the experiences of the instructor and ideas on how to improve the flipped process for future classes.

Adkins, Tonya *Johnson & Wales University*

Using Writing in Introductory Statistics to Enhance Understanding
Themed Contributed Paper Sessions: TCPS 12 - Improving Undergraduate Math Writing

In statistics classes, students must have the ability to interpret and communicate results from their analysis of data. Too often, students cannot go beyond completing an algorithm to truly examine or explain their results. Presented are examples of how writing has been used in an introductory statistics course to enhance students' understanding of the topics being learned.

Agendia, Atabong *Madonna University Nigeria*

Classification: A Fundamental Tool in Biology and Mathematics
Themed Contributed Paper Sessions: TCPS 4 - Undergraduate Research Activities in Mathematical and Computational Biology

Mathematics, Computer Science, Microbiology and Biochemistry students were seperately given the above theme as a research topic to present their findings in the annual Faculty of Science inter-departmental seminar of Madonna University Elele, Nigeria. Two students each drawn from the four departments were given this topic during their six month industrial training period running from April 2014 to September 2014. The two students from each of the departments worked together and presented a single report as a group. During the inter-departmental seminar of 1st to 5th of December 2014 , each group was given 30 minutes to present their findings. This paper looks at the reports, findings and the comments made by the panelists during the presentation. The goal was to encourage

inter disciplinary research in the undergraduate course of bioinformatics which was instituted in the undergraduate curriculum of computer science and biological science.

Akelbek, Mahmud *Weber State University*

Writing Projects in Combinatorics and Graph Theory

General Contributed Paper Sessions: Teaching or Learning Advanced Mathematics

Writing projects can actively involve students with the materials they are learning. The advantages of using writing projects can include not only gains in students' learning that stretch beyond mathematics content into the realm of critical thinking, but also overall improved attitude and success rates. Some of the writing projects can lead to future undergraduate research projects. In this presentation, we specifically discuss writing projects in upper division Combinatorics and Graph theory courses.

Akewe, Hudson *University of Lagos*

Equivalence of Some Picard-type Iterations for a General Class of Operators in Normed Linear Spaces

General Contributed Paper Sessions: Analysis and Other

In this paper, we introduce the Picard-multistep iterative procedure and prove some convergence results. We also show that the convergences of Picard-Mann, Picard-Ishikawa, Picard-Noor hybrid iterative procedures are equivalent to our Picard-multistep procedure for the class of generalized contractive-like operators. Our equivalence results unify most results studied by various authors in the literature.

Akinnukawe, Blessing *University of Lagos, Lagos, Nigeria*
Solomon A. Okunuga, *University of Lagos, Lagos, Nigeria*

A Seventh Order Block Integrator for Solving Stiff Systems

General Contributed Paper Sessions: Applied Mathematics

In this paper, an L_0- stable Second Derivative Block Integrator of uniform order seven is proposed for the numerical integration of stiff systems, including large stiff systems resulting from semi-discretization of Parabolic differential equations. The conventional 3-step second derivative backward differentiation formula is obtained from a continuous scheme while the additional methods are obtained from the second derivative of the same continuous scheme. All methods are derived via Interpolation and Collocation techniques and assembled into a block scheme. The convergence and stability properties of the block scheme are discussed and the stability region shown. The performance of the scheme as compared to other existing schemes is considered favorable.

Allen, Brian *University of Tennessee*

Ironing Out the Wrinkles in a Black Hole Horizon

Graduate Student Session: Great Talks for a General Audience: Coached Presentations by Graduate Students, Part B

The idea of "ironing out" or smoothing mathematical objects has been an important topic over the last forty years. These ideas have been applied to functions which represent the distribution of heat in a room, geometric shapes in relation to the isoperimetric problem, the solution to the millenium prize problem on the Poincare conjecture and even black holes. In this talk we will introduce the intuition of heat flow and geometric evolution equations in order to explore some of the applications mentioned above.

Allen, Elijah

Schinzel's Hypothesis H

General Contributed Paper Sessions: Number Theory and Logic or Foundations

Given an admissible set, $\mathcal{F}$, of polynomials and a positive integer k, there exist an integer n such that prime $\leq k$ may be a divisor of $f(n)$ for all $f \in \mathcal{F}$. Further more, if n is less than a bound calculated from the first prime larger than k then the each $f(n)$ will be prime. In this talk we will discuss how the author plans to show that for large enough k that there will exist n that gives us a set of primes for $\mathcal{F}$.

Allen, Valerie *John Jay College, CUNY*

Al-Khwarizmi, Anselm, and the Algebra of Atonement

Themed Contributed Paper Sessions: TCPS 1N - History and Philosophy of Mathematics

In this paper I compare Persian mathematician al-Khwarizmi's Algebra (c. 830) with what first seems an unlikely companion, St. Anselm's Cur Deus Homo, (c. 1098), which argues for a theory of atonement by satisfaction through Christ's sacrifice. I claim that the two texts exhibit sufficiently similar logic to suggest that Anselm had some general familiarity with algebraic thinking as it had disseminated itself throughout Western Islamic culture. Al-Khwarizmi's text would be translated into Latin, after all, in less than 50 years (Devlin, 48, 57). I will focus on al-Khwarizmi's two main concepts: restoration (al-jabr) and balance (al-muqabala). Al-jabr refers to moving a negative quantity to the other side of the equation so that it becomes positive. The concept of negative number, however, is represented as a positive number in debt (Oakes and Alkhateeb, 53). Anselm also uses debt to reconceive atonement. Al-muqabala, variously translated as balance or confrontation, refers to the movement of like terms onto one side of the equation so that it can properly balance with or "confront" (some Latin translations use opponere) the unlike terms on the other side of the equation. It balances different but commensurable things with each other. Al-muqabala raises the question of what kind of equality informs both al-Khwarizmi's algebraic and Anselm's salvation equations. I argue for a complex concept of balance informing both texts that derives ultimately from Aristotle's notion of the equitable (to epiekes).

Almodovar Velazquez, Leyda *University of Iowa*

Could Topology Provide Insight into Huntington's Disease?

Graduate Student Session: Great Talks for a General Audience: Coached Presentations by Graduate Students, Part C

Huntington's disease (HD) is an inherited brain disease that results in the progressive degeneration of nerve cells in the brain. HD has a broad impact on the person's motor, cognitive and psychiatric faculties and unfortunately, it has no cure. How is HD related to mathematics? Topologists can study the brain networks structures of healthy subjects and subjects predisposed to HD in order to identify different brain behavior among the subjects. Cutting edge tools from topological data analysis (TDA), an area where algebraic topology, statistics and computational geometry intersect, can be applied in order to analyze data. Specifically, the idea behind TDA is to describe the "shape" of the data by representing them as a geometrical object, describing the relationship between data points, thus possibly providing new information that could not be obtained via statistical methods alone.

Alvarado, Alejandra *Eastern Illinois University*

Dessin D'Enfants and Shabat Polynomials

Themed Contributed Paper Sessions: TCPS 2B - The Contributions of Women to Mathematics: 100 Years and Counting

In 1984, Alexander Grothendieck, inspired by a result of Gennadii Belyi from 1979, constructed a finite, connected planar bipartite graph via rational functions $\mathbb{P}^1(\mathbb{C}) \to \mathbb{P}^1(\mathbb{C})$ with critical values $\{0, 1, \infty\}$ by looking at the inverse image of the triangle formed by these three points. He called such graphs Dessins d'Enfants. Conversely, Riemann's Existence Theorem implies that every finite, connected planar graph arises in this way. We are interested in constructing Shabat Polynomials (generalized Chebyshev polynomials), the Belyi functions corresponding to trees. This construction comes down to finding the roots of a system of nonlinear equations.

Alzugaray, Maria *Suffolk County Community College*

For Developmental Students, a Different Way of Working with Fractions, Solving Linear Equations, Obtaining the Equation of a Straight Line and Rigorously Defining Real Numbers

General Contributed Paper Sessions: Teaching or Learning Devlopmental Mathematics and Assessment

There are methods of working with fractions and solving linear equations that are substantially different from the ones used in regular American textbooks. In this talk we will show these methods and how they can be easily explained to developmental students. We will also show in detail why these methods help students be more efficient and acquire ideas that prepare them better for subsequent mathematical courses. We will show how to obtain the equation of a straight line and rigorously introduce the concept of a real number, again, in a way completely different from the ones used in regular textbooks. The teaching described in this talk is part of a logical mathematical sequence developed over several years with the objective of giving developmental students clear definitions and as many needed proofs as

possible. As it turns out it is in great agreement with the Common Core Standards. We will show how the techniques students learn make them more proficient working with fractions and equations, which frees time to discuss proofs while covering the required curriculum.

Andersen, Brooke *Assumption College*

Using Strong Notions of Reducibility to Distinguish Complete Sets
General Contributed Paper Sessions: Number Theory and Logic or Foundations

We discuss several strengthenings of Turing Reducibility and show that they can be used to distinguish complete sets.

Anderson, Jacqueline *Bridgewater State University*

Revised Writing Across the Math Major
Themed Contributed Paper Sessions: TCPS 12 - Improving Undergraduate Math Writing

At Bridgewater State University, our mathematics department is currently undergoing a process of reflection and revision as to how writing is implemented in the courses for our major. I will share my recent efforts, some successful and some unsuccessful, to improve student writing in Calculus I and Abstract Algebra. Projects include online discussion boards, proof portfolios with multiple opportunities for revisions, glossaries, and exam corrections with written explanations of revised solutions. I will present the details of these projects, discuss the challenges I encountered, and evaluate their effectiveness. I will also share some preliminary data assessing the success of the proof portfolio project, along with some information about how our department is planning to proceed to collectively improve student writing in all of our courses.

Anjom Shoa, Mohammad Hassan *University of Birjand*
Mohammad Hossein Hosseinie, *University of Birjand*

Valuation Derived from Graded Ring and Module and Krull Dimension Properties
General Contributed Paper Sessions: Algebra and Linear Algebra

In this paper we show if R is a graded ring then we can define a valuation on R induced by graded structure, and we prove some properties and relations for R. Later we show that if R is a graded ring and M a graded R-module then there exists a valuation on of M which is derived from graded structure and also we prove some properties and relations for R. In the following we give a new method for finding the Krull dimension of a valuation ring.

Anjom Shoa, Mohammad Hassan *University of Birjand*
Mohammad Hossein Hosseinie, *University of Birjand*

Valuation Derived from Graded Ring and Module and Krull Dimension Properties
PosterFest 2015: A Poster Session of Scholarship by Early Career Mathematicians and Graduate Students

In this paper we show if R is a graded ring then we can define a valuation on R induced by graded structure, and we prove some properties and relations for R. Later we show that if R is a graded ring and M a graded R-module then there exists a valuation on of M which is derived from graded structure and also we prove some properties and relations for R. In the following we give a new method for finding the Krull dimension of a valuation ring.

Archey, Dawn *University of Detroit Mercy*
Xiaohui Zhong, *University of Detroit Mercy*
Linda Slowik, *University of Detroit Mercy*
Pamela Zarkowski, *University of Detroit Mercy*
Kathleen Zimmerman-Oster, *University of Detroit Mercy*
Ryan Todoroff, *University of Detroit Mercy*

An Assessment of the Challenges of STEM Women Faculty in an Urban Predominatly Undergraduate University
PosterFest 2015: A Poster Session of Scholarship by Early Career Mathematicians and Graduate Students

TRANSFORM UDM!, launched August 2014, is an Institutional Transformation Catalyst project funded by the NSF ADVANCE program to the University of Detroit Mercy (UDM). An in-depth self-assessment of the current workplace

climate was undertaken to identify the needs of STEM women faculty at UDM, in order to inform future efforts and strategies focused on positive changes. Such efforts seek to develop a foundation for women in STEM fields to achieve parity with their male colleagues, as well as help the university provide support to STEM women so they may fulfill their full potential. As the first step of this project, a faculty work experience survey was conducted in November 2014 to identify specific issues impeding the recruitment, retention, and promotion of STEM female faculty. Although preliminary results indicate that the campus climate is generally positive, gender differences do exist in a number of areas. Female STEM faculty will be assembled in focus groups to begin dialogue on these differences and how to address them. Another component of the grant, NetWalking, was launched as an informal "walk and talk" program for promoting health and well-being among faculty. Promotion and sustaining efforts, program participation, and reaction of university faculty will be presented.

Armstrong, Alyssa *Wittenberg University*

Reflections on Using Mastery-Based Testing in a Calculus II Course

General Contributed Paper Sessions: Teaching or Learning Calculus

In an effort to reduce students' test anxiety and to encourage students to understand calculus concepts in their entirety, mastery-based testing allows students to try problems continuously throughout the semester until they have demonstrated complete understanding. In the spring 2015 semester, I implemented this assessment technique in two sections of Calculus II at Wittenberg University, a small private liberal arts university in Springfield, Ohio. At the conclusion of the course, I administered an attitudinal survey in order to gather information from my students about their experience with mastery-based testing. In this talk, I will provide information about how I implemented mastery-based testing in my courses, and then I will discuss my impressions as well as my students' experiences with this assessment technique.

Asplund, John *Dalton State College*
Joe Chaffee
James Hammer, *Ceder Crest College*

DI-Pathological Conjectures and Results

General Contributed Paper Sessions: Graph Theory

Minimum dominating sets (smallest set of vertices adjacent to each other vertex in the graph) and maximum independent sets (largest set of vertices that are **not** adjacent to each other vertex) are very interlinked in principle and within the literature. There are many natural questions that have been asked in relation to both of these concepts. One such concept are DI-pathological graphs. A graph in which each maximal (Yes, maximal!) independent set intersects each minimum dominating set is called *DI-pathological*. Investigating these graphs may lead to solving Hedetniemi's conjecture on inverse domination. In this talk we will discuss the link between this conjecture and DI-pathological graphs as well as some recent results on the smallest such graph.

Atwood, Alexander *Suffolk County Community College*

Estimating the Number of Extraterrestrial Civilizations in a Statistics Class

General Contributed Paper Sessions: Teaching or Learning Introductory Mathematics, Part A

The Drake Equation, formulated by Astronomer Frank Drake in 1961, provides a means of quantitatively estimating the number of advanced extraterrestrial civilizations in our galaxy which may be detectable by their radio emissions. The equation consists of seven factors, of which four are conditional probabilities. A critical examination of these four probabilities and their corresponding uncertainties provides a powerful way of motivating the study of probability in a Statistics Class. We can then ask, "Are we alone in the galaxy?"

Austin, Jathan *Salisbury University*
Susanna Molitoris-Miller, *Kennesaw State University*

Exploring Probability Using The Settlers of Catan

General Contributed Paper Sessions: Teaching or Learning Introductory Mathematics, Part A

Game-related scenarios are often used to engage students in mathematical problem solving. In this talk, the authors will discuss ways in which The Settlers of Catan, a popular property-building and trading board game, provides many opportunities to explore probability and logical thinking.

Awtrey, Chad *Elon University*

Polynomials, Discriminants, and Root Counting in Number Fields
General Contributed Paper Sessions: Algebra and Linear Algebra

Let f be a polynomial of degree n with integer coefficients, irreducible over the rational numbers. Let α be a complex root of f and let V be the vector space over the rationals spanned by the powers of α. Then V is a finite-dimensional vector space with dimension equal to n. Two important characteristics of f are its discriminant and the number of its roots that are contained in V. In this talk, we will describe how to compute each quantity using only linear algebra and polynomial arithmetic. We will end with an application to computing the Galois group of f when $n = 4$.

Ayebo, Abraham *North Dakota State University*

Reenactment of the Calculus Controversy: Newton vs Leibniz
Themed Contributed Paper Sessions: TCPS 1D - History and Philosophy of Mathematics

Mathematics has a very rich history. To appreciate the mathematics we teach and learn today, both students and teachers should have some experiences related to the historical and cultural aspects of the evolution of mathematics. The National Council of Teachers of Mathematics (NCTM) states that mathematics is "one of the greatest cultural and intellectual achievements of humankind, and citizens should develop an appreciation and understanding of that achievement, including its aesthetic and even recreational aspects" (NCTM, 2000, p. 4). In this talk, I will describe how a history of mathematics course designed for pre-service teachers was taught by having students travel back in time and assume the roles of mathematicians of antiquity. In particular, I will describe how our class reenacted the Newton-Leibniz dispute about who should get credit for the creation of infinitesimal calculus.

B

Bělík, Pavel *Augsburg College*

Project-Based Numerical Mathematics and Computation Course at Augsburg College
Themed Contributed Paper Sessions: TCPS 14 - Projects, Applications and Demonstrations to Enhance a Numerical Analysis or Computational Mathematics Course

We present ideas used in the Numerical Analysis and Computation course at Augsburg College, Minneapolis, MN. The main objective is active learning that combines both theory and implementation and testing of numerical algorithms using the free software GNU Octave. Student learning assessment is done primarily through homework and team projects that include written and oral presentations.

Baggett, Patricia *New Mexico State University*
Andrzej Ehrenfeucht, *University of Colorado*

A Prehistory of Arithmetic
Themed Contributed Paper Sessions: TCPS 1N - History and Philosophy of Mathematics

Current beliefs about the development of arithmetic in preliterate societies are that it started with counting, followed by the development of number words and algorithms for arithmetic operations. John Leslie's hypothesis in The Philosophy of Arithmetic (1817), that arithmetic originated with needs for dividing resources (partitioning), and not counting, suggests a different trajectory. With simple computing boards, arithmetic could have developed very far before numbers got their names, and before arithmetic procedures (algorithms) were codified. This means that the development of number words and algorithms may have been a final stage of development of arithmetic, dictated by needs for communication within large social groups. All known counting boards (abaci) are efficient computing devices with very narrow ranges of application. John Napier in Rabdology (1617) gave an example of a computing board that allows one to carry out all "basic" arithmetic operations, and it does not require that the user know any specific system of number names or follow any specific procedures. So Napier's board is an example of a computing device that makes Leslie's hypothesis more plausible. We will present the principle of the design of such computing boards, and compare them to known examples of ancient computing devices. We will also address a modern question: "Is it possible to acquire arithmetic skills without learning arithmetic algorithms?" References Leslie, Sir John (1817). The Philosophy of Arithmetic. Edinburgh & London: A. Constable & Company. Also http://books.google.com/books/about/The˙philosophy˙of˙arithmetic.html?id=qnq4AAAAIAAJ Napier, John (1617/1990). Rabdology. Cambridge, MA: MIT Press

Baker, Ellie *Freelance*

Turning Infinity Inside Out: A Seamstress's Conundrum
Themed Contributed Paper Sessions: TCPS 5A - Recreational Mathematics: New Problems and New Solutions

Many of us learned at some point how to make a torus from a square piece of paper by gluing the edges of the square together in a certain sequence. In this talk I will describe what happened when I tried to create an "infinity scarf" by sewing a torus out of a rectangular piece of cloth using essentially the same procedure. An infinity scarf, for those not up on current fashion, is constructed in an endless loop, typically worn wrapped around the neck one or more times. Working with fabric that had an infinitely repeating pattern printed on one side, I wanted the pattern to match up and connect both top to bottom and side to side, thereby bringing the infinity-ness of my scarf to a whole new level. In order to hide the seams where the torus was sewn together, standard sewing procedure was used. This entails first sewing the torus inside out, where the seams are visible and easily accessible, and then turning it right-side out to hide the seams. In order to do this, a small gap is left unsewn on the boundary, and the torus must be turned right-side out by pushing it through this hole, which is then hand sewn together at the end of the process. The result contained a surprise, which I will illustrate with pictures. It describes a pitfall that should be of interest to anyone who sews or is interested in the topology of surfaces in 3-dimensional space. It also gave rise to an entertaining puzzle whose solution is a set of sewing instructions that successfully avoid the problem.

Baltus, Christopher *SUNY Oswego*

The Arc Rampant in 1673: An Early Episode in the History of Projective Geometry
Themed Contributed Paper Sessions: TCPS 1C - History and Philosophy of Mathematics

An arc rampant is a piece of a conic section tangent to three given lines, with given endpoints on two of those tangents. François Blondel (1618–1686) made tracing an arc rampant the second problem in Résolution des quatres principaux problèmes d'architecture, 1673. Independently, the young Philippe de la Hire (1640–1718) took up the problem in a short work of 1672, and incorporated it into his first work of projective geometry, Nouvelle Méthode en Géométrie, 1673. For both, the problem was suggested by Abraham Bosse, engraver and collaborator of Girard Desargues. Both found that the construction involved harmonic conjugates, and both used, for the first time, the term "harmonic."

Barg, Michael *Niagara University*

Student Engagement and Learning through Reading and Writing in Differential Equations
Themed Contributed Paper Sessions: TCPS 12 - Improving Undergraduate Math Writing

A first "Introduction to Differential Equations" course is a prime place in the undergraduate curriculum for students to learn computational algorithms, model development, and, perhaps most importantly, to acquire the ability to interpret and communicate results. In an effort to get students to more fully appreciate this latter skill that cannot be easily memorized or formalized as a procedure, I introduced a reading/writing project into my course. In this talk, I will describe the project and detail its implementation. In particular, the project is structured to engage the students throughout the semester. Students have an opportunity to digest material at their own pace. However, individualized meetings with me and due dates spaced at various stages of the project help to keep the students on track. With this approach, the project can reinforce connections between content lessons and the students' current understanding. To demonstrate the efficacy of the project, data from my last three sections of the course will be presented. Additional anecdotal evidence and commentary from students will also be provided.

Barnes, Ronald *UH-Downtown*
Sergiy Koshkin, *UH-Downtown*
Jeong-Mi Yoon, *UH-Downtown*
Ryan Pepper, *UH-Downtown*
Plamen Simeonov, *UH-Downtown*
Timothy Redl, *UH-Downtown*
Volodymyr Hrynkiv, *UH-Downtown*
Arati Pati, *UH-Downtown*

High Impact Practices at UHD: Calculus I Teaching Circle
General Contributed Paper Sessions: Teaching or Learning Calculus

Calculus I is an important undergraduate course for all sciences and engineering majors. We proposed a program which fosters engagement in Calculus I classroom. The underlying idea is to anticipate needs of students who struggle with

math, engage them in additional educational activities and create a safety net for helping them at the right time. We developed the course webpage which includes pre-testing for prerequisite skills with follow-up measures to utilize the helpline for them by directing review worksheets, online homework assignments, common final exam component to focus instruction on them with acquiring basic skills, common final exam review, instructional video, and information of external course materials. The deliverables is completed as the result of the circle activities such as prerequisite test, common final exam, and online homework until the end of the implementation semester. All the results will be assessed and revised for the consecutive semester.

Barnett, Janet *Colorado State University - Pueblo*

An American Postulate Theorist: Edward V. Huntington

Themed Contributed Paper Sessions: TCPS 1K - Special Session on Mathematical Communities

Like many American mathematicians of his generation, Edward V. Huntington (1874–1952) began his mathematical studies in the United States, but completed his doctoral work in Germany. With others of his generation, he went on to help create a mathematics research community within the US. Huntington is often remembered today for his efforts to build the infrastructure necessary to support such a community, including the founding of new American professional organizations like the Mathematical Association of America. Of equal importance to the new community were his contributions to the body of mathematical research produced in the US, and especially his work in an entirely new field known today as "American Postulate Theory." In this talk, we discuss Huntington's 1904 paper "Sets of Independent Postulates for the Algebra of Logic" as an exemplar of the research agenda of the American Postulate Theorists. We further consider the role that this research played within the larger development of mathematical logic, and its importance in gaining international recognition for the developing mathematical research community in the US.

Barrow-Green, June *The Open University*

Sylvester's Amphigenous Surface

Themed Contributed Paper Sessions: TCPS 1F - Special Session in Memory of Jackie Stedall

On 8 December 1870, the Danish born mathematician Olaus Henrici exhibited "a large model of Sylvester's amphigenous surface" at a meeting of the London Mathematical Society. This ninth order surface, which HJS Smith described as "of great importance in the theory of equations of the fifth order", was later displayed at the great exhibitions of scientific instruments and mathematical models in South Kensington in 1876 and in Munich in 1893. In my talk I shall discuss the history of this curious surface, setting it in the context of Henrici's career and his interest in mathematical models.

Bartlova, Tereza *Charles University in Prague*

Romance in Many Dimensions

General Contributed Paper Sessions: History or Philosophy of Mathematics

It is the general impression that Jules Verne and Herbert George Wells should be considered as the principal founders of the science fiction. But only few people are aware of the fact that almost at the same time another authors also published books in the very same genre. Over one hundred years ago, English schoolmaster and theologian produced a slender book, which involved the elements of satire on the self-limitation of social perspective in Victorian England and at the same time an introduction to the geometry of higher dimensions, called Flatland. The questions that interest us are: Who was the author of this book? How much was he interested in mathematics? How did he influence mathematicians and how did mathematicians influence him? We shall discuss various issues concerning this book including the questions of inspiration, its consequences in education, mathematics, geometry and history, and its moral impact.

Bartz, Jeremiah *Francis Marion University*

Classification of Complete 3-nets

PosterFest 2015: A Poster Session of Scholarship by Early Career Mathematicians and Graduate Students

Nets are certain configurations of lines and points in the complex projective plane. They appear in the study of resonance varieties of complex hyperplane arrangement complements. In this poster, we present a classification of complete 3-nets, a family of nets which satisfy an additional property, and describe their connections with complements which are aspherical spaces.

Bartz, Jeremiah *Francis Marion University*

Teaching Strategies for Summer Math Courses

General Contributed Paper Sessions: Teaching or Learning Introductory Mathematics, Part B

There are many challenges involved when teaching math courses during the summer. These courses usually occur in a compressed academic term where concepts are introduced at an accelerated pace. In this talk, we discuss strategies and ideas to stimulate class engagement, combat fatigue, and optimize content absorption under significant time constraints.

Bates, Rachel *Redlands Community College*

Alternative Pathway for General Education Mathematics Students

Themed Contributed Paper Sessions: TCPS 16 - Curriculum Development to Support First Year General Education Mathematics Students

The traditional developmental mathematics course pathway is a barrier for many students rather than a road map to mathematics success. With the goal of remediation, developmental mathematics courses continue to fail students. The data largely shows that remediation in higher education mathematics has failed to help large numbers of students achieve a college degree. For many decades, college algebra has been the gateway course for undergraduate education. Most degree options require college algebra although most non-STEM careers require very little algebra. The need to reform undergraduate mathematics is upon us. It is time to provide parallel pathways for undergraduate students. Current and future non-STEM careers will require educated people that can understand how to analyze data or quantify uncertainty. A Pathway to Student Success was initiated at RCC. This involved reviewing assessment tools used in placement of students, advising and student services and support. A multiple pathway approach was designed to allow students to move through their respective degree or certificate pathway. Within developmental mathematics, the number of remediation courses was reduced from three to just two. Additionally, non-STEM students were provided with an alternative undergraduate mathematics course: General Quantitative Reasoning.

Bates, Robert *University of Hawaii at Manoa*

Operator Diagonalizations of Multiplier Sequences

General Contributed Paper Sessions: Analysis and Other

We consider hyperbolicity preserving operators with respect to a new linear operator representation on R[x]. In essence, we demonstrate that every Hermite and Laguerre multiplier sequence can be diagonalized into a sum of hyperbolicity preserving operators, where each of the summands forms a classical multiplier sequence. Interestingly, this does not work for other orthogonal bases; for example, this property fails for the Legendre basis. We establish many new formulas concerning the Q_k's of J. Peetre's 1959 differential representation for linear operators in the specific case of Hermite and Laguerre diagonal differential operators. Additionally, we provide a new algebraic characterization of the Hermite multiplier sequences and also extend a recent result of T. Forgacs and A. Piotrowski on hyperbolicity properties of the polynomial coefficients in hyperbolicity preserving Hermite diagonal differential operators.

Baum, Emily *Georgia College and State University*
Kirsten Morris, *Georgia College and State University*

Engaging Students in Mathematics through AWM at Georgia College

PosterFest 2015: Highlights from AWM Student Chapters

As the Association for Women in Mathematics celebrates their 10th anniversary of the formation of the first AWM student chapters, the AWM chapter at Georgia College celebrates their first year. In March 2014, Georgia College brought AWM to Milledgeville, Georgia. Since then, we have already begun to grow while working on our campus and in our community to promote equal opportunity and access to the study of mathematics. We have accomplished this through bringing guest speakers to campus, leading math activities for high school and middle school students, and hosting events on campus to promote discussion about the impact of women in mathematics. The poster will highlight the activities of our AWM Chapter.

Baxter, Andrew *Penn State University, University Park*
Fran Arbaugh, *Penn State University, University Park*
George Andrews, *Penn State University, University Park*

The Pennsylvania Math Initiative: The First Three Years
Themed Contributed Paper Sessions: TCPS 13 - Successful STEM Programs for Elementary Education Majors

The Pennsylvania Mathematics Initiative was founded at Penn State University in 2012 to improve mathematics achievement in Pennsylvania's schools. PMI's primary focus is strengthening mathematical proficiency and teaching expertise in teachers in grades K–5. We accomplish this goal through professional development workshops for in-service teachers, led by experienced mathematicians and mathematics educators. PMI's workshops are are based on the model developed by Ken Gross and the Vermont Mathematics Initiative. Participants engage directly with problem-solving and experience the mathematics first-hand. We have adapted VMI's workshops to integrate a focus on teaching mathematics, which we believe strengthens the outcomes of the workshops by easing transfer into the participants' classrooms. As of August 2015 we will have worked with more than 45 teachers in over 10 districts across Pennsylvania. We will discuss our methods, our results, the challenges faced, and our plans for expansion into the Pittsburgh and Philadelphia areas.

Becerra, Linda *University of Houston-Downtown*
Ron Barnes, *University of Houston-Downtown*

On Mathematical Reasoning and the Decision Problem
General Contributed Paper Sessions: History or Philosophy of Mathematics

This presentation considers what is now known as the Decision Problem: its evolution, solution and implications. It explores how relevant mathematics (especially mathematical logic) evolved - describing the contributions of a number of individuals (including Leibniz, Frege, Hilbert, Gödel and Turing) whose work either directly or indirectly contributed to a more precise understanding and statement of the Decision Problem and ultimately to its solution. The talk touches on Gödel's proof of his First Incompleteness Theorem and Turing's resolution of the Halting problem. Turing's resolution of the Halting Problem directly led to the resolution of the Decision Problem.

Beers, Donna *Simmons College*
Catherine Crawford, *Elmhurst College*

Linear Algebra and Forensics
General Contributed Paper Sessions: Algebra and Linear Algebra

Have you ever doctored a photo of yourself so that you look taller or thinner or free of blemishes or other imperfections? With the ready availability of digital technology, we have all become photographers; and, free, online photo editing tools allow us to alter our pictures to suit our pleasure. The downside of this, however, is that when we look at photos, whether in tabloids or on the Web, we wonder: Is this a fake? For, just as you can alter pictures to make yourself look more attractive, so, too, politicians, advertisers, and others with particular agendas are using digital imaging tools to manipulate photos to create false impressions. Determining whether a photo has been doctored is just one of the many questions that photo forensics tries to answer. Linear algebra offers powerful tools for carrying out digital photo forensics. In this talk we will explore two applications: detection of explicit images through use of the RGB color model and image reconstruction from compressed data files using the Inverse Discrete Cosine Transform.

Beery, Janet *University of Redlands*

Jackie Stedall and the Mathematics of Thomas Harriot
Themed Contributed Paper Sessions: TCPS 1F - Special Session in Memory of Jackie Stedall

This presentation will survey Jackie Stedall's excellent, thorough, and wide-ranging scholarship on the mathematics of Thomas Harriot (c. 1560-1621), including his algebra, geometry, combinatorics, and interpolation formulas. It will highlight Stedall's distinctive approach to historical research, and her commitment to making source materials more readily available to scholars and students. The influence of other scholars on Stedall, as well as her own influence on the speaker, will be briefly considered.

Behrens, Carl *Alexandria VA*

How Does the Mind Construct/Discover Mathematical Propositions?

Themed Contributed Paper Sessions: TCPS 1J - Special Session on Philosophy of Mathematics

Recent discoveries in cognitive science probe deeply into the mental processes of mathematicians as they practice their art. George Lackoff and Rafael Nunez have focused most extensively on the roots of mathematical subjects, proposing that much advanced mathematics derives from schemas and conceptual metaphors used and developed for more common purposes. But other cognitive scientists, among them Antonio Damasio, Stanley Greenspan, and Stuart Shanker have directed their attention to the role of emotions in the practice of rational thought. Greenspan and Shanker argue that the ability to create symbols and to reason is not hard-wired in the human brain, but is actually learned through emotional signaling beginning in the first year of life. This presentation will attempt to tie together these various threads from cognitive science into a view of how mathematics develops and is practiced.

Benoy, Ben *National Security Agency*

Public Key Cryptography: From Abelian Groups to Yellow Padlocks in 30 Minutes Flat

Invited Paper Sessions: MAA Invited Paper Session: The Non-Traditional "Traditional NSA Mathematician"

Modern cryptography relies on many different tools in order to achieve the interrelated goals of Confidentiality, Integrity, and Authentication. When most people think of cryptography they think of protecting data from prying eyes using a code or cipher, that is, confidentiality. However, those ciphers require that all parties to the communication share a secret: the key. How can you distribute your secret key – and keep it safe from eavesdroppers – if you don't already have a way to communicate securely? Solving that problem is the domain of Public Key Cryptography, which is largely based on the hardness of certain problems in number theory and abstract algebra. This talk will describe the problem space, and then explain how to bootstrap your way from an Abelian group all the way up to a secure communications channel.

Berman, Glenn *Dakota State University*

Using Turn Based Games to Introduce Modeling and Optimization

Themed Contributed Paper Sessions: TCPS 8 - Mathematics in Video Games

Turn based video games allow users to experiment with choices and gather data on outcomes. This makes them an ideal environment to apply simple modeling. This talk will look at using games such as Persona 3, Nocturne, Fallen London, and others to teach students to gather data, turn data into models, and then use those models to inform decisions in playing the games.

Best, John *Summit University of Pennsylvania*

Excursions in Combinatorial Taxicab Geometry

General Contributed Paper Sessions: Geometry

Taxicab Geometry is an easily described example of a non-Euclidean metric space. Many theorems in Euclidean Geometry have analogues in Taxicab geometry. We'll begin by looking briefly at the some theorems in Euclidean combinatorial geometry. Among these will be some results on Erdös type distance problems, Borsuk's Theorem, and a few others. We will then look at the Taxicab versions of these results. This talk will be accessible to undergraduate students.

Bhargava, Manjul *Princeton University*

MAA Centennial Lecture 6 Recent Results Toward the Birch and Swinnerton-Dyer Conjecture

Invited Addresses: MAA Centennial Lecture

Over the past half-century, the Birch and Swinnerton-Dyer Conjecture has become one of the most notoriously difficult unsolved problems in mathematics, and has been listed as one of the seven million-dollar "Millennium Prize Problems" of the Clay Mathematics Institute. In this talk, we describe the problem in elementary terms, and the surprising and beautiful ways in which it is related to several well-known open problems in number theory. Despite the difficulties in solving it, there is actually quite a bit known now towards the conjecture. We will give a survey of what is known — including several recent advances — and, finally, what remains to be done!

Bistafa, Sylvio *University of São Paulo*

Euler's Dissertation on Logic

Themed Contributed Paper Sessions: TCPS 1E - The Mathematics of Euler

In October 1720, the 13 years old Leonhard Euler entered the Philosophical Faculty at University of Basel. In the summer of 1722, he obtained the prima laurea with a lecture De Temperantia [On moderation]. In January of the same year, the 14 years old Euler appeared as respondent, with a discourse in Latin on Logic, consisting of 21 Propositions and 12 Corollaria. In the Propositions section, Euler considers that Logic is an art, mainly occupied with the discovery of the truth, which teaches us how to properly employ our reason. Reason, says Euler, is that human capacity to perceive 'things' within and beyond oneself, in order to establish the relations among them by making comparisons, and by judging to what extent the relations are in agreement. He then considers that 'our' Logic differs from the Dialectics of the ancients, and since it can more effectively provide what needs to be demonstrated, Logic has its maximum employment in all Sciences. Euler opens the Corollaries section speculating on the remembrance of the soul separated from the brain after death. He then moves on to consider that the study of Physics is useful to the Philosopher as well as to the Theologian, and that the Physics method can even expose to us evidences of the Divine Force, Virtue, and Wisdom, and that with reason, we can gradually see very clear evidences of the existence of God. After attributing the main role of Ethics that of pursuing happiness, he then closes the section digressing on apparently disconnected themes such as the usefulness of oriental history to scholars, controversies about biblical passages and languages, and the usefulness of Philology to the Theologian.

Blackman, Terrence *The University of Denver*

Mathematics, Mathematicians, Mathematics Education and Equity: Challenges and Opportunities

Invited Addresses: NAM David Harold Blackwell Lecture

African Americans have a long and honorable tradition of doing Mathematics and Mathematics Education in the African American community. In this talk, from a perspective of excellence and equity, I will address the critical necessity of engagement in Mathematics Education, by all mathematicians and in particular, African American mathematicians. In so doing, I will describe some of the challenges and opportunities for undergraduates considering careers in the mathematical sciences.

Blankenship, Robin *Morehead State University*

Teaching Mathematical Proof Writing Skills in a General Education Course: Graph Theory Algorithms and Color-Coding

Themed Contributed Paper Sessions: TCPS 12 - Improving Undergraduate Math Writing

Liberal arts majors often enter their general education mathematics course with a significant amount of math phobia, having previously struggled to develop the communication and reasoning skills that they need in order to be successful in mathematics. Given a rigid structure in which to place their reasoning helps to keep them focused, and color-coding can be used to visually demonstrate what algorithmic steps have happened in the past, what is happening in the current step, and what will be considered in future steps. This talk will focus on algorithms in graph theory: Fleury's, Kruskal's, Nearest Neighbor, Cheapest Link, and Gantt Scheduling.

Blum, Dorothee *Millersville University*

An Algebra Course for Pre-Service Middle Level Teachers

General Contributed Paper Sessions: Teaching or Learning Introductory Mathematics, Part B

In 2009 Millersville University developed curricula in four concentrations for Pennsylvania's new middle level certification for teachers of grades 4–8. All four concentrations (mathematics, science, social studies, and English language arts) require a common set of courses in education, English, science, social studies and mathematics, and then each concentration has its own set of advanced courses. The mathematics department created three new courses for this program that are taken by all pre-service middle-level teachers: a course in geometry, a course in data analysis and probability, and a course in algebraic foundations. Unlike calculus courses where textbooks abound, there appears to be a shortage of textbooks for these new middle-level courses. In particular, no textbook has been found that meets all of the requirements approved for our algebra course. In this presentation, we address this deficiency by introducing in-house course materials that were developed to cover the required algebra content which ranges from basic set theory and number theory and counting to functions and algebraic properties and structures involving integers, real

numbers, polynomials, the integers modulo n, and matrices, with a prevailing emphasis on patterns and mathematical justification.

Bodner, Lynn *Monmouth University*

Geometric Islamic Star Patterns of Carved Mamluk Domes
Themed Contributed Paper Sessions: TCPS 6B - Mathematics and Art

Geometric Islamic ornament is characterized by endlessly repeating patterns, many of which feature highly symmetric, intricate star polygons. In the 15th century, the Circassian Mamluks (of Egypt and Syria) decorated not only planar surfaces but also the exteriors of their domes with increasingly more sophisticated interlacing star patterns. Most of the stars in both the planar and spherical patterns are comprised solely of straight line segments, but a few are comprised of circular arcs, alone or in combination with line segments. This paper will illustrate and compare some of these lavishly carved spherical patterns with their decorative planar counterparts. In addition, the underlying polygonal grids for some of the patterns will be explored.

Boman, Eugene *Penn State, Harrisburg Campus*
Robert Rogers, *SUNY, Fredonia*

Where is the Differential in Differential Calculus?
Themed Contributed Paper Sessions: TCPS 19B - Innovative Approaches in the Calculus Sequence

A casual glance through the table of contents of a representative sample of the calculus textbooks published since the middle of the twentieth century will quickly convince you that, by and large, these books are all homeomorphic, if not isomorphic. Even the the texts generated by the calculus reform movement of the late nineties barely departed from the standard script. The topics are presented in much the same order and in much the same fashion. At one level this makes sense. The topics build on one another in a logical progression so the form of the texts follows this function. But is this how our students learn/perceive the subject? There has recently been in the mathematics community a growing realization that the history of mathematics is a rich source of ideas for teaching mathematics. This concept may be effectively applied to the calculus sequence. In this talk, we will demonstrate how techniques applied by Newton, Leibniz, and others working "before derivatives" can be used not only to enhance students' ability to solve problems, but also to help students develop their intuition as a prelude to more rigorous approaches. We will provide specific topics, examples, and problems to help accomplish this while staying within the framework of a standard calculus sequence.

Borkovitz, Debra *Wheelock College*

Reflections on Twenty Years of Wheelock College's Math/Science Majors for Prospective Elementary Teachers
Themed Contributed Paper Sessions: TCPS 13 - Successful STEM Programs for Elementary Education Majors

When Massachusetts began requiring prospective elementary teachers to have an Arts and Sciences major, Wheelock College, an institution with roots in the 19th century kindergarten movement, developed an interdisciplinary Math/Science major for prospective elementary teachers, and in 1994, hired their first ever mathematician (me) to implement it. The major has developed in the context of an institution with no history of a traditional math major, but much history of using active pedagogies and manipulatives. The talk will include a description of the mathematics curriculum, pedagogies, and goals of Wheelock's current STEM-related majors and minors for prospective preK-8 teachers, reflection on changes over the years and on key insights and challenges, as well as results from a recent qualitative study interviewing students who have taken intermediate and advanced inquiry-based mathematics courses at Wheelock.

Boute, Raymond *Ghent University*

Rekindling Critical Thinking: Heeding Major Errors in Typical "Transition to Proof" Textbooks
General Contributed Paper Sessions: Teaching or Learning Advanced Mathematics

Mathematics is slowly recovering from unwanted side-effects of the "mathematics reform" that took place a few decades ago. Quite encouraging is the revived interest in proofs, evident from the growing number of "introduction to proof"-type textbooks in undergraduate curricula. Unfortunately, many of these texts contain self-conflicting definitions, thus defeating their very purpose. Sloppiness and uncritical "borrowing" of definitions and explanations from

other books seem to be the main causes. Various examples are given, also showing that, interestingly, flawless treatments were commonplace 50 years ago. Especially problematic are the most basic concepts of relations and functions. In the simplest definitions [e.g., Bourbaki, Suppes], a *relation* is a set of pairs, and a *function* is a relation that is *functional*, i.e., where no two pairs have the same first member [more sources given]. Correct accounts for the concept of a *function* from A to B, the notation $f : A \to B$, *onto*-ness etc. follow naturally. Still, current textbooks use a convoluted way to define *exactly* the same concepts via the Cartesian product and, perhaps in the resulting confusion, make additions that cause contradiction. Similar issues are discussed for the concept of *truth set*, a typical topic in "transition to proof" books. Well-chosen problem statements can teach students to read math texts more critically and prevent errors from becoming epidemic. Proper use of symbolic notation and reasoning is most clarifying in this respect. One conclusion is that definitions (and ensuing theorems) are *tools* for studying mathematical concepts and hence, like any tools, deserve diligent design. The rift between formalism and Platonism is artificial, arguably even misleading.

Boyle, Bernadette *Sacred Heart University*

The Index of a Numerical Semigroup in Four Generators

General Contributed Paper Sessions: Algebra and Linear Algebra

In her 2013 paper, The Index of a Numerical Semigroup, Veliche develops an explicit formula to compute the index of Gorenstein numerical semigroup rings which have three generators. In this talk, we will discuss extending Veliche's results to a family of Gorenstein numerical semigroup rings with four generators. Although there are some methods that exist to compute the index of such semigroup rings, we will talk about developing an explicit formula which only requires knowledge of the generators to compute the index of the Gorenstein semigroup rings with four generators.

Bradley, Robert *Adelphi University*

Euler on L'Hôpital's *Analyse*

Themed Contributed Paper Sessions: TCPS 1E - The Mathematics of Euler

The Marquis de l'Hôpital was Johann Bernoulli's first student and Leonhard Euler was one of his last. During the first half of the seventeenth century, de l'Hôpital's *Analyse des infiniment petits* (1696) was the standard introduction to the differential calculus in the French-speaking world and beyond. In fact, only the first four chapters of the *Analyse*, which were based on the lessons given to the Marquis by Bernoulli in 1691–92, were introductory in nature - the later chapters dealt with matters of active research in the 1690s. At various times during his career, Euler worked on problems that arose from de l'Hôpital's textbook. In this talk, I will consider some of these results, relating to topics including cusps, evolutes, and foundational matters.

Bressoud, David *Macalester College*

Calculus at Crisis

Invited Addresses: MAA James R. C. Leitzel Lecture

The predominance of calculus in high school, recognition of the importance of modeling dynamical systems – especially in the biosciences, and existence of sophisticated online resources have changed what students need from college calculus. Despite recent insights into what it means to understand calculus and how students achieve this knowledge, failure rates are unacceptably high, and passing is no guarantee of ability to use the ideas of calculus. Together, these forces confront departments with a series of decision points around what to teach and how to teach it.

Briggs, Carly *University at Albany*

Beyond Computation: A Team-Based Learning Approach to the Limit Definition of the Derivative

Themed Contributed Paper Sessions: TCPS 19B - Innovative Approaches in the Calculus Sequence

In this talk, I will demonstrate a Team-Based Learning activity that I developed to help calculus students unravel the limit definition of the derivative and associated formulas. In teams, students are asked to sort certain limits into categories of their choosing. After naming their categories, teams are asked to explain their decisions during an extensive debriefing session. This activity requires students to compare various derivative formulas. By identifying subtle differences between formulas that are often overlooked during computational exercises or traditional lectures, students can better recognize when the application of each formula is appropriate. Requiring a team decision forces students to translate their knowledge into words. By making thinking visible, students observe their classmates' organization

of the information allowing them to further revise and refine their own understanding. During the debriefing session, they receive focused and immediate instructor feedback in a low-stakes setting, dispelling any misconceptions. A potential drawback of this activity over a traditional approach would be loss of time for practicing computations. Some challenges specific to the sorting task include quickly distilling teams' complex results for use during debriefing and effectively directing the debriefing session. I will discuss how to fit this task into a busy semester as well as task management strategies.

Brookfield, Gary *California State University, Los Angeles*

Can this Polynomial be Factored?

General Contributed Paper Sessions: Algebra and Linear Algebra

Even high school students have to learn something about factoring polynomials - at least quadratic polynomials with integer coefficients. Strangely, hardly anyone – even math professors – know much about the factorization of polynomials beyond what is taught in high school. This talk will discuss what is known about the factorization of degree three through five polynomials in one variable.

Brown, Christopher *California Lutheran University*

Modeling Duck-Gull-Human Interactions in California

Themed Contributed Paper Sessions: TCPS 18 - Using Modeling for Teaching Differential Equations: Before, During, After

In California, duck, gull, and human populations interact in complex ways. We present a differential equations course project modeling interactions among these three populations, based on the USGS Breeding Bird Survey (BBS) data. The BBS data set is large, complex, and has a good amount of uncertainty from multiple sources. This exposes students to some real-world challenges in modeling, as well as allowing use of the project across multiple classes. We will discuss the use of this project to explore nonlinear systems as they are introduced, provoke discussion on modeling with systems of differential equations, and promote technical reading and writing in the course. We also discuss the use of a suitable alteration of this project to explore more advanced techniques in the context of a scientific computing course. Throughout, we will indicate the challenges we have faced as a consequence of placing real-world data in the hands of undergraduates.

Brown, Ezra *Virginia Tech*

Five Families Around a Well: A New Look at an Ancient Problem

Themed Contributed Paper Sessions: TCPS 1P - History and Philosophy of Mathematics

The title problem comes from Chapter 8 of the ancient Chinese classic "Nine Chapters of the Mathematical Art." It involves solving five linear equations in six unknowns, and many scholars have described the techniques used in the "Nine Chapters" for solving this and similar problems, and have shown that the techniques anticipated nineteenth-century methods by almost two millennia. This talk is a two-part story about a feature of the problem's answer that may have previously gone unnoticed. The first part is about what happens when you look at a historically interesting problem through non-historical eyes. The second part is about a student who got excited about the problem and proved a theorem that gives the answer for n families.

Buechner, Jeff *Rutgers University-Newark*

What is an Adequate Epistemology for Mathematics?

Themed Contributed Paper Sessions: TCPS 1J - Special Session on Philosophy of Mathematics

If we accept a mathematical epistemology in which we can know mathematical propositions with less than mathematical certainty, new possibilities become available for what counts as mathematical knowledge. For instance, if there are formal systems susceptible to the Gödel incompleteness theorems in which the consistency of Peano arithmetic is proved with less than mathematical certainty and the epistemic modality in which it is proved satisfies a reasonable notion of justification, then the limitations of the Gödel theorems will have been dramatically circumvented. In a 1972 paper, Georg Kreisel parenthetically remarks on the cogency of such an epistemology, but without developing it, while subsequent literature simply ignores it. A stumbling block for a mathematical epistemology that licenses knowing mathematical propositions with less than mathematical certainty is the necessity of mathematical propositions. But

work by Saul Kripke in his epochal Naming and Necessity severed the connection between the metaphysical notion of necessity and the epistemic notion of certainty, which opened the possibility of knowing a mathematical proposition in a different epistemic modality than mathematical certainty. In my talk I will examine various conceptions of mathematical proof that answer to different views of what is an adequate epistemology for mathematics, as well as different mathematical epistemologies. I'll argue that the resulting framework allows one to provide different characterizations (each relative to a different mathematical epistemology) of the difference between informal and formal mathematical proofs, and the difference between informal and formal rigor.

Burroughs, Elizabeth *Montana State University*

Mathematical Modeling for Elementary Mathematics Teachers

Themed Contributed Paper Sessions: TCPS 15 - Democratizing Access to Authentic Mathematical Activity

Modeling, a process by which mathematicians develop and use mathematical tools to represent, understand, and solve real-world problems, provides important learning opportunities for students. Two questions are critical for educators interested in using modeling in classrooms. (1) When should students begin to use mathematics to model their world? (2) How should such opportunities be constructed and carried out? In this talk, I will present arguments that students should engage in mathematical modeling beginning in elementary school, and that modeling is a means to help students use mathematics to understand and respond to important issues. I will present a framework for use in courses with pre-service and in-service teachers to engage them in creating opportunities for mathematical modeling at the elementary school level.

Buske, Dale *St. Cloud State University*

Exploring Multivariable Calculus Concepts in Context through Physical Surfaces

Themed Contributed Paper Sessions: TCPS 19A - Innovative Approaches in the Calculus Sequence

For instructors of multivariable calculus, the National Science Foundation funded project Raising Calculus to the Surface (DUE

Butler, Darlene *Arkansas State University-Beebe*

African American Women Mathematicians

Themed Contributed Paper Sessions: TCPS 2A - The Contributions of Women to Mathematics: 100 Years and Counting

The push to entice more African American females to enter the field of mathematics has garnered some returns, but more interest could be generated if students knew more about the contributions of female African American mathematicians in history. This presentation will discuss the first two African American women to obtain Ph.D.'s in mathematics and the contributions they made to the field and to their communities. An overview of the lives of Martha Euphemia Lofton Hayes and Evelyn Boyd Granville will be presented.

Butler, Steve *Iowa State University*

Variations on Apollonian Circle Packing Rules

Invited Paper Sessions: AMS-MAA Invited Paper Session: The Arithmetic of the Spheres

Apollonian circle packings are based on the simple rule that for any three given mutually tangent circles we can insert a unique circle in the space between them and tangent to all three of the original circles. We will see that there are in fact many possible rules that give rise to different properties and behaviors and that will in turn inspire different packings of spheres. By then examining the packings of spheres we will discover new and beautiful packings of circles (so from two dimensions to three dimensions and finally back to two dimensions).

Byer, Owen *Eastern Mennonite University*

New Perspectives on Polygonal Area

General Contributed Paper Sessions: Geometry

In this talk I will present some quite interesting but seemingly not well-known results on polygonal area: 1. A different way of defining the "base" and "height" of a triangle that still yields the familiar area formula; 2. An elementary proof of a formula (similar to the Shoelace formula) for finding area of a polygon in terms of vertex coordinates; and 3. An

elementary proof that if every other vertex of an even-sided polygon is translated by the same vector, the area of the polygon is unchanged.

Byrne, Martha *Earlham College*

The Poincaré Disk Model in GeoGebra

Themed Contributed Paper Sessions: TCPS 21 - Show Me Geometry: Geometry Software and Tablet Demonstrations

The free geometry and algebra software, GeoGebra, can be used for graphing functions and Euclidean constructions, but it can also be used to illustrate the Poincaré disk model for hyperbolic geometry. Given the non-intuitive nature of hyperbolic geometry, hands-on models are important for student comprehension. This talk will present the construction of the model in GeoGebra, and the creation of simple that instructors can share with students. These tools will allow instructors and students to draw the line connecting two arbitrary points, see limiting parallel rays, find common perpendiculars, and measure distances.

C

Calinger, Ronald *Catholic University of America*

Leonhard Euler: The Final Decade 1773 to October 1783

Themed Contributed Paper Sessions: TCPS 1E - The Mathematics of Euler

This paper briefly examines highlights of Euler's research from 1773 to 1783 on number theory, especially prime numbers, vibrating chords in competition with d'Alembert, magic squares, the rings of Saturn, and mechanics, including moments of forces. It covers interactions with Lagrange and Euler's circle, especially with Nicholas Fuss. It continues with Euler's contributions to forming modern mathematical cartography, his second ship theory for Turgot, and response to Kulibin's proposal for a bridge across the Neva. On a personal level, it explores Euler's relations with Denis Diderot, his second marriage, his interactions with Frederick the Great, and his departure from the Imperial Academy in 1777. It closes with Euler's election to the American Academy of Arts and Sciences, his role in the inauguration of Princess Catherine Dashkova as director of the Imperial Academy, and his final days.

Callon, G. Daniel *Franklin College*

A Project-Based Numerical Analysis Course

Themed Contributed Paper Sessions: TCPS 14 - Projects, Applications and Demonstrations to Enhance a Numerical Analysis or Computational Mathematics Course

In business and industry, mathematicians who use numerical analysis techniques do so to solve specific problems that they are facing. To better simulate this environment, I have taught numerical analysis three times as a project-based course, with no tests and no final. Students work in teams that are reshuffled with each project. There is an introductory project focused on sources and minimization of error, and then five major projects that each address an important area of numerical analysis. Each team receives its own project, which means that teams can share ideas freely because they will likely not be using the same specific numerical method since they have different projects. Another interesting feature is that not only are students are asked to provide feedback to me on their teammates' contributions on individual projects, but at the end of the semester each student gives one-on-one feedback to a classmate and receives one-on-one feedback from a different classmate. I will discuss the advantages and challenges of this approach and mistakes I have made, as well as how I have had to make adjustments in response to changes in student characteristics.

Cantarella, Jason *University of Georgia*

Cy: A 3D-Printed Robot for Calculus Teaching

Themed Contributed Paper Sessions: TCPS 9 - What Can a Mathematician Do with a 3D Printer?

How far CAN you go with a 3d printer? In this talk, we demonstrate a small robot which throws a ball bearing from a rotating arm into a coffee cup. Students in the first-semester calculus class learn to predict the landing of the ball from the rotation speed of the arm. The robot will be there for the audience members to try out at the talk. The robot

is built with a 3d-printed structure joining some standard components (an Arduino, a servomotor, an electromagnet), and we'll also discuss how the robot was designed and printed.

Cape, Joshua *Johns Hopkins University*

Polynomials: An Exploration

Graduate Student Session: Great Talks for a General Audience: Coached Presentations by Graduate Students, Part B

Polynomials are among the most simple and "nice" functions in mathematics. They appear everywhere: throughout high school, undergraduate, and even graduate-level courses. It is exciting to realize that thinking in terms of polynomials can inform our understanding of many topics in mathematics, even those that are seemingly unrelated. Join us as we explore the role of polynomials in branches of mathematics beyond calculus and linear algebra. In addition, we will see how collections of polynomials can be interpreted not only algebraically but also geometrically! To this end, we highlight the connection between so-called invariant polynomials and the study of singularities within the context of recent research in algebraic geometry.

Caples, Christine *University of Iowa*

Classifying Tangles

Graduate Student Session: Great Talks for a General Audience: Coached Presentations by Graduate Students, Part A

A knot can be thought of as a knotted piece of string with the ends glued together. A tangle is formed by intersecting a knot with a 3-dimensional ball. The portion of the knot in the interior of the ball along with the fixed intersection points on the surface of the ball form the tangle. Tangles can be used to model protein-DNA binding, so another way to think of a tangle is in terms of segments of DNA (the strings) bounded by the protein complex (the 3-dimensional ball). Like knots, the same tangle can be represented by multiple diagrams which are equivalent under deformations (no cutting or gluing allowed). A tangle invariant is a value that is the same for equivalent tangles. Tangles can be classified into families which allows one to compute invariants more quickly as well as study properties of tangles that may be useful for solving tangle equations.

Carpenter, George *Louisiana Tech University*
E. A. Sherer, *Louisiana Tech University*
D. P. O'Neal, *Louisiana Tech University*
I. B. Magana, *Louisiana Tech University*
P. Adhikari, *Louisiana Tech University*
Holly Grigsby, *Louisiana Tech University*
Katie Evans, *Louisiana Tech University*

Development and Implementation of a Pharmacokinetic Model as the Target Equation for a PID Control System

General Contributed Paper Sessions: Applied Mathematics

A photoplesthmograph (PPG) device relies on pulse oximetry to noninvasively determine concentration of optically active materials in the bloodstream. A prior group analyzed control methods interlinking the PPG as feedback for an automated injection pump. This study used real-time concentration measurement capabilities of the PPG to develop a pharmacokinetic model as the target equation for a PID control system for controlling the concentration of Indocyanine Green (ICG) during injection, using an automated injection pump to keep injections at a constant rate. The experimental plan performed calibration trials to identify the desired injection profile curve of ICG and develop the pharmacokinetic model; created/tuned a PPG control program utilizing PID control to utilize the ICG target model; and performed validation experiments to demonstrate application of the controller/ model. To develop the model, 22 injections were given to standard BALB/c lab mice and the model/parameters were identified using WinBUGS software. PID control software was developed to manage the injection pump based on PPG measurement. PID tuning was done using the Ziegler-Nichols Tuning Rule. The expected injection profile from the model was set as the target equation to be used for injections in the PPG control software. Nine injections in standard BALB/c mice were performed to verify that the developed control software/pharmacokinetic model can follow a desired concentration profile during injection.

Carpenter, Jenna *Louisiana Tech University*
D. P. O'Neal, *Louisiana Tech University*

Supporting the Success of Women Faculty through an NSF ADVANCE Grant: Looking Back, Moving Forward
General Contributed Paper Sessions: Mentoring and Outreach

For the last six years, Louisiana Tech University has had an NSF ADVANCE Grant to support the success of women faculty in STEM programs. The focus has been on improving the climate, providing professional development and leadership training and efforts to retain and promote women faculty. Through nine different programs, the project has realized significant gains related to climate and training. This talk will look at which programs will be retained moving forward and how the university is planning to build on this success.

Carter, J. Scott *University of South Alabama*

An Introduction to Quandle Cohomology
Invited Paper Sessions: MAA Invited Paper Session: Algebraic Structures Motivated by Knot Theory

The most easily defined invariants of a knot are related to the diagram of the knot to be colorable. Colorability conditions are given at the crossings of the diagram, and an associated algebraic structure called a quandle can be defined. The axioms of a quandle are derived from the Reidemeister moves. A similar structure and set of coloring conditions can be given for knotted trivalent graphs. The Reidemeister moves and their analogues suggest a secondary invariant that assigns certain values in an abelian group to crossings. The function values are cocycles in a specific homology theory. In this talk, we will work from the ground up and demonstrate how the algebraic structures are necessitated by the geometric descriptions.

Case, James *SIAM*

Using Differential Equations to Analyze the Energy Future
Themed Contributed Paper Sessions: TCPS 18 - Using Modeling for Teaching Differential Equations: Before, During, After

Consider an island economy powered in part by renewable energy, and in part by (exhaustible) fossil fuels. Wishing to make "best possible" use of the latter, the island's "energy czar" faces a subtle planning problem. The problem is analyzed with the aid of differential equations.

Castillo-Chavez, Carlos *Arizona State University*

MAA Centennial Lecture 4 The Role and Function of Mathematical Models in Interdisciplinary Mentorship through Research: Lessons from the World of Epidemics
Invited Addresses: MAA Centennial Lecture

We live in an interconnected world in which seeking solutions to societal problems no longer makes sense within the confines of single-discipline organized institutions. The nation's ability to train 21st century scientists depends on systems of learning and thinking that are naturally embedded within interdisciplinary educational research/mentorship models. The use of multiple modes of doing science including the systematic use of computer experiments and data science (Big Data) must be at the heart of a modern 21st Century STEM education. As Steve Strogatz observes "... cancer will not be cured by biologists working alone. Its solution will require a melding of both great discoveries of 1953 [Fermi-Pasta-Ulam introduction of the computer experiment and Watson & Creek discovery of the chemical structure of DNA]. Many cancers, perhaps most of them, involve the derangement of biochemical networks that choreograph the activity of thousands of genes and proteins. As Fermi and his colleagues taught us, a complex system like this can't be understood merely by cataloging its parts and the rules governing their interactions. The nonlinear logic of cancer will be fathomed only through the collaborative efforts of molecular biologists – the heirs to Dr. Watson and Dr. Crick –and mathematicians who specialize in complex systems – the heirs to Fermi, Pasta and Ulam." In this lecture, I will highlight (1) the role that interdisciplinary research challenges has played in shaping the training and mentorship of students from high school to the postdoctoral level and (2) the impact that has had on my own research program. The discussion will be centered on questions that arise in the study of disease dynamics (Ebola and Influenza) across levels of organization and over multiple spatiotemporal scales. The examples used are the result of the research carried out with a myriad of collaborators (undergraduate, graduate, postdoctoral students and colleagues) over the past three decades

Castillo-Garsow, Carlos *Eastern Washington University*

Mathematics Education Commentary: At the Interface Between Applied Mathematics and Mathematics Education

Invited Paper Sessions: MAA Invited Paper Session: Improving Access to Mathematical Modeling Research

Dynamical systems modeling requires nuanced ways of doing mathematics and imagining situations that are often overlooked, both by applied mathematicians who take these ways of thinking for granted, and by mathematics educators, who rarely have the experience with applied mathematics necessary to see them. In response to the above presenters, Carlos Castillo-Garsow will discuss the results of recent case study research in student thinking and their implications for the teaching of mathematics students.

Chan, Julian *Weber State*

Counting with Your Toes!

Themed Contributed Paper Sessions: TCPS 6A - Mathematics and Art

Counting with your toes is a project that is themed on a collaborative and interdisciplinary project between mathematics and dance. The unusual pairing of these two courses lead to memorable and social ways to combine mathematics and the arts.

Chatham, Doug *Morehead State University*

The *n*-Queens Problem with Forbidden Placements

Themed Contributed Paper Sessions: TCPS 5A - Recreational Mathematics: New Problems and New Solutions

For $n = 1$ or $n > 3$, it is well-known that we can place n queens on the squares of an n-by-n chessboard so that no two queens are in the same row, column, or diagonal. Suppose r of the chessboard squares are marked as forbidden territories where no queen can be placed. How many nonattacking queens can we place on the n-by-n board with r forbidden squares? We reveal some partial results using coloring and 0-1 integer programming and discuss the extent to which the general problem remains open.

Chayes, Jennifer *Microsoft Research*

MAA Centennial Lecture 2 Network Science: From the Online World to Cancer Genomics

Invited Addresses: MAA Centennial Lecture

Everywhere we turn these days, we find that networks can be used to describe relevant interactions. In the high tech world, we see the Internet, the World Wide Web, mobile phone networks, and a variety of online social networks. In economics, we are increasingly experiencing both the positive and negative effects of a global networked economy. In epidemiology, we find disease spreading over our ever-growing social networks, complicated by mutation of the disease agents. In biomedical research, we are beginning to understand the structure of gene regulatory networks, with the prospect of using this understanding to manage many human diseases. In this talk, I look quite generally at some of the models we are using to describe these networks, processes we are studying on the networks, algorithms we have devised for the networks, and finally, methods we are developing to indirectly infer network structure from measured data. I'll discuss in some detail particular applications to cancer genomics, applying network algorithms to suggest possible drug targets for certain kinds of cancer.

Chen, Wen-Haw *Department of Applied Mathematics, Tunghai University*

Four Stages in Teaching Linear Algebra: From Diagnosis, Connection, Deepening to Application

General Contributed Paper Sessions: Teaching or Learning Advanced Mathematics

Linear algebra is a fundamental and important subject for students in science, engineering and management schools etc. In this paper, we present a research about dividing the teaching of linear algebra course into four stages: diagnosis, connection, deepening and application, and then investigating the improvement of teaching and learning linear algebra. The course carried out in the academic year 2013–14 at Tunghai University in Taiwan. In the first stage "diagnosis," we assess students' prior knowledge before processing the course. Secondly, we develop in the stage of "connection" the material for the bridging course. Thirdly, we concern how to "deepen" the teaching of abstract theories. The final stage is to review whether students can "apply" learned knowledge to solve practical problems designed by the characteristics of different fields. Some teaching methods such as problem-based learning together with the aid of computer algebra system had been integrated in the four stages.

Chen, Zhengqing *Clarkson University*

Fourier, Duality, and the Uncertainty Principle

Graduate Student Session: Great Talks for a General Audience: Coached Presentations by Graduate Students, Part C

In this 20 minute talk, we will first go back to the key and beautiful idea behind the whole Fourier framework. By appreciating this, we will be able to understand the mathematical concept, or, the inescapable fate of uncertainty, which is closely tied to the concept of duality. These concepts are actually not as unfamiliar as they sounds: You may have heard of Heisenberg's Uncertainty Principle and the wave-particle duality in physics. They are not too much different. Through the Fourier lens, we will see with sharp focus both the mathematical and physical interpretation of these ideas of uncertainty and duality.

Cheshire, Daniel *Texas State University*

Finite Topological Spaces as a Pedagogical Tool for Teaching Concepts in Calculus

Themed Contributed Paper Sessions: TCPS 19B - Innovative Approaches in the Calculus Sequence

This presentation will demonstrate a set of in-class activities that use basic ideas from the field of point-set topology to support students' conceptual understanding of continuous functions in an introductory calculus course. Through a series of explorations, students are introduced to the relevant properties of real open intervals as they relate to continuous functions. However, these properties are first introduced in the abstract context of finite topological spaces, temporarily muting many of the concrete but misleading features of their representations in the Cartesian plane. The underlying structure of the property of continuity can then be accessed and conceptualized by the students before being translated back into the real coordinate system. Finite topological spaces are powerful pedagogical tools in introductory topology classes (Helmstutler & Higginbottom, 2012). The relative ease in calculating with these spaces allows one to quickly check properties, counterexamples, and conjectures, providing students access to a useful abstract representation of important properties such as continuity of functions and connectedness. As this presentation will demonstrate, these tools are similarly useful in calculus instruction. The audience will participate in applying a procedure to determine the continuity of functions on finite topologies. This understanding will then be translated to an interpretation of the epsilon-delta definition of continuity for real-valued functions, with illustrated examples of how this definition fails for discontinuous functions. Extensions of these ideas to explorations of the topological property of connectedness and the intermediate value theorem of calculus will be discussed.

Chichester, Frederick

Near-Isosceles Pythagorean Triples

General Contributed Paper Sessions: Number Theory and Logic or Foundations

If the integers of the Pythagorean triple (a, b, c) are arranged in a ascending order, then a rerpresents the length of the shorter leg, b the length of the longer leg, and c the hypotenuse of the corresponding Pathagorean triangle. If this triangle closely approximates an isosceles triangle, the triplet is then said to be "near-isosceles." This can occur in two ways. The first approach is to find values of the Euler integers, m and n, for generating primitive Pythagorean triples (PPTs) for which the two smaller integers (a and b) satisfy the condition b - a = 1. An algorithm is developed for generating the values of m and n needed to produce a series of PPTs satisfying this condition. The accuracy of the approximation to the corresponding isosceles triangle is represented by 1/a. The second approach is to find values of m and n for generating PPTs for which the two larger integers b and c satisfy c - b = 1. An algorithm for generating a series of values of m and n to produce PPTs satisfying this condition is shown. The accuracy of the approximation to the isosceles tiangle is represented by 1/b. The results of these two approximations are displayed in a combined table.

Chiorescu, Marcela *Georgia College*
Darin Mohr, *Georgia College*
Brandon Samples, *Georgia College*

Enhancing Student Learning Experience through Maple

General Contributed Paper Sessions: Mathematics and Technology

There are many potential benefits for students from integrating Maple into mathematics classrooms: increased focus on conceptual knowledge, increased connections between multiple representations and development of mathemat-

ical thinking. During the academic year 2014–2015, we designed and integrated Maple tutorials and projects into mathematics courses (Calculus I and II, Linear Algebra). These activities enhance our student's learning potential by providing them with a technology tool that dynamically increases understanding while also preparing them for future careers in mathematics where proficiency in technology is key. We will present what we have done and (some) preliminary results.

Choi, Ji Young *Shippensburg University of PA*

Jacobsthal Sequence in Ternary Represented Modified Collatz Sequences
General Contributed Paper Sessions: Number Theory and Logic or Foundations

A modified Collatz sequence starting with a positive integer N is $a_0 = N$, and $a_{k+1} = (3a_k + 1)/2$ if a_k is odd and $a_k/2$ else. This talk will present a ternary representation of a modified Collatz sequence, and show that the number of 1's in the repeated part in the ternary representation of the modified Collatz sequence starting with any multiple of a large power of 3 is the Jacobsthal number.

Clair, Bryan *Saint Louis University*

Ten Years of Student Art in a Math Class
Themed Contributed Paper Sessions: TCPS 6B - Mathematics and Art

For more than a decade, Saint Louis University has been offering the "Math and the Art of M.C. Escher" course to fulfill a core mathematics requirement. We have developed an open access online textbook at http://math.slu.edu/escher. This talk will focus mainly on the art assignments that form a major part of the course, and the student produced mathematical art that results.

Clark, David *Grand Valley State University*

I Need Some Focus! Helping Calculus Students Navigate Mathematical Writing
Themed Contributed Paper Sessions: TCPS 12 - Improving Undergraduate Math Writing

Calculus courses are an ideal place to introduce students to professional writing. However, the bewildering array of conventions and fine details can make it difficult for novice writers to focus on the most important aspects of mathematical writing. We describe a structure for introducing and assessing mathematical writing in calculus classes. This structure has three interlocking components: First, a set of advanced portfolio problems or lab activities. Second, a carefully chosen set of "focuses" for each activity that gradually introduce students to key concepts in mathematical writing. Third, an assessment method that makes a useful distinction between "significant" and "minor" errors, as well as separating mathematical issues from writing style – a feature that helps instructors give useful formative feedback and focuses students on the most important aspects of writing. This structure can also incorporate revisions. This structure is extremely flexible and can be used consistently across many different assignments. We will describe the implementation of this system in a variety of differential and integral calculus courses, give advice for its effective use, reflect on its strengths and weaknesses.

Clark, David *Randoph-Macon College*

Geometry in 18th Century Japan: Exploring and Creating Sangaku
Themed Contributed Paper Sessions: TCPS 6B - Mathematics and Art

During the Edo Period (1603–1868), Japan was almost completely isolated from the West, including the products of the Western revolutions in math and science. At the same time, the Japanese witnessed a cultural renaissance in the visual and performing arts, music, fashion, ceremony — and mathematics. Geometry intersected with religious tradition to create a unique genre of folk art known as sangaku. In this talk, after introducing Edo Period mathematics, we'll follow a group of undergraduates traveling to Japan to learn about the fascinating cultural history of sangaku.

Clark, Jeffrey *Elon University*

Revising for Clarity
Themed Contributed Paper Sessions: TCPS 12 - Improving Undergraduate Math Writing

This talk will address helping students to revise papers and presentations of moderate length or greater. Experienced mathematicians struggle with identifying with their readers and audience in terms of how best to communicate their

ideas; less-experienced students have an even harder time. This presentation will share basic techniques of outlining and prioritizing that can help the students to achieve greater clarity in their writing.

Clark, Timothy *Loyola University*

Pictures of Syzygies

Invited Paper Sessions: MAA Invited Paper Session: Concrete Computations in Algebra and Algebraic Geometry

We describe a diversity of pictorial, combinatorial, and topological objects whose structure can be used to encode and understand the notion of $syzygy$ in commutative algebra. A $syzygy$ is a tuple $(a_1, \ldots, a_n) \in R^n$ such that $a_1 g_1 + \cdots a_n g_n = 0$, where $g_1 \ldots g_n$ is a set of generators for a module over a commutative ring R.

Coan, Boyd *Norfolk State University*

Exterior Algebra in the Undergraduate Curriculum

General Contributed Paper Sessions: Teaching or Learning Advanced Mathematics

We continue to explore the traditional and non-traditional uses of Exterior Algebra in the undergraduate curriculum pursuant to some earlier discussions at MAA conferences. This report is more of a survey of some important results rather than a technical paper. The goal is to motivate further study of an area of mathematics which has received relatively little attention in recent literature. On the traditional side, we review how differential forms are used in linear algebra, in the proof of Stokes Theorem, and in reformulations of Maxwell's Equations. The non-traditional uses of Exterior Algebra will be included in a survey of topics more algebraic in nature. Such topics as additive Abelian group theory, combinatorics, ring theory, coding theory, and grobner bases may be discussed.

Coffman, Adam *Indiana-Purdue Fort Wayne*
Yuan Zhang, *Indiana-Purdue Fort Wayne*

An Example for Green's Theorem with Discontinuous Partial Derivatives

General Contributed Paper Sessions: Analysis and Other

Green's Theorem in multivariable calculus is usually stated with a hypothesis that the partial derivatives are continuous. I will present an example of a function where the partial derivatives exist but are discontinuous, to which a stronger version of Green's Theorem applies.

Collins, Dennis G.

Collins Math Magic Number Blocks and the Wobble-Square Method of Multiplication

General Contributed Paper Sessions: Teaching or Learning Introductory Mathematics, Part A

The paper mostly repeats a presentation at the MAA Indiana Section Meeting at Trine University Oct. 18, 2014. A set of manipulatives, comprising about 36 rectangular-solid blocks, allows formation and checking of equations and translation into language, with significant closure properties. Application to the wobble-square method of multiplication is described, where wobble(n) = n(n+1).

Collins, Lee N. *County College of Morris*
Tom Osler, *Rowan University*

Generalizing the Law of Cosines

General Contributed Paper Sessions: Geometry

The law of cosines for any triangle with sides of lengths a, b, and c states that $c^2 = a^2 + b^2 - 2ab\cos\gamma$, where γ is the angle opposite side c. We use a geometric approach to show that this formula generalizes nicely for an arbitrary quadrilateral with sides a, b, c, and d, and any five sided polygon with sides a, b, c, d, and e. Furthermore, we show the generalization extends to any polygon with n sides, as well as any polyhedron with n faces.

Comar, Timothy *Benedictine University*

The Dynamics of Pulse Vaccination Models

Themed Contributed Paper Sessions: TCPS 4 - Undergraduate Research Activities in Mathematical and Computational Biology

This particular talk with focus on results we have obtained with undergraduate students researchers on the dynamics of epidemic models. The models are pulse vaccination models using impulsive differential equations. A pulse vaccination strategy periodically provides a fraction of the population with vaccination against a particular disease. One of the models incorporates a time delay for the period of time required for an exposed individual to become infective. Conditions for disease free period solutions and endemic solutions are provided. We also discuss some avenues for future work by considering the introduction of stochastic behavior into these models and agent based versions of some of these models.

Cone, Randall *Salisbury University*

Inquiry-Based Learning in ODE Classes: Stable or Unstable?

Themed Contributed Paper Sessions: TCPS 18 - Using Modeling for Teaching Differential Equations: Before, During, After

Can Inquiry-Based Learning (IBL) be substantially and effectively included in undergraduate elementary ODE classes? Are student presentations enough? Can mathematical modeling through ODEs be productively encouraged and competently assessed using IBL methods? In this presentation, we examine and discuss these questions as they have been explored, and partially answered, over the last five years in classroom contexts.

Cone, Randall *Salisbury University*

Mathematics and Poetry: The Sweetest Noise

Themed Contributed Paper Sessions: TCPS 6A - Mathematics and Art

In this paper, we discuss visualizations and content analyses of poetry, as (partially) determined by mathematical and computational processes. We focus on works by Emily Dickinson, Robinson Jeffers, and John Milton.

Conner, AnnaMarie *University of Georgia*
Laura Singletary, *Lee University*

Focusing on Mathematical Arguments

Themed Contributed Paper Sessions: TCPS 20 - Evidence-Based Approaches to the Mathematical Preparation of Secondary Teachers

The importance of collective argumentation is highlighted in the Common Core State Standards Third Standard for Mathematical Practice, which states that students should be able to "construct viable arguments and critique the reasoning of others." Collective argumentation occurs when a group works together to arrive at a conclusion (supporting it with evidence). One way to help teachers' focus on important mathematical ideas is to use Toulmin's (1958/2003) conceptualization of arguments to reflect on mathematics teaching. His model of an argument has seven components, but Krummheuer (1995) suggested for collective argumentation it can be reduced to three main core components that help us to think about the important content of a mathematical argument: data is information provided that supports the claim, the warrant is reasons that link the data to the claim, and the claim is the result or statement being established. We use Toulmin's model to help preservice secondary mathematics teachers examine classroom discussions, focusing specifically on the mathematical arguments. With Toulmin's model in mind, we have preservice teachers consider the specific contributions made during an episode of argumentation, purposefully focusing on the extent to which students contribute to the argument and to reflect on the extent to which students' reasoning is made public in the classroom to benefit other students' learning. During this presentation, we will present evidence to show how using Toulmin's model helps preservice teachers to focus on important mathematics during classroom discussions and to consider how to prompt students to contribute their reasoning.

Conway, John *Princeton University*

New Ideas about the Geometry of Triangles

Invited Paper Sessions: Special Invited Session: The Geometry of Triangles

The geometry of triangles is an old subject. I will discuss some ideas that tie together its different parts and make it easy to remember many old and new theorems.

Cook, Grace *Bloomfield College*
Michael Schiro, *Bloomfield College*
Kevin Kline, *Bloomfield College*

Reorganization and Innovation in First Year General Education Mathematics Courses

Themed Contributed Paper Sessions: TCPS 16 - Curriculum Development to Support First Year General Education Mathematics Students

In an effort to increase passing and retention rates, Bloomfield College embarked on a reorganization of their freshman general education math program starting in the summer of 2013. A summer program was developed for incoming students to review pre-algebra concepts. MyFoundationsLab was used to varying degrees of success. That fall all freshmen were placed into one of two general education math classes, College Algebra or Pre-Calculus. These two math classes were broken down into regular and supported sections. The supported classes met two additional days with a math specialist. Graphing calculators were used extensively. As the year progressed, changes were made to the curriculum based on instructor and student feedback. At the end of the year, the two math classes had a pass rate of 78% for the fall and 86% for the spring. The summer 2014 program was restructured to align with another general education math class, Understanding Our Quantitative World. The program incorporated group projects, online work, and graphing calculators to create an interactive experience. Approximately 26% of the students were able to waive the Quantitative World course based on their success in the program. The College Algebra course was further revised for fall 2014 to incorporate arithmetic and algebra modules, while trigonometry was removed. Based on diagnostic test scores, students had staggered start dates. For the spring 2015, the arithmetic modules and staggered starts were removed. The fall 2014 passing rate increased to 89%, while the spring 2015 passing is not yet available. Further revisions are planned for the spring and fall of 2015. These include creating a new course, moving topics between courses, and changing pre-requisites.

Cooke, Roger *University of Vermont*

Grattan-Guiness's Work on Classical Mechanics

Themed Contributed Paper Sessions: TCPS 1Q - Special Session in Memory of Ivor Grattan-Guinness

Over a long career spanning 45 years, Grattan-Guinness evinced an interest in nearly everything in the universe that had even the remotest connection with mathematics: philosophy (especially epistemology), logic, physics, religion, music, art, education, economics, psychology, and much more. Although it could be said that his strongest area was logic and its history, his fundamental contributions to our understanding of the history of classical mechanics are a recurring theme throughout his brilliant career, beginning with the first of his works that brought him to the attention of Mathematical Reviews, his 1969 paper "Joseph Fourier and the revolution in mathematical physics", which was followed soon by a short paper discussing whether Fourier anticipated linear programming in 1970, and then, two years later, by the magisterial monograph on Fourier's life and work that established him as one of the leading lights among historians of mathematics. From this root, he branched out into a general study of nineteenth-century French mathematicians, culminating in his definitive three-volume masterpiece Convolutions in French Mathematics, published in 1990. His interest in this area never left him, and the last of the 153 papers by him reviewed or indexed in Mathematical Reviews 117 were given full reviews published in 2014, was on Poinsot's theories of the couple in mechanics.

Cooper, Andrew *North Carolina State University*

Definitions as Proof Blueprints

Themed Contributed Paper Sessions: TCPS 12 - Improving Undergraduate Math Writing

A perennial question students have when asked to write a proof is, "Where do I start?". In this talk, I will describe an assignment that leverages this concern to teach several important lessons about mathematical writing. The assignment

requires the student to create, for a given definition D, a blueprint for a proof that "X is D". In addition to generating a tool for the student's own future use, the blueprint assignment focuses her attention on the consequent of an implication, requires her to interact with definitions in a new and deep way, and reinforces the distinction between discovering an argument and writing that argument up into a proof.

Couch, Elly *University of North Alabama*

The Effect of Technology-Enhanced Lessons in the Math Classroom

PosterFest 2015: A Poster Session of Scholarship by Early Career Mathematicians and Graduate Students

As a future math teacher, I am strongly encouraged to incorporate different forms of technology into my teaching methods as a way to enhance my students' learning and keep my students attentive during class. Many school systems, and more specifically math classrooms, are adopting iPads, Chrome Books, and other forms of technology for their students to use in the classroom. Does using technology really help students understand the math concepts that are being taught? Our research seeks to determine if incorporating technology into a math classroom improves student understanding as compared to no technology. Specifically, we focus on a lesson about projectile motion incorporating a software simulation and a physical model with a flight computer, compared to a traditional lecture. In our technology-enhanced lesson, we taught students about projectile motion by going through the mathematical basics of projectile motion with a rocket flight simulation and a PowerPoint presentation. After the lesson, the students observed a live rocket launch to reinforce the lesson concepts. We attached a flight computer to the rocket to record flight data, and students used the data from the rocket flight to explore the essential mathematical concepts of projectile motion using the software simulation. Early results from regional high school and middle school classrooms indicate improvements as measured by pre-test and post-test assessments for both control and experimental groups.

Cox, Geoffrey *Virginia Military Institute*

Creating Online Problems that Develop Mathematical Strategies and Reduce Student Frustration

Themed Contributed Paper Sessions: TCPS 19B - Innovative Approaches in the Calculus Sequence

As online learning resources become more prevalent, well-thought out online problems become increasingly important. The author of such problems must be aware of the limitations of algorithmically-based problems, as well as the technology available to the circumvent learning objectives. In this talk, I will give examples of how sequentially written WebWork problems can help develop important mathematical strategies and obstruct the ability of students to trivialize problems using computer algebraic systems (i.e. Wolfram Alpha). In addition, I will discuss how this practice can also help reduce student frustration commonly associated with online problems. Although the content will be completely calculus based, its application is well suited for other courses.

Crans, Alissa *Loyola Marymount University*

An Introduction to Quandles

Invited Paper Sessions: MAA Invited Paper Session: Algebraic Structures Motivated by Knot Theory

A quandle is a set equipped with two binary operations satisfying axioms that capture the essential properties of the operations of conjugation in a group and algebraically encode the three Reidemeister moves from classical knot theory. This notion dates back to the early 1980's when Joyce and Matveev independently introduced the notion of a quandle and associated it to the complement of a knot. We will focus on an introduction to the theory of quandles by considering examples, discussing applications, and introducing recent work in this area.

Cretney, Rosanna *The Open University*

The Construction of Map Projections in the Works of Lambert and Euler

Themed Contributed Paper Sessions: TCPS 1F - Special Session in Memory of Jackie Stedall

Prior to the eighteenth century, though many different map projections were proposed and used, no theory was known that aided the development of new projections or explored connections between existing ones. However, in 1772, a memoir published by Johann Heinrich Lambert marked the beginning of a general mathematical theory of cartography. This was quickly followed by further papers on the same subject by Leonhard Euler (three papers, 1777) and Joseph-Louis Lagrange (two papers, 1779). These advances were enabled by various new developments and trends in mathematics over the preceding century, such as the growing preference for analytic mathematics over classical

geometrical methods, and the development of calculus, in particular, the theory of partial differential equations. The historical exposition at the beginning of Lagrange's 'Premier mémoire sur la construction des cartes géographiques' allows one to know which other authors influenced his work. However, it is not as easy to determine the influence of other authors on Euler: though he probably read Lambert's memoir on map projections, he made no direct reference to it in his own papers. In this talk, I will compare and contrast Euler's work on map projections with that of Lambert, with a view to exploring the connections between the two.

Crist, Randall *Creighton University*
Gintaras Duda, *Creighton University*

Integrating First-year Physics and Mathematics through Project-based Learning
General Contributed Paper Sessions: Teaching or Learning Calculus

Modeling the Physical World is a year-long course at Creighton University taken by well-prepared freshmen who arrive at college with Calculus I credit. The course is six credit house per semester, and integrates the material of General Physics I with Calculus II, and General Physics II with Calculus III (multi-variable). The course uses both lecture and project-based pedagogy, and focuses on the integration of physics and mathematics. We will discuss some of the conflicts and resolutions learned from uniting the subjects, and successes and failures while using project-based learning.

D

D'Antonio, Lawrence *Ramapo College*

Combatting the "Legion of Half-Wits": the Contentious Mathematicians of the Paris Academy of Sciences
Themed Contributed Paper Sessions: TCPS 1K - Special Session on Mathematical Communities

The title of this talk is a quote from Samuel Formey, referring to the duty of the scientific academies of the Enlightenment to drive out superstition and ignorance by establishing secure knowledge, of which mathematics is the most perfect model. In this talk we will consider the role of mathematicians in the history of the Paris Academy of Sciences. We will examine several episodes of confrontations involving members of Academy. For example, the Rolle - Varignon debate on the metaphysics of calculus, in which conservative forces, led by Rolle, argued that the recently introduced calculus lacked rigor. Academicians such as l'Hôpital and Varignon defended the new analysis by emphasizing its elegance and effectiveness. A later episode is the long battle fought by Cartesians, led by Fontenelle, who fought against the introduction of Newtonianism, whose champions were Maupertuis, d'Alembert, and Clairaut.

Dai, Zhewei *Alma College*

Empowering Undergraduate Students through Project-Oriented Independent Studies
General Contributed Paper Sessions: Teaching or Learning Advanced Mathematics

In empowering undergraduate students in independent studies, the author took the approach of student-driven projects that started easily accessible, and then became progressively harder. In this talk, the author will share what was learned as the key success components and challenges from supervising numerous independent studies in the field of Inverse Problems.

Daubechies, Ingrid *Duke University*

MAA Centennial Lecture 3 Mathematics for Art Investigation
Invited Addresses: MAA Centennial Lecture

Mathematical tools for image analysis increasingly play a role in helping art historians and art conservators assess the state of conservation of paintings, and probe into the secrets of their history. The talk will review several case studies, Van Gogh, Gauguin, Van Eyck among others.

Dauben, Joseph *City University of New York*

Fuzzy Logic and Contemporary American Mathematics: A Cautionary Tale
Themed Contributed Paper Sessions: TCPS 1M - Special Session in Honor of Karen Parshall

Fuzzy Logic was inaugurated in 1964 by a professor at the University of California, Berkeley, Lotfi Zadeh, who was interested in the mathematics of complex systems and the role mathematics might play in behavioral, social, and

environmental sciences, as well as medicine and technological applications, especially artificial intelligence, pattern recognition, etc. The article that first put fuzzy logic on the map, "Fuzzy Sets," was sent to the journal *Information and Control* in November of 1964, and published the following year, in 1965. Earlier Zadeh had presented the gist of his ideas about fuzzy set theory during a seminar at Berkeley, to which the reaction was mostly negative. As one of its major critics, Rudolph E. Kálmán (who won the National Medal of Science in 2009) objected: "No doubt Professor Zadeh's enthusiasm for fuzziness has been reinforced by the prevailing political climate in the U.S.—one of unprecedented permissiveness." Other critics argued that there were no useful applications of fuzziness, that there was nothing that fuzzy logic or set theory offered that could not be done just as well by ordinary probability theory. Nevertheless, the first dramatic applications of fuzzy logic were made in Japan, and soon China followed suit. Why was fuzzy mathematics so slow to find an appreciative audience in the US? Why does it continue to attract vehement critics? The battle to establish fuzzy logic as a viable part of contemporary mathematics in America, and to decide whether it represents a revolutionary paradigm shift in doing so, as some have claimed, will be the focus of this presentation.

Dauben, Joseph *City University of New York*

Ivor Grattan-Guinness (1941-2014) and his Contributions to the History of Analysis, Set Theory, and Applied Mathematics

Themed Contributed Paper Sessions: TCPS 1Q - Special Session in Memory of Ivor Grattan-Guinness

Ivor Grattan-Guinness was always adamant that the foundation of the history of mathematics should be the mathematics itself, whereas its wider social context should also be kept in mind. How these factors played out in his early research in the 1960s and 70s will be the focus of this presentation. Beginning with his early archival work in Germany and Sweden, his first books reflect his primary interests in various ways: *The Development of the Foundations of Mathematical Analysis from Euler to Riemann* (MIT Press, 1970); *Joseph Fourier, 1768-1830. An account of his life and work, based on a critical edition of his monograph on the propagation of heat, presented to the Institut de France in 1807* (MIT Press, 1971); and *Dear Russell–Dear Jourdain: a Commentary on Russell's Logic, Based on His Correspondence with Philip Jourdain* (Duckworth, 1977). Ivor's research on Fourier was undertaken in collaboration with his mentor and colleague, Jerome Ravetz, whose own book, *Scientific Knowledge and its Social Problems* (Oxford, The Clarendon Press) also appeared in 1971. How that collaboration influenced Ivor's thinking, as well as the influences in those early years of Thomas Whiteside, Sir Karl Popper, and Sir Edward Collingwood, among others, will help to describe the larger framework within which Ivor's interests were developing in the 1970s. When it appeared in 1997, Ivor's *The Rainbow of Mathematics: A History of the Mathematical Sciences* (Fontana, 1997) represented the other end of the spectrum of the history of mathematics to which he devoted his scholarly career, not only to the exemplary writing of that history, but to its professional development as well, on which this presentation will also touch.

Dawson, John *Penn State York*

Ivor Grattan-Guinness's Legacy to History and Philosophy of Logic

Themed Contributed Paper Sessions: TCPS 1Q - Special Session in Memory of Ivor Grattan-Guinness

Historians and philosophers of logic are greatly indebted to Ivor Grattan-Guinness, not only for his books, articles and reviews on those topics, but for documents he unearthed in archives, for his founding and editing of the journal History and Philosophy of Logic, and for his steadfast promotion of the study of history and philosophy of logic through courses he taught at Middlesex University and lectures he delivered at conferences worldwide. This talk will briefly survey those contributions.

De Witt, Meghan *St Thomas Aquinas College*

Using Projects to Enrich and Expand in the Classroom

Themed Contributed Paper Sessions: TCPS 11B - Cultivating Critical Thinking through Active Learning in Mathematics

But why do I need to know this? When will I ever use this? Who cares? To address these common questions of students in a mathematics course we discuss various projects and enrichment activities designed to encourage students to not only use the mathematics they are learning in class but enjoy the experience. Projects range from quick assignments to semester long investigations and come from College Algebra, through Linear Algebra and Operations Research.

De Young, Gregg *The American University in Cairo*

Adelard's Euclid and the Arabic Transmission Attributed to al-Ḥajjāj

Themed Contributed Paper Sessions: TCPS 1N - History and Philosophy of Mathematics

Adelard of Bath created the earliest Latin version of the Elements in the first half of the twelfth century, translating from one or more Arabic manuscripts. The Latin text was edited by Busard, who suggested that Adelard had relied primarily on an Arabic manuscript containing features of the al-Ḥajjāj transmission because his translation differs in several significant ways from the translation made by Gerard of Cremona (whose characteristics reflect mainly the extant IsḤāq-Thābit Arabic transmission). In the three decades since Busard produced his edition, further studies of the Arabic transmission attributed to al-Ḥajjāj have appeared. Using evidence ranging from verbal quotations to diagram construction techniques ascribed to al-Ḥajjāj found in several primary and secondary Arabic transmission sources, we can now offer a more nuanced analysis of the Arabic source(s) upon which Adelard based his Latin translation. In doing so, we are able to situate Adelard's Latin translation more precisely within the convoluted landscape of the medieval Euclidean transmission.

DeBello, Joan *St. John's University*

Positive Female Role Models in Mathematics: The Importance, Influence, and Impact of Their Contributions in Attracting Females to Mathematics

Themed Contributed Paper Sessions: TCPS 2B - The Contributions of Women to Mathematics: 100 Years and Counting

This paper will discuss the many positive female role models in mathematics. It will discuss the importance, influence, and impact of introducing young girls to these positive role models to increase their interests in mathematics and their desire to pursue majors and careers related to mathematics. The paper will go through some of the most prominent women in mathematics and ways to introduce these women to the students from elementary school through college and beyond. It will discuss many of the programs created in honor of these prominent women to help inspire and attract young girls to mathematics, as well as the many scholarships and programs offered to help young women with their studies at the undergraduate level and beyond.

DeCesare, Richard *Southern Connecticut State University*

Robert Patterson: American 'Revolutionary' Mathematician

Themed Contributed Paper Sessions: TCPS 1G - History and Philosophy of Mathematics

Robert Patterson was an Irish-born mathematician who came to the United States just before the American Revolution, served in the war, and taught at the University of Pennsylvania. Among his other accomplishments, Patterson was elected President of the American Philosophical Society, appointed Director of the U.S. Mint, and carried on a long correspondence with Thomas Jefferson, before, during, and after Jefferson was president. Patterson's mathematical accomplishments, in the context of the Colonial Period in American history, will be illustrated with excerpts from his published works and his correspondence with Jefferson.

Del Valle, Sara *Los Alamos National Laboratory*

Global Disease Monitoring and Forecasting with Wikipedia

Invited Paper Sessions: MAA Invited Paper Session: Improving Access to Mathematical Modeling Research

Efforts to mitigate the impacts of infectious disease depend on accurate and timely monitoring to measure the risk and progress of disease. We examine a freely available, open data source for this use: access logs from Wikipedia. Using linear models, language as a proxy for location, and a systematic article selection procedure, we tested 14 location-disease combinations and demonstrate that these data feasibly support an approach that overcomes these challenges. Specifically, our proof-of-concept yields models with r^2 up to 0.92, forecasting value up to the 28 days tested, and several pairs of models similar enough to suggest that transferring models from one location to another without re-training is feasible. Based on these preliminary results, we close with a research agenda designed to produce a disease monitoring and forecasting system that is significantly more comprehensive than the current state of the art.

DeLegge, Anthony *Benedictine University*

Calculus for Life Sciences: A Two-Semester Calculus Sequence for Biology and Health Science Majors

Themed Contributed Paper Sessions: TCPS 19A - Innovative Approaches in the Calculus Sequence

At Benedictine University, our most and third most popular majors are health science and biology, respectively. As a result, a vast majority of students that take our first-semester calculus courses are one of these majors. This presents a challenge, as these students would likely benefit much more from a life science-centered approach to calculus as opposed to the traditional physics-based approach. Thus, Benedictine's math department created a two-semester calculus sequence, Calculus for Life Sciences I and II, targeted specifically for these students. This sequence maintains the rigor of the traditional calculus sequence, but changes the order and emphasis of topics to make the course more meaningful to life science majors. In this talk, I will discuss these changes as well as the benefits and challenges with teaching these courses.

Demaine, Erik *Massachusetts Institute of Technology*

MAA Centennial Lecture 1: Replicators, Transformers, and Robot Swarms: Science Fiction through Geometric Algorithms

Invited Addresses: MAA Centennial Lecture

Science fiction is a great inspiration for science. How can we build reconfigurable robots like Transformers or Terminator 2? How can we build Star Trek-style replicators that duplicate or mass-produce a given shape at the nano scale? How can we orchestrate the motion of a large swarm of robots? Recently we've been exploring possible answers to these questions through computational geometry, in the settings of reconfigurable robots (both modular and folding robots that can become any possible shape), robot swarms (which may be so small and simple that they have no identity), and self-assembly (building computers and replicators out of DNA tiles).

Denne, Elizabeth *Washington & Lee University*

Topology, Calculus and 3D Visualization

Themed Contributed Paper Sessions: TCPS 9 - What Can a Mathematician Do with a 3D Printer?

I will discuss how I used 3D printing to help students visualize mathematical objects in an Introduction to Topology course I taught. I'll also discuss how students have created models of objects typically seen in Calculus II and Multivariable Calculus courses.

Dent, Gelonia *Medgar Evers College*

To STEM or Not STEM

Invited Paper Sessions: Special Session: "Notes of a Native Son": The Legacy of Dr. Abdulalim A. Shabazz (1927-2014)

In an effort to increase the number of STEM degree recipients, populations of color are being targeted and tracked into the study of mathematics and science. What effect has this effort had on the quality of education and will future generations of mathematicians actually have the opportunities promised by the driving forces of STEM. Also, Dr. Shabazz's philosophy of "all students can learn mathematics", is this really true?

Devaney, Bob *Boston University*

1960–1979

Invited Paper Sessions: MAA Invited Paper Session: Generations of Monthly Gems

In this talk I will give a brief overview of the history of "chaos" in the area of mathematics known as dynamical systems. Chaos had been observed by many mathematicians, including Poincare in the late 19th century, Julia and Fatou in the 1920's, and Smale and Lorenz in the 1960's, though none of these mathematicians called the crazy things they were seeing "chaos." This changed dramatically when the pioneering article by Li and Yorke called Period Three Implies Chaos appeared in the *Monthly* in 1975. This very short article has had a major impact on the field of dynamical systems. First, it introduced the term "chaos,"; which had never been used before in science, and, suddenly, mathematicians (and other scientists) realized that this phenomenon was commonplace. Consequently, the area now known as "chaos theory" exploded. Second, it showed that even the iteration of a quadratic function on the real line

could be chaotic. And, finally, it proved a remarkable result that, if a continuous real function had a periodic point of period three, it necessarily had periodic points of all periods as well as a chaotic regime.

Dewar, Jacqueline *Loyola Marymount University*

A Well-Kept Secret: Women in Mathematics Education

Themed Contributed Paper Sessions: TCPS 2A - The Contributions of Women to Mathematics: 100 Years and Counting

Until recently, mathematicians rarely garnered anything approaching the public recognition that scientists commanded. Even asking calculus students to write the names of as many mathematicians as they can in one minute, results in short lists (Newton, Leibniz, Galileo, Euclid, Pythagoras), often with misspellings and inappropriate entries (Einstein). Rarely does the name of a woman mathematician appear (unless it is the instructor's name). Given the general lack of knowledge about people who did mathematics, it is not surprising that women who contributed to mathematics education during the second half of the 20th century are hardly recognized at all. This talk will celebrate the lives and accomplishments of three women in mathematics education: Ruth Afflack (California State University Long Beach), Natalie Ambrose (Immaculate Heart High School), and Teri Perl (The Learning Company). Each was an author of books or educational materials, an activist for significant causes both in and outside of mathematics, and a teacher of pre-college or college students. Each is a co-founder of one or more of the following: a company, a non-profit organization focused on encouraging women in mathematics, and a religious community. All were pioneers, leaders, and mentors to many, including the author of this paper. Many of their publications, materials, and products remain valuable and timely to this day. A bibliography will be provided.

Dichone, Bonni *Gonzaga University*
David Wollkind, *Washington State University*
Richard Cangelosi, *Gonzaga University*

A Model for Soil-Plant-Surface Water Relationships in Arid Flat Environments

General Contributed Paper Sessions: Interdisciplinary Topics in Mathematics and Modeling or Applications

An existing weakly nonlinear diffusive instability hexagonal planform analysis for an interaction-diffusion plant-surface water model system in an arid flat environment is extended by additionally performing a rhombic planform analysis. A threshold-dependent paradigm that differs from the usually employed implicit zero-threshold methodology is introduced to interpret stable rhombic patterns. The results are represented by closed-form plots in the rate of precipitation versus the specific rate of plant density loss parameter space. From those plots, regions corresponding to bare ground and vegetative Turing patterns consisting of tiger bush (parallel stripes and labyrinthine mazes), pearled bush (hexagonal gaps and rhombic pseudo-gaps), and homogeneous distributions of vegetation, respectively, are identified. Then that predicted sequence of stable states along a rainfall gradient is both compared with observational evidence and used to motivate an aridity classification scheme.

DiDomenico, Steve *Northwestern University Library*
Linda Newman, *University of Cincinnati Libraries*

The Quest for Digital Preservation: Will Part of Math History Be Gone Forever?

Themed Contributed Paper Sessions: TCPS 1N - History and Philosophy of Mathematics

Libraries, archives, and museums have traditionally preserved and provided access to many different kinds of physical materials, including books, papers, theses, faculty research notes, correspondence, and more. These items have been critical for researchers to have a full understanding of their fields of study as well as the history and context that surround the work. However, in recent years many of these equivalent materials only exist electronically on websites, laptops, private servers, and social media. These digital materials are currently very difficult to track, preserve, and make accessible. Future researchers may very well find a black hole of content: discovering early physical materials and late electronic records, but little information for the late 20th though early 21st Centuries. In other words, a portion of history, including the field of Mathematics, may be lost unless this electronic content–perhaps some content you have right now–is cared for properly. The presenters will cover the issues surrounding Digital Preservation, including steps needed to make sure data is reasonably safe. Additionally they will pose a small number of discrete challenges

and unsolved problems in the field of Digital Preservation, where Mathematicians may be able to help with analysis and new algorithms.

Dietz, Geoffrey *Gannon University*

A Trouble-some Simulation

Themed Contributed Paper Sessions: TCPS 5A - Recreational Mathematics: New Problems and New Solutions

The game Trouble, featuring the beloved "Pop-o-matic bubble," has been a kid favorite for decades. Unlike some other games aimed at younger children, Trouble gives choices to the players and includes interaction between the players. We investigate to what degree these choices impact the game, namely the winner of the game and the length of the game. Using a C++ program written to simulate the game, we present evidence that choices made (including where to sit relative to other players) can significantly improve (or lessen) one's probability of winning and can affect the average length of a game. A variety of possibilities for future work will also be given. Please note that "How to make a 5-year-old cry x% of the time" is not a subtitle of this talk and so all information should only be used for good and not for evil.

Dillon, Meighan *Kennesaw State University*

Five Things The Calculus Texts Leave Out and What We Can Do About It

Themed Contributed Paper Sessions: TCPS 19B - Innovative Approaches in the Calculus Sequence

This talk is about a few key ideas missing from the major calculus text books, starting with the premises upon which the subject is based, the discussion of which seems to be missing almost entirely from standard treatments. For example, the idea that a projectile moving in a line achieves maximum height when its velocity is zero is an assumption. When we bring this to their attention, students find that an exciting idea— maybe it's not true! Can we even know whether or not it's true?— but the books don't treat it this way. They proceed as though it's a fact, one that's part of common knowledge. Another example is the idea of what it means for a function of two variables to be differentiable. Many calculus texts side-step the question entirely, when it's a beautiful idea that can help students better understand what goes on in single variable calculus. The talk will discuss these and other examples of strange omissions from the books that we may do well to endeavor to include in our courses.

DiMarco, David *Neumann University*
Ryan Savitz, *Neumann University*
Fred Savitz, *Neumann University*

Stability — A New Way to compare Statistical Measures: Theory and Applications for Assessing Learner Achievement and Teaching Effectiveness

General Contributed Paper Sessions: Probability or Statistics

Assessment. Indeed, the watchword for institution of higher education accountability in the twenty-first century is assessment. Consequently, accumulating information for assessment purposes means large sets of data, necessitating applications of statistical measures. We wish to introduce a new concept that gives an indication of to what degree the value of a measure can be changed by altering one, or more, of the data values, whether or not they ultimately become outliers. This concept will be called "stability". It is known that some measures are vulnerable to excessive changes when data values around the center are altered, but the concept of stability quantifies this vulnerability, so the stability of different measures can be compared. Also it will be shown that stability deals with more than just this vulnerability, it also measures vulnerability to changes away from the center.

Donahue, Matthew *University of Tulsa*
Nick Cogan, *Florida State University*
Leonardo De La Fuente, *Auburn University*

Modeling the Effect of Biofilm Development within Plant Diseases

PosterFest 2015: A Poster Session of Scholarship by Early Career Mathematicians and Graduate Students

Despite multiple bacterial infections causing widespread damage to the citrus, wine, and other fruit industries, there has been little attention paid to modeling the development and progression of the structures formed by the bacteria within these diseases. A multiphase framework of partial differential equations will be used to examine the dynamic

behavior and fluid/structure interactions of the biological system. Perturbation analysis will be used to determine potential causes and tendencies of patterns developed by biofilm formed within microfluidic chambers. Further numerical studies will be used to investigate dynamics on a finite domain resembling the behavior of the system *in vitro* and *in planta*.

Donoghue, Eileen *City University of New York/CSI*

A Pair of Early MAA Presidents = A Pair of Mathematics Historians: Florian Cajori and David Eugene Smith

Themed Contributed Paper Sessions: TCPS 1B - History of Mathematics

In this centennial year, it should be noted that two early presidents of MAA, Florian Cajori (1917) and David Eugene Smith (1920), were influential historians of mathematics whose notable works are available in print today. This paper will discuss links between Cajori and Smith, including an exploration of their pioneering initiatives to survey the state of academic mathematics in late 19th century America. Cajori's wide-ranging survey solicited faculty responses from 168 universities and colleges, 45 normal schools (for teacher training), and 181 secondary schools. University respondents included Simon Newcomb at Johns Hopkins, Thomas Fiske at Columbia, and G. B. Halsted at Texas. Smith surveyed normal school students regarding their experiences in mathematics, including their attitudes toward and perceived success in the subject. He also analyzed thousands of examination results to determine what differences, if any, might be found between male and female performance in mathematics. Smith's and Cajori's initiatives offer a glimpse into what are often obscure arenas: mathematics classrooms in the late 19th century.

Dorée, Suzanne I. *Augsburg College*

Just Enough Algebra – Or How Teaching Interesting, Useful Algebra in Applied Contexts Incorporating Active Learning Led to Higher Student Engagement and Success

Themed Contributed Paper Sessions: TCPS 16 - Curriculum Development to Support First Year General Education Mathematics Students

We can improve developmental mathematics by making the content relevant and useful, implementing successful pedagogies, and reducing the number of courses required to prepare students for college level mathematics. Augsburg College has been part of this national effort for 21 years, successfully teaching a one semester Applied Algebra course that replaced Intro/Intermediate and some of College Algebra. On-going consultation with partner disciplines insures that students are ready for subsequent study of quantitative mathematics, statistics, science, economics, and business. Content focuses on linear and exponential models, aligning with AMATYC (Crossroads/Beyond) and MAA (CRAFTY Curriculum Foundation Project, College Algebra) recommendations. Every example, activity, homework, and exam question is set in an applied context connected to students' future studies, their everyday life, or their life as a citizen. In class, after seeing one introductory example, students actively collaborate to solve increasingly complicated problems. Augsburg's students are diverse in many ways, including students with learning disabilities, students of color, first-generation students, and returning adult students. Pass rates are over 85% and students succeed in subsequent courses at the same rate as their peers who tested out. In this talk, I will show a few examples from the course and identify key steps of the course redesign process that other colleges can use.

Duca, Alina *North Carolina State University*
Karen Keene, *North Carolina State University*

Calculus for Pre-Service Elementary Teachers

Themed Contributed Paper Sessions: TCPS 13 - Successful STEM Programs for Elementary Education Majors

Current reports strongly call for better preparation of science, technology, engineering, and mathematics (STEM) K-12 teachers as a way to create a STEM-literate population who can address many of the nation's problems. Developing a cadre of STEM-focused elementary teachers is one way to deal with the on-going demand to increase the STEM pipeline. The presenters will describe a two-semester course that has been developed to integrate the concepts of calculus (including derivative, limit, and integral) with some of the primary concepts (e.g. rational numbers, area, and perimeter) that future elementary teachers will need to know in their teaching career. After giving an overview of the course, the presenters will describe some class activities and discuss the importance of making connections among the various fields of mathematics at various levels in order to provide opportunities for the future teachers to develop a deep understanding of mathematics.

Dumbaugh, Della *University of Richmond*

Leonard Dickson's Other Doctoral Student from 1928

Themed Contributed Paper Sessions: TCPS 1M - Special Session in Honor of Karen Parshall

In 1928, Leonard Dickson's most celebrated student, A. Adrian Albert, earned his Ph.D. from the University of Chicago. Often recognized as Dickson's "best" student, Albert went on to become a professor at the University of Chicago and President of the American Mathematical Society. In that same year, Ko-Chuen Yang, Dickson's first—and only—Chinese student earned his Ph.D. with a dissertation on "Various Generalizations of Waring's Problem." This talk explores the content and critical importance of this dissertation.

Dunham, Douglas *University of Minnesota - Duluth*

Artistic Patterns on Triply Periodic Polyhedra

Themed Contributed Paper Sessions: TCPS 6A - Mathematics and Art

We have created repeating patterns on triply periodic polyhedra, unlike other artists, such as M.C. Escher who have created such patterns on closed polyhedra. Triply periodic polyhedra are connected polyhedra that repeat in three independent directions in Euclidean 3-space. We will consider triply periodic polyhedra that are composed of copies of a regular p-sided polygon, and have congruent vertex figures. If there are q such p-sided polygons around each vertex, we must have $(p-2)(q-2) > 4$ for the polyhedron to repeat in three dimensions. We call such a polyhedron a p, q polyhedron. Note that p and q do not determine the polyhedron. In fact we show two different $3, 8$ polyhedra. Some triply periodic polyhedra form polyhedral approximations to triply periodic minimal surfaces (TPMS). In turn, since TPMS's have negative curvature, their universal covering surfaces have the same large-scale geometry as the hyperbolic plane. Thus a repeating pattern on a triply periodic polyhedron will correspond to a repeating hyperbolic pattern, which we thus call the "universal covering pattern" of the patterned polyhedron. Our main focus will be to show triply periodic polyhedra decorated with repeating patterns. Some of these decorated polyhedra exhibit color symmetry, that is, symmetries of the polyhedra will induce color permutations on their patterns.

Dunmyre, Justin *Frostburg State University*

Reflections on a Flipped Classroom: Small Tweaks with Big Effects

PosterFest 2015: A Poster Session of Scholarship by Early Career Mathematicians and Graduate Students

It is often the case that educators lament that students do not read the textbook. This may be because as educators we realize that the students do not read the textbook; so we must lecture on that material. However, our students see that we lecture and realize that they do not have to read the textbook. Mathematics education leader David Pengelley called this "the lecture/textbook trap." Pengelley suggested a model that uses a style of flipped classroom to require students to read the textbook and come prepared for classroom discussion. For the last two years, I have employed the Pengelley flipped classroom model to create engaging classrooms. In this poster, I will discuss my implementation of the Pengelley model for my mathematics classrooms. This implementation has been well received by students of all levels, from introductory courses (Elementary Probability and Statistics, Precalculus, and Calculus) to advanced courses (e.g. Differential Equations and Nonlinear Dynamics). Over the last two years, I have applied tweaks that have made the model more successful for students of Frostburg State University. Anecdotal evidence suggests that my flipped classrooms have successfully created an environment with highly motivated students, and even the unmotivated students find themselves engaged for the majority of the class time.

Dunn, Scott *University of South Carolina*
Douglas B. Meade, *University of South Carolina*
Philip B. Yasskin, *Texas A&M University*

Goblet Design in Calculus II

Themed Contributed Paper Sessions: TCPS 9 - What Can a Mathematician Do with a 3D Printer?

The acquisition of a 3D printer in our departments is proving to be a wise investment. In this presentation we will describe ways in which access to a 3D printer has re-invigorated a long-standing project as well as provided instructors with access to manipulatives. While most uses are related to the volume of solids — either formed by rotation or with known cross-sections, we have also used the printer to prepare physical examples of fractals, including Koch

snowflakes, Menger cubes, and Sierpinski gaskets. We will also discuss some of the tools and techniques we have found most useful when preparing our own models for printing.

Duran, Pablo *The University of Texas at Austin*

The Use of Mathematics in Ecology, Evolution and Behavior

General Contributed Paper Sessions: Interdisciplinary Topics in Mathematics and Modeling or Applications

The results of a study on the mathematics in use in the area of ecology, evolution and behavior will be presented. This study consisted of a content analysis of peer-reviewed publications in the area. Samples of highly cited articles published during the last 15 years were analyzed. The analysis focused on identifying the main mathematical and statistical tools used, as well as the most common problems for which these tools were used. Implications of the results of the study on the development of the undergraduate biological sciences curriculum as it relates to mathematics will be briefly discussed.

Durig, Rebekah *Southern Illinois University*
Oneal Summers, *Southern Illinois University*
Gregory Budzban, *Southern Illinois University*

3-D Printing and Triply-Periodic Minimal Surfaces

Themed Contributed Paper Sessions: TCPS 9 - What Can a Mathematician Do with a 3D Printer?

Because of the increase in accessibility of 3D printing, students and researchers alike can easily print mathematical models, introducing new possibilities in the realms of research and education. We explore the use of 3D printing as a tool for investigating topics in undergraduate and graduate level mathematics. This is done through an examination of our work using 3D printing to investigate triply periodic minimal surfaces, as well as by considering some of the ways 3D printing could be useful when exploring extensions of our work to graduate level and research level mathematics. Additionally, our work includes introducing 3D printing in the classroom, both in advanced high school courses and in undergraduate classes, particularly those topics which rely on multivariable calculus and/or geometry. To this end we consider the use of 3D printing in clarifying traditional coursework in the classroom and as a medium through which students gain skills in mathematical programming in a purposeful, applied setting.

Dutta, Tarini *Gauhati University*

Bifurcations, Chaos and Fractal Dimensions in Population Models

General Contributed Paper Sessions: Interdisciplinary Topics in Mathematics and Modeling or Applications

This paper deals with some beautiful applications of nonlinear population models in Biosciences via bifurcations, chaos and fractal dimensions. In fact, the sole objectives are to carry out a detailed analysis of (i) Period- doubling bifurcations of the **Ricker population model**, where r is interpreted as an intrinsic growth rate and k as the carrying capacity of the environment. This model gives the expected number x_{t+1} (or density) of individuals in generation $t+1$ as a function of the number of individuals in the previous generation t. (ii) the Lyapunov exponent for confirming the occurrence of chaos (iii) the effect of chaos with the following concepts: (a) Coefficient of variation (b) Time series analysis (c) Immigration and (d) Emigration; (i) various fractal dimensions, namely, box-counting dimension, Hausdorff dimension, information dimension, correlation dimension, etc. Further, this paper also poses a few open problems in the field of Biosciences.

Dwelle, Kayla *Ouachita Baptist University*

Creative, Critical and Correct: Achieving Common Objectives in an Introductory Proofs Course

Themed Contributed Paper Sessions: TCPS 11A - Cultivating Critical Thinking through Active Learning in Mathematics

Many of us who teach an introductory proofs course have some common objectives. We wish to produce students who can think creatively to solve problems and prove theorems, who can critique their own and others' work, and who can accurately assess and communicate the truth of a mathematical statement. Possibly more than any other course common to mathematics majors, these objectives are best achieved through active learning. The goals of this talk are two-fold: (1) Discuss issues in implementing a Modified Moore Method in a beginning proofs course including

strategies for producing independent, enthusiastic learners and overcoming obstacles such as deficits in student "buy-in", confidence or persistence. (2) Assessing progress and gains in this type of course through pre- and post- tests, portfolios, and student feedback.

E

Edmonds, Brenda *Johnson County Community College*
Cathleen O'Neil, *Johnson County Community College*
Rob Grondahl, *Johnson County Community College*

A Voluminous Vessel

Themed Contributed Paper Sessions: TCPS 9 - What Can a Mathematician Do with a 3D Printer?

In 2006 Brenda Edmonds adapted (with permission) a project by Steve Kifowit of Prairie State College, Illinois, for second semester calculus students that employs finding surfaces and solids of revolution. Students create a drinking glass - the voluminous vessel - by rotating functions about an axis. There are constraints on the height, width, and thickness at the rim. The functions must be continuous and have non-constant derivatives, but students may be creative within these constraints. Students demonstrate their integration prowess by calculating the volume of the material needed, the volume of liquid the vessel will hold, and the surface area of the outside of the vessel. Edmonds developed a rubric for evaluating the project and envisioned producing a real version of the vessel. By 2013 Johnson County Community College had acquired a 3D printer, and Cathleen O'Neil followed Edmonds's lead by giving students the option to produce a stereolithographic file that could be printed. Working with Tom Hughes of the drafting department where the 3D printer resides, the first vessel was produced. Since then Rob Grondahl has continued the project with his Calculus II students, who use the RevolutionPlot3D function in Mathematica revolving a parametrization of their function to create their .stl file. Grondahl aids students by adding a ring to the rim and a disk to the base to create a solid 3D object. The math department now has four vessels in its gallery.

Edwards, Christine *National Security Agency*

Teaching Computers to See

Invited Paper Sessions: MAA Invited Paper Session: The Non-Traditional "Traditional NSA Mathematician"

The human brain is the ultimate computing machine. Its ability to identify objects and recognize events in images and videos is unparalleled by the most advanced, state-of-the-art computer vision algorithms. The field of Neurally Inspired Computing is a type of machine learning that seeks to model the human visual cortex to enable computers to not only see pixels as bits in a matrix, but to allow machines to go further and recognize objects within images and describe them in a way that is currently unique to humans. Computer vision algorithms that use the brain as a model, so-called neuro-mimetic algorithms, have been designed by mathematicians, statisticians, computer scientists, and engineers using the language of mathematics and statistics to emulate some of the brain's most fundamental processes. At their core they learn how best to represent the data, building up from low-level features to high-level concepts using numerical optimization techniques and statistical inference. In this talk I will give a brief description of some of state-of-the-art neurally inspired algorithms and show how Neurally Inspired Computing is changing the field of Computer Vision.

Edwards, Richard *Michigan State University*
Vince Melfi, *Michigan State University*
Dave Bramer, *Michigan State University*
Jeff Craig, *Michigan State University*
Andrew Krause, *Michigan State University*
Amanda Lorenz, *Michigan State University*

Design and Implementation of a Quantitative Literacy Course at a Large Research Institution

Themed Contributed Paper Sessions: TCPS 16 - Curriculum Development to Support First Year General Education Mathematics Students

This talk is a report on the process of designing and implementing two new mathematics courses at a Tier-1 research institution. Following up on an institutionally recognized need for alternatives to traditional College Algebra, a team

of faculty and graduate students built a two- course sequence around the concept of quantitative literacy. Each course consists of four modules with particular themes, such as "Health and Risk", "Numbers in the Natural World", and "Politics and Voting". The process of moving a course from initial conception to fruition took nearly two years. The talk will highlight various aspects of this process including: The initial need to offer more courses that fulfill the University core graduation requirement; Working with and obtaining the support of the Department of Mathematics, the College of Natural Sciences, and the University; Selecting an appropriate textbook; Designing the structure of the course; Writing new materials that connect mathematics with compelling contexts; Considering student-centered pedagogical approaches that can be implemented in a large-enrollment course; Designing appropriate assessments; Balancing creativity and logistics; Lessons learned from our mistakes; and a report of the (in progress) initial course pilot.

Edwards, Steven *Kennesaw State University*
William Griffiths, *Kennesaw State University*

A Bad But Fruitful Way To Count N Choose K

General Contributed Paper Sessions: Number Theory and Logic or Foundations

If n choose k is counted by adding bad choices and then correcting, a combinatorial identity results which provides a link between a sum of Fibonacci numbers and the figurate numbers for n-dimensional cross-polytopes

Effiong, Louis *Abia State Polytechnic, Aba, Nigeria*
Jonathan Imumolen Oahimire, *University of Port Harcourt, Port Harcourt, Nigeria*
James U. Okafor, *Abia State Polytechnic, Aba, Nigeria*

Heat and Mass Transfer in an Electrically Conducting Micropolar Fluid with Thermal Radiation and Heat Generation

PosterFest 2015: A Poster Session of Scholarship by Early Career Mathematicians and Graduate Students

Heat and mass transfer effects on unsteady flow of a micropolar fluid over an infinite moving permeable plate in a saturated porous medium in the presence of a transverse magnetic field are studied. The governing system of partial differential equations is transformed to dimensionless equations using dimensionless variables. The dimensionless equations are then solved analytically using perturbation technique to obtain expressions for velocity, microrotation, temperature and concentration. With the help of graphs, the effects of the various important parameters entering into the problem on the velocity, microrotation, temperature and concentration fields within the boundary layer are discussed. Also the effects of the pertinent parameters on the skin friction coefficient and rates of heat and mass transfer in terms of the Nusselt number and Sherwood numbers are presented numerically in tabular forms. The results shows that the observed parameters have significance influence on the flow, heat and mass transfer.

Eisenberg, Michael *University of Colorado*
Hilary Peddicord, *National Oceanic and Atmospheric Administration*
Sherry Hsi, *Lawrence Hall of Science, Berkeley*

Math on a Sphere: an Interactive Programming System for Spherical Geometry

Themed Contributed Paper Sessions: TCPS 21 - Show Me Geometry: Geometry Software and Tablet Demonstrations

This demonstration will present Math on a Sphere (MoS), an interactive programming system for exploring and understanding spherical geometry. The basic idea behind MoS is that it permits users to create geometric patterns on a representation of a sphere in much the same fashion as the interactive "turtle" in the well-known Logo and Scratch languages. In MoS, the spherical turtle-a programmable pen-can be given commands to move forward or back along the arc of a great circle and to turn right or left, in addition to many other graphical commands (e.g., for changing the color or the width of drawn lines). MoS is freely available over the Web (see the site mathsphere.org) and its website is accompanied by introductory materials for understanding the language and exploring basic preliminary ideas of spherical geometry. To date, we have used the system in several museum workshops (at the Lawrence Hall of Science, Berkeley CA) and to introduce spherical geometry to middle school students in Boulder, CO. This demonstration will illustrate the rich mathematical (and aesthetic) capabilities of MoS. We will demonstrate how the system can be used to explore spherical triangles: the dependence of their interior angle total on area, and the (spherical) Law of Sines.

We will present simple programs to generate the projection of the five Platonic solids on the surface of the sphere; and will use the system to explore predator-prey curves and spirals when realized on the sphere.

El Turkey, Houssein *University of New Haven*
Gulden Karakok, *University of Northern Colorado*
Milos Savic, *University of Oklahoma*
Gail Tang, *University of La Verne*
Emilie Naccarato, *University of Northern Colorado*

Discussing Mathematical Creativity at the Undergraduate Level

Themed Contributed Paper Sessions: TCPS 11B - Cultivating Critical Thinking through Active Learning in Mathematics

Critical and creative thinking are two important aspects of professional mathematicians' work. Hence, one of the goals of an introductory proof-based course should be to guide students on how to self-monitor when attempting to prove a mathematical statement. In-class discussions of techniques that students can use to self-evaluate their proving processes could promote their critical thinking and mathematical creativity. There are many studies on exploring students' creativity at the primary and secondary levels (e.g. Silver, 1997) but there is far less research in mathematical creativity in undergraduate mathematics. Our research group attempts to address this particular need by exploring ways in which students can be encouraged to self-direct during the proof construction process. We have conducted several studies and used the results to develop a formative assessment tool for proof-based undergraduate courses, named the Creativity-in-Progress Rubric (CPR) on Proving. The CPR on Proving is aimed to help students self-reflect on their proof attempts by Making Connections and Taking Risks. We conjecture students in proof-based classes could be encouraged to make connections to various definitions, theorems, examples, or representations. They could also be encouraged to take risks when attempting a proof through flexible thinking about different proof approaches, utilizing different tools and tricks, persevering in their work, posing questions, and by evaluating their work. In this presentation we will describe the CPR on Proving, share the ways in which we implemented it in an introductory proof course, and provide some in-class implementation suggestions.

El-Zanati, Saad *Illinois State University*
Sabrina Allen, *Illinois State University*
Maggie Kopp, *Illinois State University*
Mike Plantholt, *Illinois State University*
Shailesh Tipnis, *Illinois State University*

On Decomposing Regular Graphs and Multigraphs into Forests

General Contributed Paper Sessions: Graph Theory

Let G be a forest with n edges. We conjecture that G necessarily decomposes every $2n$-regular graph and every n-regular bipartite graph. We confirm these conjectures in the case when G consists of at most two stars.

Elkies, Noam *Harvard University*

G-sharp, A-flat, and the Euclidean Algorithm

Invited Addresses: Pi Mu Epsilon J. Sutherland Frame Lecture

Why does Western music almost universally use the same repeating pattern of $7 + 5$ notes seen in the piano's white and black keys, and why does each of these notes (especially the black ones, like G-sharp / A-flat) get more than one name? Using a piano, the audience's voices, and more traditional lecture materials, I'll outline how music, physics, and mathematics converged to produce this structure, including an overlap between one thread of music history and the first few steps of the Euclidean algorithm applied to the logarithms of 2 and 3.

Emmens, Howard *BSHM*

The Life and Letters of William Burnside

Themed Contributed Paper Sessions: TCPS 1R - History of Mathematics

William Burnside (1852–1927) is remembered today primarily as a group theorist. The changes between the 1897 and 1911 editions of his book Theory of Groups of Finite Order show how far the subject developed during that period

and the extent of Burnside's own contributions. He came to group theory in mid-career; it was not his first area of interest, nor his last: his published papers (almost two hundred of them) also include other contributions in algebra and in analysis and geometry. His early work was in applied mathematics, which he taught throughout his career, spent mainly as a professor at the Royal Naval College. Perhaps to compensate for his relative academic isolation there he was an active member and for two years president of the London Mathematical Society. In retirement he became interested in statistics, writing a textbook on probability (published posthumously - his only book apart from the two editions of his group theory text) and corresponding with the statistician R A Fisher. A series of twenty-three letters to Fisher forms a significant part of his known surviving correspondence: only about fifty other items are known, mostly isolated letters to H F Baker or to Joseph Larmor (mainly on mathematical problems but some to do with university appointments), but there are indications in these and elsewhere that he may have been a more prolific correspondent than this paucity suggests. If other letters to or from Burnside could be found they could help to illuminate the development of his mathematical thought.

Eng, Genghmun

Perfect Heptagons and 13-Sided Triskaidecagons

General Contributed Paper Sessions: Geometry

Constructing the regular heptagon and triskaidecagon are impossible by compass and straight edge alone. Both require an angle trisector, which is usually not included in the construction, making them incomplete. A complete construction is developed for both, using an unmarked X-Y coordinate system and any square hyperbola H form Y=C/X, to enable integrating trisections into the construction. The special trisection relationship needed for both cases was derived by A. M. Gleason [Amer. Math. Monthly 95(3), 1988] using cyclotomic polynomial analysis: $6\cos(2\pi/7) = -1 + [\cos(\theta)/\cos(3\theta)]$, $\cos(3\theta) \equiv 1/(2\sqrt{7})$; $12\cos(2\pi/13) = (\sqrt{13}-1) + (7-\sqrt{13})[\cos(\theta)/\cos(3\theta)]$, $\tan(3\theta) \equiv \sqrt{3}(\sqrt{13}+1)/(7-\sqrt{13})$. We show that both of these formulas can be accommodated using a similar construction technique. The construction proofs, and motivation for how a square hyperbola naturally arises, provide nice examples of combining constructive geometry and elementary trigonometry.

Ensley, Doug *Shippensburg University*
Lea Adams, *Shippensburg University*
Barbara Kaskosz, *University of Rhode Island*

Assessing the Effects of Interactive Technology on Concept Retention in Precalculus

Themed Contributed Paper Sessions: TCPS 10 - The Scholarship of Teaching and Learning in Collegiate Mathematics

'Mobile Math Apps' is an NSF DUE project focused on creating smartphone-based, interactive applications for learning precalculus-level mathematics and assessing the impact on student learning from these applications. The team of investigators includes two mathematicians and a psychologist collaborating on interface development, mathematics pedagogy, and assessment. The assessment plan for this grant has been multi-faceted and modified with each step (and misstep) since the assessment phase started in Fall 2012. The three primary research questions are, (a) Will there be increased level of activity with technology that is implemented on a smartphone? (b) Are there any differences in concept mastery among students who use a smartphone app compared to students who do not? and (c) Are there differences in concept retention among students who use a smartphone app compared to students who do not? This presentation will focus on some failed attempts to answer the first two of these questions, but we will present results from the sound methodology used to address the third question. We believe this methodology includes sufficient randomization and ease-of-implementation that it will be adaptable to other studies where the effect of single type of teaching intervention is to be measured.

Eyster, Tamara *Kaplan University*
Lea Rosenberry, *Kaplan University*

Audio, Documents, and Screens, Oh My! Free and Easy Online Collaboration

General Contributed Paper Sessions: Mathematics and Technology

Online collaboration tools allow faculty to work with students and peers remotely. Whether you are teaching an online class or helping a student outside of class, free and easy tools are available which include whiteboards, screen and document sharing, and audio/video capabilities. Several options will be examined and compared, including Realtime

Board, Google Hangouts, Twiddla, and join.me. Each of the tools can be used to demonstrate problem solving, conduct brainstorming activities, work collaboratively on projects, and student demonstrations. Other important benefits for students include increasing instructor presence by enhancing the connections between instructors and students, providing a means for live interactions, and allowing for immediate communication which can reduce stress and misunderstanding.

Ezroni, Shylee *Wentworth Institute Of Technology*
Ely Biggs, *Wentworth Institute Of Technology*
Jack Reff, *Wentworth Institute Of Technology*

Tomographic Image Processing

General Contributed Paper Sessions: Interdisciplinary Topics in Mathematics and Modeling or Applications

Nearly 70,000 people every year will be diagnosed with a brain tumor. Brain tumors are very dangerous and it is important to know the size of them so they can be dealt with. The goal of this project is to use brain scan images that contain a tumor within them, and extract the volume of the tumor from the images. We took a number of 2-dimensional "slices" of a healthy human brain and constructed a 3-dimensional figure using functions that were coded in Matlab. Our functions calculate the centroid of each figure within the slices, then the area of the figure and then, after finding this information for all of the slices, the approximate volume of the figure. After applying our functions to all of our slices we calculated the volume of our brain to be approximately 75691 mm^3. Our future work includes writing a function that would detect a smaller figure (a tumor) within the figure in the slice and apply our functions to that.

F

Falconer, Isobel *University of St Andrews*

J. D. Forbes and the Development of Curve Plotting

Themed Contributed Paper Sessions: TCPS 1P - History and Philosophy of Mathematics

When, in 2012, experimental evidence for the Higgs boson was announced, it came in the form of a curve with a blip, immediately understood by the audience. Yet 190 years earlier, in 1823, the practice of curve plotting was so unusual that S. H. Christie felt it necessary to explain not only the meaning of the curve for magnetic variation that he presented in the Philosophical Transactions but also the process of defining the axes, representing the data as dots, and drawing the curve. The development of curve plotting as a technique for relating observational data to mathematized theory appears to have been surprisingly difficult. Early promoters, such as Lambert, were not followed, and not until the 1830s did the method start to spread, following the work of Playfair and Quetelet in statistics, and Herschel and Forbes in natural philosophy (Beniger & Robyn 1978; Hankins, 1999; Tilling 1975). Tilling identifies a step change in the ubiquity of curve plotting among scientists, initiated by J.D. Forbes, Professor of Natural Philosophy at Edinburgh 1833-1859. Beginning in 1834, he used curves both to present and to analyse observational results relating to heat, meteorology, and glacial flow. Based on an investigation of Forbes' notebooks, this paper discusses the role of curve plotting in Forbes' science, his practices in plotting, and the influences on his use of curves. The investigation gives new insights into why the development of curve plotting may have been so difficult, and why, finally, it took off in the 1830s. References Beniger, J., & D.Robyn. 'Quantitative Graphics in Statistics'. Am. Statistician 32 (1978) 1-11 Hankins, T. 'Blood, Dirt, and Nomograms'. Isis 90 (1999) 50-80 Tilling, L. 'Early Experimental Graphs'. BJHS 8, (1975) 193-2

Farrington, Eleanor *Massachusetts Maritime Academy*

Parametric Equations at the Circus: Trochoids and Poi Flowers

Themed Contributed Paper Sessions: TCPS 6A - Mathematics and Art

Poi spinning is a performance art, related to juggling, where weights on the ends of short chains are swung to make interesting patterns. We study a certain class of moves for poi where the patterns created are centered trochoids. Like all curves in the cycloid family, they are best expressed using parametric equations. Using the calculus of the curves, we find that there are just a few places where one pattern can be smoothly transformed into another.

Fasanelli, Florence *MAA*

History of Mathematics in Washington, DC

Themed Contributed Paper Sessions: TCPS 1A - History of Mathematics

Known for its inside-the-beltway politics, Washington DC, has also been the place for mathematical achievements including the invention of tabulating machines by Herman Hollerith resulting in the organization of IBM; the demonstration of the Morse Code in 1844 by the artist whose painting of the House Chamber was used to restore the building in 1958; the astronomical work of the first Black man of science resulting in the somewhat square layout of the city; and the only observatory in the United States where fundamental positions of the sun, moon, planets, and stars are continuously determined in a building formerly staffed by the U. S. Navy Corps of Professors of Mathematics. The people, the institutions established in the Federal City and the mathematics will be explored.

Feldman, William *University of Arkansas*

Non-Linear Operators Satisfying Orthogonality Properties

General Contributed Paper Sessions: Analysis and Other

For various spaces of continuous functions, operators which may not be linear from functions on X to functions on Y are considered. An operator T will be classified as *locally determined* if for each $y \in Y$, there is a corresponding $x \in X$ so that if if $f = g$ on any neighborhood of x, then $Tf(y) = Tg(y)$ and T will be classified as *point-wise determined* if $f(x) = g(x)$ implies $Tf(y) = Tg(y)$. Various characterizations of these operators are provided. For the special case of functions corresponding to Dedekind complete Banach lattices and consequently extremally disconnected spaces X, it is shown that T is locally determined if and only if T is finitely disjointness preserving and orthogonally additive. For the point-wise determined operators the characterizations then relates to analogs of a weighted composition operators, i.e., $Tf(y)$ is a function of $f(x)$. Consequences for bijections are considered which then relate to Hilbert space effects.

Fital-Akelbek, Sandra *Weber State University*

One of the Most Significant Woman in Matrix Theory - Olga Taussky-Todd

Themed Contributed Paper Sessions: TCPS 2A - The Contributions of Women to Mathematics: 100 Years and Counting

Olga Taussky -Todd, the torchbearer for matrix theory, is one of the most significant woman in the field of matrices. She wrote numerous research papers in the areas of algebraic number theory, integral matrices, and matrices in algebra and analysis. She received several honors and, at that time, she was one of the few women holding a mathematics research and a faculty position at a higher institution. In this talk, we present her most significant contributions to mathematics and some highlights of her life.

Flapan, Erica *Pomona College*

Topological Symmetries of Molecules

Invited Paper Sessions: MAA Invited Paper Session: Algebraic Structures Motivated by Knot Theory

Chemists have defined the *point group* of a molecule as the group of rigid symmetries of its molecular graph in $\mathbb{R}^3$. While this group is useful for analyzing the symmetries of rigid molecules, it does not include all of the symmetries of molecules which are flexible or can rotate around one or more bonds. To study the symmetries of such molecules, we define the *topological symmetry group* of a graph embedded in $\mathbb{R}^3$ to be the subgroup of the automorphism group of the abstract graph that is induced by homeomorphisms of $\mathbb{R}^3$. This group gives us a way to understand not only the symmetries of non-rigid molecular graphs, but the symmetries of any graph embedded in $\mathbb{R}^3$. The study of such symmetries is a natural extension of the study of symmetries of knots. In this talk we will present a survey of results about the topological symmetry group and how it can play a role in analyzing the symmetries of non-rigid molecules.

Flowers, Timothy *Indiana University of Pennsylvania*
Shannon R. Lockard, *Bridgewater State University*

Bijections between Hyper m-ary Partitions

General Contributed Paper Sessions: Number Theory and Logic or Foundations

Hyper m-ary partitions are integer partitions whose parts are powers of m and where each part appears at most m

times. In this talk, we will show bijections between partitions with different values of m. These lead to interesting identities for the hyper m-ary partition function, $h_m(n)$.

Ford, Pari *University of Nebraska at Kearney*
Amy Nebesniak, *University of Nebraska at Kearney*

How to Hook Pre-Service Teachers on Professional Development
General Contributed Paper Sessions: Mentoring and Outreach

Learning to be an effective math teacher doesn't stop at graduation. We will discuss how we organized a pre-service math teachers' conference as a way to introduce our students to the importance of lifelong learning. Participants will learn how professional growth can be taught in an undergraduate education program. We will discuss how a pre-service teachers conference helped students realize that membership in a professional organization, such as the National Council for Teachers of Mathematics and the Mathematics Association of America, and attendance at math education conferences are key to being an effective teacher. Participants will gain insight into our strategies for recruiting quality presenters and how to engage students throughout the day. Participants will engage in dialogue focusing on how pre-service teachers are taught the role of professional development. We will encourage participants to think about how introducing undergraduates to subject-specific educational conferences could positively impact their future involvement as early career teachers. Participants will gain understanding about why we decided to organize a math education conference for our pre-service teachers and details about how it became a community event. Student reactions to the conference and their thoughts on future professional development based on the experience are enlightening!

Fowler, Kathleen R. *Clarkson University*

Mathematical Modeling Experiences in Secondary Schools
Invited Paper Sessions: MAA Invited Paper Session: Improving Access to Mathematical Modeling Research

In the past years math modeling has been recognized as a necessary practice for students to maintain interest in STEM disciplines and build skills to succeed in school, college, and beyond. Math modeling hones problem-solving skills, fosters creativity and collaborations, and brings relevance to mathematics. We discuss initiatives at the national and local levels that support incorporating math modeling into the secondary school curriculum. We describe successful implementations on varying scales as examples for best practices.

Fowler, Katie *Clarkson University*
Leah Granger, *Clarkson University*

AWM at Clarkson University
PosterFest 2015: Highlights from AWM Student Chapters

Clarkson's AWM student chapter has been informally known as the 'math club' since 2004. Meetings are open to all students regardless of gender and activities are often developed in collaboration with our SIAM Student Chapter and Pi Mu Epsilon. Meetings and activities expose students to the world of professional mathematics, help students obtain information about graduate school and careers, and develop leadership skills through service to the university and local community. Events included peer tutoring for the freshmen gateway exams in Calculus, grading for the national MATHCOUNTS competition, sponsoring industrial and academic speakers, running activities at the local Pi Day Celebration (roughly 300 local middle and high school students and teachers attending and 40+ volunteers) and the Annual Undergraduate Research Symposium in Mathematics Dessert Reception held each Fall.

Frenzen, C.L. *Naval Postgraduate School*

Algebra, Analysis, and Geometry in the Solution of the Basel Problem
General Contributed Paper Sessions: Analysis and Other

A solution to the Basel Problem is given that uses the integral from 0 to π of $\log M(e^{ix})$ to represent the Basel series, where M is a Möbius transformation. The form of the integrand allows one to use algebra, (complex) analysis, and geometry (of a rhombus) to present three short, rigorous solutions of the Basel Problem. We also compare our solution to several similar methods of solution for the Basel Problem.

Fuchs, Elena *University of Illinois Urbana-Champaign*

Dynamics of Apollonian Circle Packings
Invited Paper Sessions: AMS-MAA Invited Paper Session: The Arithmetic of the Spheres

Several years ago, Dan Romik constructed a dynamical system on the unit circle which allowed to prove various interesting theorems about Pythagorean triples. In this talk, we discuss a similar construction in a higher dimensional setting which yields results about Apollonian packings. This is joint work with Sneha Chaubey.

Fuchs, Shay *University of Toronto Mississauga*

Teaching with Your Mouth Shut - Inquiry Based Learning in Upper Level Mathematics Courses
Themed Contributed Paper Sessions: TCPS 11B - Cultivating Critical Thinking through Active Learning in Mathematics

In the Fall of 2010 and 2011 I taught an Introduction to Topology course at the University of Toronto Mississauga. The course was taught using the traditional lecture approach. Although I enjoyed delivering the lectures, students were extremely passive, and performed poorly on tests and exams. In 2012, I have decided to re-design the course and deliver it as an IBL (Inquiry Based Learning) course. I hardly lectured, and instead, most of class time was devoted to students' presentations, followed by class discussions. I have continued to use this method in 2013 and 2014. The students reacted very positively to this new approach. They became active and excited about the material, and performed well on tests and exams. Almost all students mentioned on the course evaluations how they prefer this method over traditional lectures. Inquiry Based Learning in Mathematics is based on a wide body of research and has a long track record of success. In this talk I will explain how I run my topology course, and the benefits of Inquiry Based Learning.

Fuhrman, Kseniya *Milwaukee School of Engineering*
Cynthia Farthing, *University of Iowa*

Teaching Linear Independence with Process Oriented Guided Inquiry Learning (POGIL)
General Contributed Paper Sessions: Teaching or Learning Advanced Mathematics

In this talk we will present an in-class Linear Algebra POGIL activity designed according to guidelines from an MAA PREP POGIL workshop. Using a series of questions and class discussions the students were able to construct a definition of Linear Independence and apply it to problems. Students developed content knowledge through a learning cycle structure of Exploration, Concept Invention/Term Introduction, and Application. We will present the lesson plan and analyze student work. We will address the effectiveness of this activity and discuss the benefits and challenges of this approach.

Funkhouser, Charles *California State University Fullerton*
Miles R. Pfahl, *Turtle Mountain Community College*
Harriet Edwards, *California State University Fullerton*

Native American-based Mathematics Materials for Undergraduate Courses
General Contributed Paper Sessions: Mentoring and Outreach

This project has developed and researched undergraduate mathematics materials based in the culture and mathematics of Native American Peoples for integration into undergraduate courses. Mathematics topics include probability and statistics, number theory, transformational geometry, calculus, and pre-service elementary and secondary education-related content. These materials–both paper and electronic–are classroom ready, and are developed and piloted in consultation with Tribes in the Rocky Mountains, the Plains, the Pacific Northwest, and the Southwest. This work is an NSF DUE TUES Type 2 funded project.

G

Gaines, Benjamin *Iona College*

(0,2)-Deformations and the Hilbert Scheme
PosterFest 2015: A Poster Session of Scholarship by Early Career Mathematicians and Graduate Students

String Theory and Mathematical Physics have inspired a number of interesting questions in Algebraic Geometry. In particular, there are predictions about the relationship between a Calabi-Yau threefold, of the form $\mathbb{C}^3/\mathbb{Z}_p$, and its

crepant resolutions. We find there is a lower bound on the number of deformations that exist for the tangent bundle of any crepant resolution, and this lower bound can be found by a combinatorial count of $(0,2)$-deformations for $N = (2,2)$ conformal field theories on the orbifold. We also show that this lower bound is achieved when the resolution used is the G-Hilbert scheme, and that in general this minimum is not achieved. We expect the discrepancy to be explained by worldsheet instanton corrections coming from rational curves in the orbifold resolution.

Gallian, Joseph *University of Minnesota Duluth*

Seventy-Five Years of MAA Mathematics Competitions

Invited Addresses: MAA Chan Stanek Lecture for Students

In this talk we provide facts, statistics, oddities, curiosities, videos, and trivia questions about the mathematics competitions that the MAA has sponsored for 75 years.

Galluzzo, Benjamin *Shippensburg University*

Day One Modeling Discussions

Themed Contributed Paper Sessions: TCPS 18 - Using Modeling for Teaching Differential Equations: Before, During, After

Dynamic real world processes can often be described through the language of differential equations. In this talk, we will discuss an early in the semester activity that invites students to explore the mathematical meaning of everyday descriptions of real world phenomena. By encouraging seemingly "math-free" engagement on day one, in conjunction with a discussion of qualitative properties of solutions, many students develop confidence in their ability to build mathematical models in the context of differential equations.

Gan, Xiao-Xiong *Morgan State University*

Composition of Formal Laurent Series

General Contributed Paper Sessions: Analysis and Other

Composition of Formal Laurent Series Xiao-Xiong Gan Department of Mathematics, Morgan State University, Baltimore, MD 21251 Abstract The space of formal Laurent series was invented around 3 years ago. This space is endowed with all operations which are endowed in the space of formal power series including linear operation, Cauchy product and composition. Composition is a significant character of the space of formal power series. We introduce the composition of a formal Laurent series with a formal power series over complex field C.

Garcia, Stephan *Pomona College*

The Graphic Nature of Gaussian Periods

General Contributed Paper Sessions: Number Theory and Logic or Foundations

At the age of eighteen, Gauss established the constructibility of the 17-gon, a result that had eluded mathematicians for two millennia. At the heart of his argument was a keen study of certain sums of complex exponentials, known now as *Gaussian periods*. It turns out that these classical objects, when viewed appropriately, exhibit dazzling array of visual patterns of great complexity and remarkable subtlety. (Joint work with Bill Duke, Trevor Hyde, and Bob Lutz).

Garciadiego, Alejandro *UNAM*

Vera on the Foundations of Mathematics

Themed Contributed Paper Sessions: TCPS 1G - History and Philosophy of Mathematics

Francisco Vera (1888–1967) lived, subsequently, in France, Dominican Republic, Colombia and Argentina in his attempt to elude Franco's dictatorial regime. He is, perhaps, one of the most prolific authors of mathematical literature in Spanish language, at least of the XXth century. He wrote more than fifty books, some of them multivolume items, covering a wide spectrum of themes. His production includes elementary textbooks, biographies, dictionaries, general treatises on the history mathematics, as well as others discussing the evolution of some of its specific branches. He also wrote on science, music, religion and, even, fiction. A polyglot character, he translated into Spanish works by Apollonius, Archimedes, Eudemus, Euclid, Hippocrates, Pappus, Proclus, Pythagoras, among many others. He published an advance textbook on theory of sets at the time some of the Latin-American mathematical communities first

emerged. On this occasion, our goal is to examine his thoughts on the foundation of mathematics, spread over several of his works that were extremely original and influential among his peers.

Garner, Mary *Gateway Community Math Center*
Virginia Watson, *Gateway Community Math Center*

Abbot and Costello Numbers

Themed Contributed Paper Sessions: TCPS 3 - Math Circle Problems Involving the Number 100 in Honor of the MAA's 100th Anniversary

The comedy team of Abbott and Costello were famous for a skit in which Costello proves that 7 x 13 equals 28. A Math Circle we led began with the skit and then explored the question "What other three numbers would work in the same way?" We applied some algebra, did some guess and check, played around, and then systematically came up with a list of numbers (less than 100) for which the routine would work. We discussed how we knew there could be no other numbers. We asked if we could extend the algorithm to numbers bigger than 100. This is a simple and fun activity that is accessible to younger students.

Garron, Alexander *Sand Box Geometry LLC*

Plane Geometry Construction of Gravity Field Mechanical Energy Curves

General Contributed Paper Sessions: Geometry

I have always been interested in utility of plane geometry to construct a standard model of gravity field mechanical energy curves. To do so I invented a **Curved Space Division Assembly**, acronym **CSDA**. A plane geometry construction combining two elementary curves, the unit circle and unit parabola.I use these two elementary curves, the unit circle and unit parabola, to get beyond problematic, difficult, square space math analytics we currently use to study and explore the effected space of a gravity central force field.These two curves, the circle and parabola, primary characteristic would be their ability to mirror a property of SAMENESS. Every parabola has sameness; long and thin, short and stout; as every circle has sameness, big or small; the difference? One curve is open, the other closed, and the most significant property? Both can be constructed with the same point. They work together doing with curves the math of square space.In this paper, I develop field analytics using two gravity field space and time squares, one for Constant Acceleration and one for Changing Acceleration, using Computer Algebra System technology. We will invoke the square of antiquity, conduct a single change on the work horse diagonals of Pythagoras to surmise the g-field space and time square for our 21st Century pursuit to understand and analyze mechanical energy curves of central force gravity field energy curves.

Gehrtz, Jessica *Colorado State University*
Mary E. Pilgrim, *Colorado State University*

RAMScholars: Increasing Student Engagement in Learning Calculus Through PBL, Oral Assessments, and Writing

Themed Contributed Paper Sessions: TCPS 11A - Cultivating Critical Thinking through Active Learning in Mathematics

Evidence-based research in education supports the use of classroom methods that encourage student engagement in learning. Providing an environment that prompts students to analyze their own learning promotes the development of metacognitive skills, and has been shown to enhance learning. This is particularly important in mathematics courses, since a robust understanding of mathematics underpins success in other STEM disciplines, and is therefore essential for supporting increased persistence in STEM fields. Regrettably, mathematics courses are often taught in traditional, non-engaging, teacher-centered ways, especially at large institutions where many thousands of students enroll in these courses each year. To address this problem, we have designed a model that incorporates problem-based learning, oral assessments, and writing as active teaching and learning strategies in the calculus classroom. Preliminary results indicate that students who participate in such activities perform better on both procedural and conceptual exam questions. We will present our framework for instruction, sample activities, sample student responses, and preliminary data. We will also discuss future plans to implement our strategies on a larger scale.

Gerstle, Kevin *University of Iowa*

Hopf Algebras: Linear Algebra in Action

Graduate Student Session: Great Talks for a General Audience: Coached Presentations by Graduate Students, Part B

A primary goal of mathematics is to create tools that can be used to describe events found in nature. Vector spaces are commonly used algebraic tools to describe such natural phenomena. Hopf algebras consist of vector spaces with additional operations including vector multiplication. These additional operations allow Hopf algebras to be used to describe more detailed phenomena in a wide variety of settings such as quantum physics. A common way to study these Hopf algebras are to look at their actions using the language of mathematical representations. These representations allow us to "represent" elements and intricate computations from these structures using elementary linear algebra. Representations in turn precisely describe how Hopf algebras act on other mathematical objects such as, for instance, how a set of mathematical reflections and rotations can act on a square to produce all of its symmetries. We examine representations of Hopf algebras whose representations are particularly computationally nice to work with, showing that these representations in fact behave like integer polynomials which can be added and multiplied in a very concrete way.

Gholizadeh Hamidi, Samaneh *Brigham Young University*

Famous Mathematicians from Iran but Whom You May Not Know

Themed Contributed Paper Sessions: TCPS 1N - History and Philosophy of Mathematics

Iranians have made several significant contributions to mathematics. However, both Iranians mathematicians and their contributions are not well known in the U.S. In this talk, we will present some of these contributions including the Persian Mathematician and Father of Modern Algebra, Muhammad ibn-Musa Al-Khwarizmi; the Persian Mathematician and Poet, Omar Khayyam; and the Persian Mathematician Nasir al-Din Tusi who formulated the famous law of sines.

Ghosh Hajra, Sayonita *University of Utah*
Abeer Hasan, *Humboldt State University*

Integrating Oral Presentations in Mathematics Content Courses for Pre-service Teachers

PosterFest 2015: A Poster Session of Scholarship by Early Career Mathematicians and Graduate Students

One of the important features in mathematics teaching and learning is to develop students' mathematical vocabulary and communication skills. Here, we report on the study of assessment based oral presentation tasks in a mathematics content course for pre-service teachers at a public University in the west coast. Here, we describe the oral presentation tasks and report our findings on pre-service teachers' general perceptions and attitudes toward the use of oral presentation tasks in their mathematical learning and towards teacher preparation.

Ghrist, Michelle *United States Air Force Academy*

Two Differential Equations Projects to Help Students Apply and Synthesize Mathematics

Themed Contributed Paper Sessions: TCPS 18 - Using Modeling for Teaching Differential Equations: Before, During, After

Through the use of well-crafted projects, we can help students synthesize many disparate topics while seeing interesting applications of the math that they are learning. In this talk, I discuss two projects that I wrote for our Engineering Math course that can be used for either the "after" or the "during" time period. The first project helped students apply their knowledge of systems of ordinary differential equations by exploring the SIR disease model. The second project asked students to examine two partial differential equations on a ring and cylindrical shell. Through these projects, students practiced modeling real-life phenomena and experienced a glimpse into the applied mathematics experience: applying a variety of techniques (analytic, qualitative, and numerical) and then attempting to synthesize the various results.

Gibbons, Courtney *Hamilton College*

The Search for Indecomposable Modules

Invited Paper Sessions: MAA Invited Paper Session: Concrete Computations in Algebra and Algebraic Geometry

Short Gorenstein rings have many properties that make them interesting and easy to work with. For instance, they are finite dimensional vector spaces, and so are their finitely generated modules. In this talk, I will discuss how finding the

answer to a simple question about indecomposable modules over a short Gorenstein ring led through very interesting mathematics, including the study of continued fractions.

Godard, Roger *RMC*

Finding the Roots of a Non-Linear Equation: History and Reliability

Themed Contributed Paper Sessions: TCPS 1P - History and Philosophy of Mathematics

Finding the roots of a non-linear equation is one of the most commonly occurring problems of applied mathematics. This work concerns the fixed point and the bisection methods. We present the linear convergence properties of the fixed point technique as explained by Sancery in 1862 and Schröder in 1870. Our research on the bisection was oriented by the following sentence written by Richard Hamming in 1973: "One of the best, most effective methods for finding the real zeros of a continuous function is the bisection method... The method is robust in the sense that small round-off errors will not prevent the method from giving an interval with a sign change, and if round-off is misleading you, it is not the fault of the method but of the program that evaluates the function." Because the bisection is linked to the intermediate value theorem, we shall comment Bolzano (1817), Cauchy (1821), and Sarrus (1841) approaches. We found that the history of the bisection was not covered by historians of mathematics. But in the 1940's Turing and Wilkinson became interested by the half-interval analysis. A major breakthrough came with Wilkinson's analysis of the bisection in 1963 and the genesis of "robust" algorithms in root findings by a Dutch team.

Goff, Christopher *University of the Pacific*
Jialing Dai, *University of the Pacific*
Sara Malec, *Hood College*
Dennis Parker, *University of the Pacific*

Exploring the 100 (and 1) Spaces of Prime Climb in a Math Teachers' Circle

Themed Contributed Paper Sessions: TCPS 3 - Math Circle Problems Involving the Number 100 in Honor of the MAA's 100th Anniversary

In this presentation, we will describe our Math Teachers' Circle and explain the way that we used the Kickstarter-funded game Prime Climb (formerly Primo) to get middle school teachers thinking about primes, the Sieve of Eratosthenes, and prime factorizations.

Goldin, Rebecca *George Mason University*

2000–2015

Invited Paper Sessions: MAA Invited Paper Session: Generations of Monthly Gems

I will speak about mathematical ideas explored in papers published during the years 2000-2015. While these papers haven't acquired the dusty grandeur of "historical" yet, many of them speak to themes throughout the century. We will touch the joy and complexity of mathematics posed in simple questions, viewed through the lens of *Monthly* publications in this time period.

Goldstine, Susan *St. Mary's College of Maryland*

Maps of Strange Worlds: Beyond the Four-Color Theorem

Themed Contributed Paper Sessions: TCPS 6A - Mathematics and Art

The extensions of the Four-Color Map Theorem to more complex surfaces are difficult to visualize. For instance, without a physical model of a torus map with seven pairwise adjacent countries, it is hard to imagine that there are maps on a torus that require seven colors to color all the countries so that no adjacent countries are the same color. Making maps with large numbers of pairwise adjacent countries is a delightful artistic challenge that lends itself to a variety of media. Here, we present a selection of recent artworks in ceramics, fabric, yarn, and beads depicting single- and double-torus maps requiring the maximum number of colors.

Gomez, Monelle *The Ohio State University*
Azita Manouchehri, *The Ohio State University*
Xiangquan Yao, *The Ohio State University*

Documenting Instantaneous and Cumulative Change

Themed Contributed Paper Sessions: TCPS 15 - Democratizing Access to Authentic Mathematical Activity

As part of a larger professional development effort aimed at increasing content-specific pedagogical knowledge among K–12 mathematics teachers, participants recorded a series of events we demonstrated (such as adding and removing objects from an envelope, tossing a ball, and pouring water into a glass) in an attempt to help them consider mathematics as a tool for documenting change. These seemingly trivial activities actually motivated mathematical discourse on differences in approach when recording discrete or continuous changes and the type of models that might be suitable for documenting each. All models were displayed and teachers were encouraged to identify advantages of each suggested method or ways in which their colleagues' methods could be enhanced to account for greater precision when capturing change mathematically. Considering how to document change revealed an authentic and reflective endeavor for the teachers as they continuously refined their models and accessed more sophisticated mathematical structures. Our goal for this session is to illustrate how mathematical modeling can be used as a vehicle towards advancing mathematical thinking of teachers in ways that it might influence their perceptions of mathematics and ultimately how they may communicate the key disciplinary ideas with students. As such, the series of tasks used and the subsequent data from the teachers' own work and implementation of the tasks in classrooms provide evidence of how mathematical modeling might be infused in instruction to connect various areas of mathematics. In our session, we will elaborate on how the view of mathematics as a tool for documenting change might serve as a viable option for enhancing K-12 curriculum and instruction.

Goodman, Russell *Central College*

Experiences Teaching an Honors Seminar on Sports Analytics

General Contributed Paper Sessions: Interdisciplinary Topics in Mathematics and Modeling or Applications

This talk will offer the presenter's experience designing and teaching an honors seminar on sports analytics. The seminar, offered in spring 2015, was designed for honors students in general and not necessarily for mathematics majors. The presenter will describe effective and not-so-effective aspects of the seminar, along with ideas for improving the seminar in the future. Feedback and input from the audience will be solicited.

Goodsell, Troy *Brigham Young University-Idaho*

Orson Pratt: A Self Taught Mathematician on the American Western Frontier

Themed Contributed Paper Sessions: TCPS 1P - History and Philosophy of Mathematics

In this talk we will look at the life and mathematical works of Orson Pratt (1811-1881). Pratt had no formal education beyond elementary school and from a young age his life was very nomadic. He was one of the leaders of the pioneer movement that settled Utah in 1847 and was the first white settler to enter the Salt Lake Valley. In spite of this he became a leader in education in the early days of Utah and pursued his own studies in science, specifically mathematics and astronomy. In 1866 Pratt published a book entitled New and Easy Method of Solution of the Cubic and Biquadratic Equations. We will discuss the content of this book and look at what it accomplishes and how it fits in context with what was already known about this area of algebra.

Gordon, Marshall *Park School of Baltimore*

Critical Thinking and Mathematical Habits of Mind

General Contributed Paper Sessions: Teaching or Learning Introductory Mathematics, Part B

To promote critical thinking is to share with mathematics students the language of productive mathematics inquiry that mathematicians use. Most times when we ask them to "Think!" all they can experience is pressure and the lack of how to go about thinking. A number of problems will be presented that draw upon the mathematical habits of mind of "make the problem simpler", "change representation", "take the problem apart", and other mathematical practices which tend to be absent from mathematics textbooks. Some will be to demonstrate how algebra can be better understood by weaker students, and other problems will explore how students can take on problems they wouldn't otherwise think is possible.

Gougeon, Deborah *University of Scranton*

Probability and Possibilities: A Promising Pedagogy

General Contributed Paper Sessions: Probability or Statistics

This comparative study investigates the pedagogy used in teaching Probability in an Introductory Business Statistics course using two different teaching methods at a four-year private university. Considered one of the more difficult and often elusive topics for students to grasp, this study introduces a uniquely structured and highly successful strategy for teaching this topic. The step-by-step outline for statistical independence versus dependence described here results in a better understanding of the material by students, as verified by a marked improvement in their test grades, not only on this topic, but also topics that follow which are based on probability. Classroom-tested, this innovative approach leads to a more thorough comprehension of the concept of probability and provides more positive results than those normally achieved using traditional methods.

Graham, Ron *University of California at San Diego*

1940–1959

Invited Paper Sessions: MAA Invited Paper Session: Generations of Monthly Gems

In some ways, the period 1940-1959 was one of the golden eras in the history of the *Monthly*. We will examine several papers from this period and examine their impact on mathematics today.

Greenwald, Sarah J. *Appalachian State University*
Jacqueline Dewar, *Loyola Marymount University*

Teaching Students about Women and Mathematics: A Dialogue between Two Course Designers

Themed Contributed Paper Sessions: TCPS 2B - The Contributions of Women to Mathematics: 100 Years and Counting

How can we help inspire and retain mathematics majors? Role models are cited as one important factor. We'll highlight ways we teach students about women and mathematics. We've each taught entire interdisciplinary courses on this topic. The classes combine mathematical content with both ancient and recent history, including gender and equity issues. We'll also describe ways to teach about women and mathematics on a smaller scale, such as a portion of a mathematics course for liberal arts students, in seminar classes, and at AWM Student Chapter, Girl Scout, Sonia Kovalevsky Day, and Expanding Your Horizons Career Day events. For more information, see http://myweb.lmu.edu/jdewar/wam/ and http://cs.appstate.edu/ sjg/awm/wam.html.

Griesenauer, Erin *University of Iowa*

Demystifying Matrix Multiplication

Graduate Student Session: Great Talks for a General Audience: Coached Presentations by Graduate Students, Part B

Matrices were used by the ancient Babylonians in the fourth century BCE as a convenient way to solve systems of linear equations, and a method similar to Gaussian elimination was known and used during the Han dynasty to simplify the process, in the first and second centuries BCE. However, it wasn't until about 2,000 years later that mathematicians became interested in multiplying matrices. In this talk, we'll investigate why matrix multiplication took so long to develop: What were the changes in the conception of matrices that occurred in the eighteenth and nineteenth centuries that led to defining matrix multiplication? We'll also discuss how the operation of matrix multiplication is similar to and–more importantly–different from the usual multiplication of numbers.

Grotheer, Rachel *Clemson University*
Sarah Anderson, *Clemson University*
Amy Grady, *Clemson University*
Fiona Knoll, *Clemson University*

Clemson Student Chapter of Association for Women in Mathematics

PosterFest 2015: Highlights from AWM Student Chapters

Clemson's AWM Student Chapter was founded in the spring semester of 2013. Over the past two and a half years

we have held numerous events. We have held department colloquiums, in which Dr. Suzanne Lenhart and Dr. Sarah Greenwald were both speakers, an interview fashion show, pi day celebrations, panel discussions on careers in math, and much more. Our organization is unique at Clemson because we have both undergraduate and graduate members. There are also many Clemson faculty members who actively participate in and support our events. One of our main goals is to create a space where the undergrad students, graduate students, and faculty can meet and get to know one another outside of class. We do this through various events such as monthly tea times at Starbucks, and end of the semester celebrations. As a chapter we strive to encourage the undergraduate and graduate students as they pursue an education and careers in mathematical fields.

Grotheer, Rachel *Clemson University*
Thilo Strauss, *Clemson University*
Taufiquar Khan, *Clemson University*

Reduced Basis Method for Solving the Hyperspectral Diffuse Optical Tomography Model
General Contributed Paper Sessions: Applied Mathematics

We apply the Reduced Basis Method (RBM) to solving the governing partial differential equation for hyperspectral diffuse optical tomography (hyDOT), an emerging medical imaging modality. The governing equation for hyDOT is an elliptic PDE parameterized by the wavelength of the laser source. To generate a reduced basis, a set of a small number of parameter values must be strategically chosen. We apply a novel Markov Chain Monte Carlo method for finding the set of parameters and compare it to the standard greedy algorithm most commonly used in the RBM. We find that the Bayesian approach generates a reduced basis with a smaller relative error compared to the finite element method, though the greedy algorithm may be faster in some circumstances (for larger basis sizes).

Grotheer, Rachel *Clemson University*

Can You Reconstruct a Tiger from Its Stripes? The Mathematical Reconstruction of a Medical Image
Graduate Student Session: Great Talks for a General Audience: Coached Presentations by Graduate Students, Part C

You have probably heard of a CAT scan or an MRI, but do you know how they work? You may be surprised to learn that medical imaging devices such as the CAT scanner do not work like a camera taking a picture of your insides. Instead, the machine outputs data that gives us information about one of the properties of the tissue, such as how it scatters light (the "stripes"), which is only part of the whole picture (the "tiger"). Integration, iterative methods, and other mathematical tools are then required to get an image from this limited information. To produce this image, we need to solve what is known as an inverse problem: given the solution (the scan data or "stripes"), what were the input values (the "tiger")? This is actually very difficult and leaves some questions to be answered: How exactly do we get an image from this information? What needs to be done to the data so that we can construct a "good" image? Together we will discover just how hard (or easy?) it is to reconstruct a tiger from only its stripes!

Guo, Zoey *Northwestern University*

Spider Graphs
Graduate Student Session: Great Talks for a General Audience: Coached Presentations by Graduate Students, Part C

Mathematically, a graph is a set containing ordered vertices and edges connecting them. The adjacency matrix of a graph records exactly these data, and it has nonzero eigenvalues. What are spider graphs then? What is special about the eigenvalues of spider graphs? Why does it interest number theorists and other mathematicians? We will try to answer these questions in the talk.

Guy, Richard *University of Calgary*

A Triangle Has Eight Vertices (But Only One Centre)
Invited Paper Sessions: Special Invited Session: The Geometry of Triangles

Quadration regards a triangle as an orthocentric quadrangle. Twinning is an involution between orthocentres and circumcentres. Together with variations of Conway's Extraversion, these give rise to symmetric sets of points, lines and circles. There are eight vertices, which are also both orthocentres and circumcentres. Twelve edges share six

midpoints, which with six diagonal points, lie on the 50-point circle, better known as the 9-point circle. There are 32 circles, which touch three edges and also touch the 50-point circle. 32 Gergonne points, when joined to their respective touch-centres, give sets of four segments which concur in eight deLongchamp points, which, with the eight centroids, form two harmonic ranges with the ortho- and circum-centres on each of the four Euler lines. Corresponding points on the eight circumcircles generate pairs of parallel Simson-Wallace lines, each containing six feet of perpendiculars. In three symmetrical positions these coincide, with twelve feet on one line. In the three orthogonal positions they are pairs of parallel tangents to the 50-point circle, forming the Steiner Star of David. This three-symmetry is shared with the 144 Morley triangles, which are all homothetic. Time does not allow investigation of the 256 Malfatti configurations, whose 256 radpoints probably lie in fours on 64 guylines, eight through each of the eight vertices.

H

Haack, Joel *University of Northern Iowa*
Timothy Hall, *PGI Consulting*

Humanistic Reflections on Mathematics Magazine Problem 1951 and a Solution
Themed Contributed Paper Sessions: TCPS 1R - History of Mathematics

The humanistic side of mathematics considers mathematics as a human endeavor. Discoveries can arise in surprising ways. Solutions and proofs can be approached in a variety of ways, depending in part on what tools are available to the solver. One reason to carry out a proof is to establish mathematical truth, but another is to provide insight into why something is true. Reflecting on any particular solution can suggest extensions. We will present a particular case exemplifying these statements, based on a Mathematics Magazine problem and one of its proposed solutions, namely, characterize those integers whose 100th power ends in 376.

Hackborn, William *University of Alberta*

Euler's Method for Computing the Movement of a Mortar Bomb
Themed Contributed Paper Sessions: TCPS 1E - The Mathematics of Euler

This paper addresses Euler's efforts to "determine the movement of a bomb, or of a cannonball", published in Memoirs of the Berlin Academy of Sciences, 1755 (E217). Euler begins E217 by deriving a solution — first found and expressed using quadratures more than three decades earlier by Johann Bernoulli — for the trajectory of a projectile subject to uniform gravity and a drag force proportional to an arbitrary power of its speed; he then uses this solution to devise a numerical method with which the significant attributes (e.g. range, time of flight) of a mortar shot can be calculated by artillery officers on the battlefield. Typically a mortar bomb, intended to fly over enemy fortifications and explode in the air a short distance above its target, is shot at a relatively steep angle and low (subsonic) speed: in this case, the air resistance on the bomb is roughly proportional to the square of its speed, and the method incorporates this fact. According to a 1953 U.S. textbook on exterior ballistics, Euler's technique was used as recently as World War II.

Haines, Matthew *Augsburg College*

A Visit to the Vatican Library
Themed Contributed Paper Sessions: TCPS 1H - History and Philosophy of Mathematics

This presentation provides an overview of my positive experience of studying mathematical manuscripts and incunabula at Vatican Library.

Hall, Leon *Missouri S&T*

Interesting Women in the Missouri MAA Section
Themed Contributed Paper Sessions: TCPS 2A - The Contributions of Women to Mathematics: 100 Years and Counting

In the history of the Missouri MAA Section, some of the more interesting people through the years were and are women. Some of the names will be familiar and others not so much, but all played a role in the growth and development

of the Missouri Section and mathematics as a whole. Emily Kathryn Wyant, Margaret F. Willerding, Maria Castellani, Shirley Hill, Deborah T. Haimo, and T. Christine Stevens will be discussed.

Hall, William *North Carolina State University*
Karen Keene, *North Carolina State University*

Differential Equations Concept Inventory
PosterFest 2015: A Poster Session of Scholarship by Early Career Mathematicians and Graduate Students

Measuring student learning is a challenging, yet necessary endeavor. Educators and researchers have developed a number of different types of assessments for all different kinds of purposes. Concept inventories are one type of assessment researchers use for measuring what big ideas students do and do not understand in a given domain; they are very powerful research tools. In this poster, we describe our ongoing work in creating and validating a differential equations concept inventory. We describe the taxonomy of concepts the assessment will cover as well as our work in piloting sample items with undergraduate differential equations classes. We are looking for input on both the taxonomy and potential items for the assessment.

Hallman-Thrasher, Allyson *Ohio University*
Jeff Connor, *Ohio University*
Derek J. Sturgill, *Ohio University*

Investing the Preparation of Teachers of Mathematics: The Influence of Content Knowledge on Novice Teaching
Themed Contributed Paper Sessions: TCPS 20 - Evidence-Based Approaches to the Mathematical Preparation of Secondary Teachers

We summarize the findings from an alternative, mathematics teacher preparation program for candidates who have STEM backgrounds. We present how our candidates perceived the effect of their content knowledge on their preparation as teachers and during their first year of teaching. To strengthen our findings, the views of their mentor teachers will also be applied. For the candidates, data was collected at three different points: at the start of the program, after a year of student teaching, and after their first year of teaching. The candidates' student teaching supervising teachers' were also interviewed after the year of student teaching. Each interview included questions regarding their backgrounds and growth as teachers of mathematics. The supervising teachers covered similar topics as well as how the candidates' views of teaching aligned to their own. Because the candidates viewed themselves as content experts, they focused more on developing their pedagogy rather than content knowledge. They also explained how they used their content knowledge in providing multiple explanations to students and as an additional resource for their mentors. However, candidates and their mentors discussed their struggles in being able to transform the content into manageable pieces that their students could understand.

Hamblin, James *Shippensburg University*
Lance Bryant, *Shippensburg University*

Counting Loops and Paths: The Monoid of a Directed Graph
General Contributed Paper Sessions: Graph Theory

Given a directed graph and a designated vertex, how many steps does it take to travel in a loop from that vertex back to itself? The answer to this question relates to monoids and numerical semigroups. In this talk we will explore various examples and discuss the monoid associated with an anchored directed graph.

Hammond, Christopher *Connecticut College*
Warren P. Johnson, *Connecticut College*

Multi-Opponent James Functions
Themed Contributed Paper Sessions: TCPS 5A - Recreational Mathematics: New Problems and New Solutions

The James function, also known as the "log5 method," assigns a probability to the result of a competition between two teams based on their respective winning percentages. This talk, which builds on earlier work of the authors and Steven J. Miller, explores the analogous situation where a single team competes simultaneously against multiple opponents.

Hamudra, Indu Rasika *University of South Florida*
Mohamed Elhamdadi, *University of South Florida*

Knot Theory through Quandles

Graduate Student Session: Great Talks for a General Audience: Coached Presentations by Graduate Students, Part A

A knot can be interpreted as a string connecting to its own end points without self intersecting. By tracing the string on paper we can draw a picture of the knot, something we will call a knot diagram. A major problem in the field of knot theory is the problem of determining if two different knot diagrams are the diagrams of the same knot or different different knots. How the concept of a quandle can be used to help solve the fundamental knot theory problem of determining if two different knot diagrams represent the same knot or not is the topic of this talk. We attach some algebraic structure to knots which we call Quandles and study them. Our goal is to apply this to tell knots apart.

Hanusa, Christopher *Queens College, CUNY*

Teaching Mathematical Art: Coordinating Design and 3D Printing

Themed Contributed Paper Sessions: TCPS 9 - What Can a Mathematician Do with a 3D Printer?

I teach Queens College MATH 213: Math with Mathematica as a student-driven project-based class. Our second project this Spring 2015 was to design and print a piece of three-dimensional mathematical art using Mathematica. We'll discuss the project with a focus on what worked, and present the fruits of the students' labor. Course Materials and a Virtual Art Gallery are available online at http://qc.edu/ chanusa/courses/213/15/

Harkleroad, Leon *Bates College*

An Analyzable (Though Seldom Winnable) Card Solitaire

Themed Contributed Paper Sessions: TCPS 5A - Recreational Mathematics: New Problems and New Solutions

Card solitaire games notoriously resist analysis. This talk will present a solitaire that joins the very short list of those whose winning probabilities have been found amenable to evaluation. The odds of succeeding at the game can be determined by counting certain walks along the edges of a tesseract.

Hassebrock, Frank *Denison University*
Lewis Ludwig, *Denison University*

Student Beliefs on Math Ability and Sense of Belonging to a Math Community

Themed Contributed Paper Sessions: TCPS 10 - The Scholarship of Teaching and Learning in Collegiate Mathematics

This is a preliminary report on a study conducted in the fall of 2014 with 11 entry-level mathematics courses at Denison University - a national liberal arts school of 2100 students. The goal of the project was to replicate aspects of Carl Dweck's research on implicit theories of intelligence and ability with respect to math ability via pre/post semester surveys. We considered the following questions: (1) Do women and men students in lower-level mathematics courses differ in their implicit theories of math ability? (2) Do women and men students differ in their sense of belongingness to a math community and does belongingness correlate with implicit theories of math ability? (3) Are there changes in students' implicit theories and sense of belongingness over the course of the semester?

Hattaway, Amanda *Wentworth Institute of Technology*
Kathleen Grace Kennedy, *Wentworth Institute of Technology*
Emma Smith Zbarsky, *Wentworth Institute of Technology*

Summer Curriculum for Selected Incoming Freshmen and Transfer STEM Students

Themed Contributed Paper Sessions: TCPS 17 - Curriculum and Course Development to Support First Year STEM Students

Wentworth Institute of Technology runs a six-week summer bridge program for selected incoming freshmen and transfer students majoring in STEM. The program is designed to enhance students' math skills prior to their first college semester. The program involves mathematics and engineering professors and student support staff across campus. The bridge program is in its third year and is co-sponsored by Wentworth and the National Science Foundation. During

our talk we will talk about this interdepartmental effort, the curriculum, data on how our last two cohorts have done, and on-going efforts.

Hecker, David *St. Joseph's University*
Stephen Andrilli, *La Salle University*

Designing a General Education Mathematics Course in Linear Algebra
General Contributed Paper Sessions: Teaching or Learning Introductory Mathematics, Part B

In 2010, a new General Education requirement in mathematics took effect at Saint Joseph's University. All students are now required to take a course which introduces them to the "beauty" of theoretical mathematics, including the use of logical arguments and the art of proof. In response, the authors designed a 3-credit mathematics option for non-math/science majors who do not place into calculus to introduce these students to many elementary results in linear algebra along with an introduction to logic and some fundamental proof techniques. The course content has evolved over the last five years as the authors received feedback from students and other instructors. In this talk, the authors will outline the topics covered in the course, and illustrate some typical exercises assigned to the students. They will also discuss how student assessment is handled, and report on the reactions of the students to the level of the course and the material covered.

Hedetniemi, Jason *Clemson University*

Identifying Codes in the Cartesian Product of a Path and a Complete Graph
PosterFest 2015: A Poster Session of Scholarship by Early Career Mathematicians and Graduate Students

We consider minimum identifying codes in the Cartesian product of a complete graph and a path. We illustrate a collection of properties which can be used to verify a subset of vertices is a valid identifying code. Using these properties, we construct and illustrate many minimum identifying codes in the cases where the complete graph is of order three, or at least five.

Heinold, Brian *Mount St. Mary's University*

Surprises from Iterating Discontinuous Functions
Themed Contributed Paper Sessions: TCPS 6A - Mathematics and Art

Iterating discontinuous functions in the complex plane produces interesting fractal-like images. In particular, using each point in a segment of the complex plane as a starting point for our iteration, we color the point according to how many iterations it takes until successive iterates are within some small tolerance of each other. The resulting images are symmetric, beautiful, and occasionally peculiar, being much different from familiar fractals such as the Mandelbrot set and Newton fractal. We will look at many of these images and examine why they look the way they do.

Hendricks, David *Abilene Christian University*
Connie Yarema, *Abilene Christian University*

Lesson Study: A Capstone Experience to Address the Recommendations of the MET II Document
Themed Contributed Paper Sessions: TCPS 20 - Evidence-Based Approaches to the Mathematical Preparation of Secondary Teachers

This presentation describes how the degree program at Abilene Christian University for math majors certifying to teach secondary mathematics address the recommendations of the Mathematical Education of Teachers II document. In particular, it will describe how one of the recommendations for in-service teachers, Lesson Study, is implemented as part of the mathematics content component of the degree. The goal of the mathematics department is to provide its teaching majors an alterative professional development to complement those typically discussed and experienced in the university's teacher education department. The focus is to build a community of practice consisting of mathematics faculty, teacher education faculty, and in-service teachers to assist these majors in building teacher capacity by connecting their knowledge gained at the university to actual practice in the classroom. Results from data collected over the past 5 years highlight teaching majors' reflections, observations by supervising faculty during student teaching, and new teachers' testimonies about how the Lesson Study experience translated into classroom practice during their first years of teaching.

Hendry, Neil *International Baccalaureate*

Conceptual Learning in Mathematics Upper Secondary Education: The International Baccalaureate

General Contributed Paper Sessions: Teaching or Learning Devlopmental Mathematics and Assessment

This presentation will look at plans the International Baccalaureate (IB) is developing to enhance conceptual understanding in mathematics. It will outline how we aim to improve the way that 16-19 year olds learn mathematics by exposing them to more creative ways of teaching and learning in the IB Diploma Programme (DP). In mathematics these approaches will include greater emphases on modelling, inquiry, collaboration, use of technology and writing and explaining mathematical reasoning. It will outline the systematic process of curriculum review adopted by the IB, how mathematics fits in with the other subjects the students must study, the wider aims of the IB Diploma Program and the IB learner profile which has far reaching objectives. The aim is to help young people to be better learners of mathematics by increasing the emphasis on conceptual understanding and creativity rather than focusing exclusively on content as many mathematics upper secondary curricula tend to do. The hope is that this will have a positive impact on the ability of the students to learn and apply mathematics in their future studies and careers. It will include some examples from curriculum documentation of the sorts of classroom activities that can enhance metacognition in mathematics and the support and advice offered to teachers to assist them in implementing inquiry-based learning in their classrooms. This in turn, it is hoped, will enable these students to take this ability to be self-regulating learners. It is hoped this will have an impact on their undergraduate studies, particularly where they contain a significant amount of mathematics but also beyond to enable them to become lifelong learners.

Henrich, Allison K. *Seattle University*

Be Inspirable!

Alder Awards: Alder Awards

Zap! A flash of inspiration strikes. You're in a summer PREP workshop, and you get a great idea for a technique you can try in your classes to encourage students to take more ownership of their learning. What happens next? You excitedly return home. You redesign your syllabus for the next class you're going to teach in the fall – incorporating your new idea. You can't wait to try it out! If this sounds like you, you're probably inspirable. Inspirable people put themselves in situations where they'll be exposed to new ideas. And what's more, they will often grab on to new ideas and run with them, changing the way they teach, mentor, approach their scholarship, and engage with their community. Inspirable people are often high achievers and agents for positive change. If I could give one piece of advice to a student or recent PhD, it would be this: Be inspirable. In this talk, I'll tell a few stories about times I've been inspirable and describe what unfolded as a result.

Herald, Meagan *Virginia Military Institute*

Modeling from Calculus to Numerical Analysis (and Everything in Between)

Themed Contributed Paper Sessions: TCPS 18 - Using Modeling for Teaching Differential Equations: Before, During, After

Beginning with the first semester of calculus, I use modeling to demonstrate the newly developed techniques and to provide some context as to why the students are required to understand this type of mathematics. In the ordinary differential equations course, I aim to expand to my student's mathematical view beyond the classroom. During this course, it is imperative for the students to actively exert the power of their mathematical knowledge and begin to develop an awareness of what mathematics can do to facilitate the understanding of the world around them. During a numerical analysis course, usually taken the semester before the students graduate, the perception of modeling alters from the earlier more regulated models to reading relevant modeling articles and culminating in the final project, their very own model analyzed numerically.

Heuett, William *Marymount University*

Experiences and Experiments in Implementing a Flipped Classroom Design in an Introductory Statistics Course

General Contributed Paper Sessions: Teaching or Learning Introductory Mathematics, Part A

For several years I have worked to design and implement a flipped classroom design in an introductory statistics course. During that time, I have experimented with the approach and assessment tools to test my methods. For example, in one

semester, two sections (70 students total) of the course were taught using the flipped classroom design and one section (35 students total) was taught using a traditional lecture style. Comparisons between the two teaching methods were drawn using both quantitative and qualitative measures. In another semester, three sections (105 students total) were taught, each with an assortment of quiz-like assessment tools aimed at motivating that students to watch the video lectures outside of class and come prepared to do the in-class activities. In this talk, I will discuss the results from my experiments, focusing on measures of student learning outcomes. I will also discuss my experiences and student perceptions about the flipped classroom approach generally.

Higginbottom, Ryan *Washington & Jefferson College*

Warmup Problems: How to Help Students Learn, Avoid Grading Homework, and Make All Your Dreams Come True

General Contributed Paper Sessions: Teaching or Learning Calculus

To collect homework, or not to collect homework? While this may not be an eternal, Shakespearean question, teachers must have an answer. Daily homework assignments seem to help students keep up and learn, but grading these assignments bogs down the instructor. In this talk I will discuss my practice for daily problem assignments and the adjustments I have made in recent years.

Hitchcock, Gavin *University of Stellenbosch*

"Remarkable Similarities": A Dialogue Between De Morgan & Boole

Themed Contributed Paper Sessions: TCPS 1P - History and Philosophy of Mathematics

We enlist other participants in a theatrical presentation aiming to bring to life the friendship and mathematical communion between Augustus De Morgan and George Boole. Commentary by an older De Morgan (1864) intersperses a dialogue between Boole and De Morgan over the years 1843–1864 based very closely on their correspondence. The dialogue displays the crucial role of De Morgan as Boole's encourager and mentor, and highlights the fellowship of minds and affinities in thought development. Frank and poignant exchanges give insight into personal struggles, contemporary publishing issues, institutional problems, religious divisions, intellectual isolation, and the excitement of creating the new mathematical logic. The dialogue also exhibits lesser-known aspects of the human side of De Morgan — his generosity, integrity and humour.

Hobson, Natalie *University of Georgia*

Realizing Reality on the Drawing Board

Graduate Student Session: Great Talks for a General Audience: Coached Presentations by Graduate Students, Part C

When drawing a railroad track, why do the two parallel rails meet at a point? In this talk, we explore the geometry of the drawing board, and by doing so we will explain this phenomenon. We will build the geometry of the drawing board from a set of axioms, just like Euclid did with his geometry. The geometry we define can be used to develop tools with which to achieve realism not only in art, but also in computer games, and other representations of the world around us. With this new understanding of the geometry we see, the mysterious ways in which buildings and railroad tracks seem to appear will be uncovered!

Holdai, Veera *Salisbury Universiry*
Barbara Wainwright, *Salisbury Universiry*

Actuarial Present Value: Calculations for Two Parametric Models

Themed Contributed Paper Sessions: TCPS 7 - Financial Mathematics

Traditional actuarial functions in the world of insurance include pricing of an insurance product (life, health, or car insurance, pension etc.) and reserving for future benefit payouts to an existing policy, i.e. estimating how much of past premium must be set aside to cover future policy obligations. In both of these endeavors the calculations involve the concept of Actuarial Present Value (APV). In this paper we present an introduction to the concept and then, for two parametric survival models, derive new formulas for the APV at policy issue of a benefit paid to beneficiaries of a policy holder at the time of death.

Holden, Joshua *Rose-Hulman Institute of Technology*

Why Induction Is Like Ice Cream: Writing About Analogies in Discrete Mathematics Courses

Themed Contributed Paper Sessions: TCPS 12 - Improving Undergraduate Math Writing

Many researchers in cognitive science and education have written about the benefits of having students use analogies. When students make an analogy between a new topic and a familiar one, they make mental connections that help them both remember and better understand the new material. At the same time, getting students to generate their own analogies contributes to their mental ownership of the material, which again stimulates their ability to remember. I wanted to develop exercises for my Discrete Mathematics courses which allowed students creativity in coming up with these analogies. At the same time I wanted to encourage them to come up with ideas they had not heard before. I will explain the educational justification and the assignments in more detail. I will also give some examples of student topic choices, including some very inventive ones! In addition to getting students to practice writing about mathematics, I believe these assignments also increased students' understanding of the material.

Hollenbeck, Brian *Emporia State University*

The Mathematics of Triphos, A World without Subtraction

Themed Contributed Paper Sessions: TCPS 5B - Recreational Mathematics: New Problems and New Solutions

The mathematics of Triphos is a setting for undergraduates to conduct original research at an accessible level, while reviewing concepts of traditional mathematics. There are two main premises that separate the Triphos system from standard mathematics. The first is that the concept of subtraction does not exist. This is because the concept of number is based on a "reality" of three forms of matter — let us call them R, G, and B. Subtraction is not needed because cancellation occurs when all three magnitudes are equal. The second premise is that the most natural angle is 60 degrees instead of 90 degrees. Thus the fundamental shape would be an equilateral triangle instead of a square. These premises allow a student to draw from his or her knowledge of linear algebra, number theory, abstract algebra, complex variables, etc. to construct new definitions and prove theorems that are more natural in the Triphos system. We will discuss some of these findings, as well as some potential avenues for future research. We will also discuss how this topic is used for a self-perpetuating seminar class at Emporia State University.

Hollings, Christopher *University of Oxford*

Soviet Views of Early (English) Algebra

Themed Contributed Paper Sessions: TCPS 1F - Special Session in Memory of Jackie Stedall

The history of mathematics emerged as a significant discipline in the USSR during the 1930s, apparently building on an earlier Russian interest. In its early stages, it was marked by two major characteristics: a nationalist tenor, and a concern over ideology. The former led to a focus on the contributions of Russian mathematicians, whilst the latter, occasionally at odds with the former, sought to reinterpret the works of historical Russian mathematicians in terms of Soviet ideology. However, as the Soviet study of the history of mathematics opened up after Stalin's death, we find the names of other (non-Russian) historical mathematicians beginning to appear as the subjects of published works. In this talk, I examine the treatment of early algebraists (particularly those in England) at the hands of Soviet authors.

Hook, Jonelle *Mount St. Mary's University*

Coprime and Prime Labelings of Graphs

General Contributed Paper Sessions: Graph Theory

A *coprime labeling* of a graph G with v vertices is a labeling of the vertices of G with v distinct integers chosen from the set $\{1, 2, 3, \ldots, k\}$ for some $k \geq v$ such that any two adjacent vertices have labels that are relatively prime. If the minimal value for k in which G has a coprime labeling is v, then the labeling is called a *prime labeling*. We will discuss results on prime labelings of various graph classes with a focus on coprime labelings of complete bipartite graphs.

Howard, James *University of Maryland University College*

Virtual Bumblebees

Themed Contributed Paper Sessions: TCPS 6A - Mathematics and Art

Based on Langton's Ant, this talk briefly describes a simple simulation environment for quasisocial behavior. The world is a sparse rectangular grid of cells. Each cell may be empty, have a red dot, or a blue dot. Superimposed over

the rectangular grid are one or more virtual bumblebees represented as yellow dots. The virtual bumblebee moves through the world by taking a single step in one of four cardinal directions placing it into an adjacent cell. There are three rules for deciding the behavior of the virtual bumblebee:
(1) At a red dot, turn 90 degrees to the right, turn the dot blue, and move forward one cell;
(2) At a blue dot, turn 90 degrees to left, turn the dot red, and move forward one cell; and
(3) At an empty square, move forward one cell. Depending on the density of occupied cells and the number of virtualized bees present in the simulation, different patterns from simply repeating loops to complex arrays suitable for modelling traffic and other quasisocial phenomena emerge.

Huang, Nick *Howard Consulting*

Dividing Process in Base-10 Number System: Reversed Dividing Process for 1/X

General Contributed Paper Sessions: Teaching or Learning Devlopmental Mathematics and Assessment

A new set of steps for dividing process, the Reversed Dividing Process, is introduced, in which the position based number representation digits for the value of 1/X are reversely output one by one compared with digit output order of the normal dividing process.

Huang, Wanwan *Roosevelt University*

Insurance and Financial Investment Strategy Under a Stochastic Process Model

Themed Contributed Paper Sessions: TCPS 7 - Financial Mathematics

To explore the investment strategy for an insurance company, the first thing is setting up an insurance risk model for the cash flow of the company. Under the model, the company invests its wealth, which we also call it its reserve, into a two assets portfolio. One of the two assets is a risk free bond. And the other is a stock under the geometric Brownian motion. The wealth value and ruin probability are simulated by Monte Carlo method. The ruin probability is defined as $Pr(\inf_{0\leq t\leq 12} U_\theta(t) < 0)$, where U denotes the wealth process, θ is the ratio of the wealth invested in the stock, and t is the time from January to December. The admissible range of θ for the investment strategy is figured out based on the simulation results and the maximum expected wealth at the end of the period is computed within this range. The project is in process and more modeling work is designed based on this two assets portfolio framework.

Huddy, Stanley *Fairleigh Dickinson University*

Master Stability Functions for Synchronized Identical Systems with Linear Delay-Coupling

General Contributed Paper Sessions: Applied Mathematics

Master stability functions can be used to determine the stability of synchronized nonlinear systems. We present the the derivation of master stability functions for the fixed point solution of any network of synchronized identical systems with linear delay-coupling and a single constant delay. We also discuss numerical methods for computing values of the associated stability measure and relate these master stability functions to the amplitude death islands found in coupling and delay space. Numerical simulations of small (3-5 node) networks with chaotic node dynamics are used to demonstrate this approach to stability.

Huffman, Cynthia *Pittsburg State University*
Scott V. Thuong, *Pittsburg State University*

Rope Geometry of Ancient India in the Classroom

Themed Contributed Paper Sessions: TCPS 1D - History and Philosophy of Mathematics

Whether intentional or not, mathematics permeated many aspects of life for various ancient cultures, including religious aspects. For example, the Pythagoreans believed “All is number.” A working knowledge of basic geometry was needed by ancient Egyptian engineers to build the pyramids and religious temples. In this presentation, we take a look at ancient Indian rope geometry which was used in the design of altars for different fire sacrifices. Geogebra applets are included for illustration and exploration. The talk will conclude with related activities that can be used in the classroom.

Hulgan, Jonathan *Oxford College of Emory University*

Integrating Ideas: A Calculus II Project

General Contributed Paper Sessions: Teaching or Learning Calculus

In second-semester calculus courses, students often have difficulty recognizing which integration techniques are appropriate for a given integral. To help combat this, we had students work in pairs to develop an integral whose solution required the sequential use of each basic integration technique discussed in class. Here we will briefly share more specific guidelines of the project, as well as our thoughts on the successes and shortcomings of the project.

Hunter, Patti *Westmont College*

Spreading the Wealth: The Ford Foundation and Eugene Northrop's Advancement of Mathematics and Science at Home and Abroad

Themed Contributed Paper Sessions: TCPS 1M - Special Session in Honor of Karen Parshall

In 1934, Eugene Northrop finished his Ph.D. in mathematics at Yale, and was competing for scarce jobs with his classmate, Saunders Mac Lane. He settled for a position at the private boarding school, Hotchkiss, where he stayed until 1943. That year, Northrop took up a post at the newly founded College of the University of Chicago. Partnering with the dean at the time, F. Champion Ward, Northrop developed and taught in the college's mathematics program. A year spent as an education consultant for the NSF and the Ford Foundation's Fund for the Advancement of Education in 1955, along with his connections to Ward, who joined had joined the foundation a few years earlier, positioned Northrop to move from the world of American liberal arts education to a role in which he helped shape the funding activities of what had become the richest philanthropic foundation in the world. This talk will consider Northrop's work at the University of Chicago, and his contributions to the development of university science in Turkey through his position at the Ford Foundation.

Huq, Aminul *University of Minnesota Rochester*
Marcia D. Nichols, *University of Minnesota Rochester*
Bijaya Aryal, *University of Minnesota Rochester*

The Importance of "Navigating Ambiguity through Context" for Students in Quantitative Sciences

General Contributed Paper Sessions: Interdisciplinary Topics in Mathematics and Modeling or Applications

Ambiguity is an inherent part of problems that arise in real world situations. The skill to navigate ambiguity is focused more so in many areas such as literature, whereas in quantitative disciplines like math and physics it is rarely focused as an objective. In mathematics and physics, we can encounter four basic types of ambiguity: content, language, context and symbolic. Translating a concept from everyday language into symbolic language and back again necessarily introduces ambiguities. When students are asked to move away from formulaic problems to consider more complex, 'real world' problems, all sorts of ambiguities slip in, and students must learn to use context to navigate the uncertain terrain. In this talk we will follow a group of students who took a context heavy Calculus course and then enrolled in an introductory Literature course and an introductory Physics course. We will explore their performance in context related tasks/problems in these courses and present our findings.

Husowitz, Barry *Wentworth Institute of Technology*

A Density Functional Study of Foams and Micro Emulsions

PosterFest 2015: A Poster Session of Scholarship by Early Career Mathematicians and Graduate Students

Density Functional theory in statistical mechanics is a powerful tool to study various phase phenomena. In my previous work, I used density functional theory to study nucleation in confined systems such as cylindrical pores and in-between two disks. Confinement effects induced nucleation phenomena that are not observed in more open systems. Density functional theory allowed us to systematically study the effect of a variety of geometric and interaction parameters on the properties and behavior of all the systems. Although more sophisticated, but computationally more demanding, theoretical approaches can be used, our results provide a fundamental physical insight into the behavior of real systems and create a solid basis for the development of more sophisticated studies. In the first part of my talk I will present these previous results and show how density functional is an effect tool to study various phase phenomena. In the second part I will present how density functional theory can be used to study the phase behavior of foams and micro emulsions. In turn the results of this density functional study can help in the engineering of foams, which are important in the food industry, engineering of various materials and biomedical technology.

Husowitz, Barry *Wentworth Institute of Technology*

Project based Learning in Numerical Analysis via Creation of a Phase Diagram and Evolving the Time Dependent Schrodinger Equation

PosterFest 2015: A Poster Session of Scholarship by Early Career Mathematicians and Graduate Students

Project-based learning gives students a chance to apply what they are learning in class to real-world problems and challenges. This dynamical approach gives the students a broader perspective of the subjecting being taught and helps them acquire deeper knowledge of the subject. Numerical analysis is a subject of mathematics that can be readily applied to real world problems. In this poster I am going to present two projects that were investigated by students in my numerical analysis class. The first one that I will present involved using density functional theory in statistical mechanics to develop a phase diagram for a simple fluid. The second one that I will present involved evolving the time dependent Schrodinger equation for a 1D system with a harmonic potential. For the phase diagram project an iterative method was developed which incorporated newton's method to find the two coexisting phases at a given temperature. In order to evolve the time dependent Schrodinger equation Euler's method was used. The results of these two projects will be presented and discussed.

Hvidsten, Michael *Gustavus Adolphus College*

Active Exploration of Desargues' Theorem and Projective Geometry

Themed Contributed Paper Sessions: TCPS 21 - Show Me Geometry: Geometry Software and Tablet Demonstrations

Students often have difficulty in conceptualizing properties of Projective Geometry. Intuition developed from perspective drawing is sometimes used to motivate lines and points at infinity, but for many there is still a conceptual hurdle to working in projective space. This is unfortunate, as Projective Geometry is one of the most beautiful and elegant ideas in mathematics. This talk will demonstrate a project that is used in the presenter's geometry class where students investigate Desargues' Theorem in models of Euclidean, Hyperbolic, and Elliptic geometries. Investigations in these models reveals the universality of Desargues' Theorem and also makes apparent how the idea of points and lines at infinity arise naturally from these models.

I

Irby, Gwendolyn *Lockheed Martin*

More than Equations

Invited Paper Sessions: Special Session: "Notes of a Native Son": The Legacy of Dr. Abdulalim A. Shabazz (1927–2014)

Dr. Shabazz taught me more than just how to solve complicated mathematical problems, he taught me life lesson that I use today in the technical industry. What most people do not realize is that studying math trains your brain to think logical, a skill that can be transferred to any line of business. It doesn't help me in my marriage, but it has assisted me in becoming a Senior System Engineer.

J

Jackson, Monica *American University*

Dr. Abdulalim A. Shabazz — Statistically Significant!

Invited Paper Sessions: Special Session: "Notes of a Native Son": The Legacy of Dr. Abdulalim A. Shabazz (1927–2014)

In this talk, I will discuss the mentoring efforts of Dr. Shabazz and the impact of his work on changing the face of mathematics and statistics. I will also discuss my work as a spatial statistician and how Dr. Shabazz helped shaped my own career path.

Janiczek, Paul *Virginia Military Institute*

Social Implications of the Königsberg Bridge Problem

General Contributed Paper Sessions: Graph Theory

In 1736, Königsberg had seven bridges, which Leonhard Euler famously showed did not provide citizens a "path" or "circuit" for touring the city. By 1905 Königsberg had added an eighth bridge. What were the mathematical and social implications of this addition? In this talk, we examine these questions and several related problems.

Janssen, Mike *Dordt College*

The Importance of α

Invited Paper Sessions: MAA Invited Paper Session: Concrete Computations in Algebra and Algebraic Geometry

The classical algebra-geometry dictionary relates an ideal I in a polynomial ring to its corresponding zero locus Z at which all polynomials in the ideal vanish. A recent object of study in projective algebraic geometry is the initial sequence $(\alpha(mZ))_{m\geq 1}$, where $\alpha(mZ)$ is the degree of a polynomial of least degree vanishing to order at least m on Z. In 2010, Bocci and Chiantini used classical algebraic geometric methods to classify all finite sets of points in $\mathbb{P}^2$ for which the first difference $\alpha(2Z) - \alpha(Z)$ is small. We will discuss their result and recent generalizations.

Jayawant, Pallavi *Bates College*

Life and Research of Vasanti Bhat-Nayak

Themed Contributed Paper Sessions: TCPS 2A - The Contributions of Women to Mathematics: 100 Years and Counting

I will present a brief biographical sketch of Vasanti Bhat-Nayak (1938-2009) who was professor of combinatorics in the Department of Mathematics at the University of Mumbai in Mumbai, India. Starting with her doctoral thesis in 1970, Professor Bhat-Nayak researched different areas of combinatorics such as block designs, variegated graphs, and graceful graphs during a mathematical career of about thirty-five years. I will discuss her work in the context of current research in some of these areas.

Jensen-Vallin, Jacqueline *Lamar University*

Beginning an Emerging Scholar's Program in Calculus II

Themed Contributed Paper Sessions: TCPS 11A - Cultivating Critical Thinking through Active Learning in Mathematics

In Calculus II during the Spring 2015 semester, students were asked to engage in active problem solving during class at least one day per week. During these Emerging-Scholars-style worksheet days, students were assigned to groups of three or four students and asked to work on "challenge problems" at the board. As with traditional ESPs, the goals of this format were: 1.To let students form a community of learners 2.To challenge students to complete difficult problems 3.To allow students to cement old concepts 4.To give students a preview of upcoming material We will discuss the specifics of these worksheet days, as well as student reaction (both formal and informal) to these techniques. Additionally, we will discuss how this method affected grade outcomes for the course and/or student attitude toward the course.

Jimenez, Jose *Penn State Hazleton*

Rethinking the Sequence of the Content of Calculus I for Deeper Conceptual Understanding

Themed Contributed Paper Sessions: TCPS 19A - Innovative Approaches in the Calculus Sequence

I have been implementing two different ideas in my calculus I class: (1) Deeper conceptual understanding. (2) Introduce the definite integral early on in the class. (1)I have produced a series of handouts and online quizzes that guide students to learn on their own some of the most basic computational aspects outside of class. Thus, I can focus on proofs, generalization, and abstraction in class. (2)I have produced three learning modules to help students develop a good understanding of the approximation process and the definition of the definite integral. I introduce this topic right after the basic rules of differentiation. Doing this, allows me to cover integration over an extended period, as opposed to cover it during the last weeks of the semester. I now get to The Fundamental Theorem of Calculus about half way through the semester. For students who have taken calculus in high school, this approach quickly introduces them to

concepts and ideas that they have not seen before. For students who have not taken calculus, this approach is somewhat more challenging, but for those who are committed, they do as well as those students who have already taken calculus.

Johannes, Jeff *SUNY Geneseo*

A Kaleidoscopic Journey

Themed Contributed Paper Sessions: TCPS 6A - Mathematics and Art

Kaleidoscopes can range from children's toys to elaborate collector's items. In this talk we will present a classification of planar kaleidscopes. We will then discuss spherical and hyperbolic kaleidoscopes. The talk will be illustrated with eyepiece photos from our kaleidoscope collection.

Johns, Carolyn *The Ohio State University*

Synchronous Active Learning in Online and Hybrid Environments

Themed Contributed Paper Sessions: TCPS 11B - Cultivating Critical Thinking through Active Learning in Mathematics

Have online students but not sure how to incorporate active learning? The Ohio State University has taken the flipped classroom to the next level. We not only have online lectures and active learning recitations but have developed a model for allowing students to attend synchronously online. Through web conferencing software and digital inking, we're able to hold active learning classes with in-person and online students at the same time. We've even taken our model to a purely online environment. Our active learning model has been particularly successful with high school students attending remotely from their high school classroom. With two years of this model under our belt, we've discovered many do's and don'ts, and are still making discoveries.

Johns, Garry *The Ohio State University*

Creating and Assessing Writing Prompts in Calculus and Below

Themed Contributed Paper Sessions: TCPS 12 - Improving Undergraduate Math Writing

The COST rubric was developed as a four-point assessment method for evaluating responses to short-answer mathematics prompts as part of the "Writing Across the Curriculum" initiative. Originally created to assist students in rewriting and self-assessing the completeness and correctness of their own written solutions, I have incorporated this simple-to-use rubric in several of my courses - from developmental mathematics through calculus. For instance, preservice teachers improve their mathematical communication skills when responding to the question "Why can't you divide by zero?" while students in developmental courses become more fluent in their mathematical reasoning when answering the prompt "Pat thinks that 1/2 + 1/3 = 2/5. Terry says that 1/2 + 1/3 = 5/6. Which answer is wrong, and how do you know?" Similarly, calculus students are required to use mathematical vocabulary and reasoning when asked the following: "If $f'(x) > 0$ for all values of x, can the function $f(x)$ have two real roots? Why?" In this talk, I will describe the COST rubric, how I present it to students, and how I grade solutions on correctness, organization, support and the writing to provide quick feedback. I will also cover strategies for creating prompts appropriate for the COST method.

Johnson, Cory *California State University, San Bernardino*

Does Calculus Help with Algebra?

Themed Contributed Paper Sessions: TCPS 10 - The Scholarship of Teaching and Learning in Collegiate Mathematics

The calculus courses at CSUSB serve students in the various STEM majors and as a result, my courses focus both on conceptual understanding and computations. One of the issues in a first-year calculus course is that weak algebra skills block students from even beginning to grasp the concepts taught. It seems that a firm foundation in college algebra is necessary in order for students to focus on the content of the course rather than the process used in problem solving. Unfortunately, there is not enough time in the term to solidify each student's algebra skills and to prepare them for their next course. This lead to the question "If no time is dedicated to algebra review, will a student's algebra skills still improve throughout a calculus course?" To explore this question, I administered a Calculus Prerequisite Skills worksheet on the first day of the winter 2015 quarter and in the last week. At the end of the course, I compared the first and second worksheet of each student to study his/her improvement. This talk will discuss the teaching methods used

in the classroom to improve student proficiency in algebra without a formal "review" and the results of the prerequisite skills worksheet.

Jones, John *Arizona State University*
Jeff Holt, *University of Virginia*

Updating the WeBWorK Open Problem Library
General Contributed Paper Sessions: Mathematics and Technology

WeBWorK is a free open-source web-based homework system. It is used by hundreds of schools and thousands of students each semester. The system comes with a collection of over 20,000 problems which can be used with the system, which is known as the Open Problem Library. Over the past two years, faculty from around the country have been working on improving the problem library and WeBWorK's interface to it. We will present these improvements, and describe how more faculty can get involved in helping to expand and maintain this important resource.

Jones, Leslie *University of Tampa*
Britney Hopkins, *University of Central Oklahoma*

Mathematics Applied Through Programming, Modeling, and Games
Themed Contributed Paper Sessions: TCPS 11B - Cultivating Critical Thinking through Active Learning in Mathematics

We present an innovative, problem-centered course for mathematics majors and minors at the sophomore level. Although mathematical topics are reviewed, the focus of the course is solving mathematical problems through the use of technology. Students see old problems anew as they work to design efficient algorithms and visual representations. They attack practical and recreational problems with mathematics that they were seemingly unaware they knew. Student capstone projects range from clever displays of theoretical concepts to games and more. We will share student work and reactions to the course, the course design, and how we set the tone of active learning from day one.

Jones, Michael *Mathematical Reviews*
Lon Mitchell, *Mathematical Reviews*
Brittany Shelton, *Albright College*

Counting with Fractals and the Mysterious Triangles of Behrends and Humble
Themed Contributed Paper Sessions: TCPS 5B - Recreational Mathematics: New Problems and New Solutions

As discussed on the NY Times Word Play blog, Steve Humble designed a hands-on activity to demonstrate concepts from an exhibit on hidden order in apparent random processes to celebrate the tenth anniversary in 2012 of the Baltic Centre for Contemporary Art in Gateshead, England. I will review the activity using playing cards, and demonstrate how one row of cards generates the Behrends and Humble's mysterious triangle (of cards) as well as its relationship to Pascal's triangle. Behrends and Humble proved a result about when the apex of the triangle is determined by the other two vertices. Generalizing their result, we count the minimum number of cards needed to determine the apex of the triangle for other rows. The answer involves Sierpinski's fractal triangle and the base three representation of the row number. We also explain how linear algebra can be used to determine whether a set of cards in the triangle can be used to determine all of the other cards in the triangle.

Joyce, Peter *CCBC*

New Canonical Forms for Matrices Over a Principal Ideal Domain
General Contributed Paper Sessions: Algebra and Linear Algebra

This paper contains new Canonical Forms for matrices that extends the Smith Canonical Forms for mxn matrices over a principal ideal domain. The resulting matrices can be used to encrypt and decrypt data.

K

Kaganovskiy, Leon *Touro College Brooklyn Campus*

Applications of R to Introductory and Intermediate Statistics

General Contributed Paper Sessions: Teaching or Learning Introductory Mathematics, Part A

In this presentation we would like to explore using freely available R Statistics Package to teaching Statistics at various levels to create codes which provide efficient, hands-on Scientific Computing tools to enhance students' learning of Statistics concepts and real world Data Analysis. Among the topics considered are graphical Data Analysis plots, regression, ANOVA, ANCOVA, repeated measures and mixed design, etc...

Kahng, Byungik *University of North Texas at Dallas*

Emphasizing Mathematical Writing in On-line Courses

Themed Contributed Paper Sessions: TCPS 12 - Improving Undergraduate Math Writing

These days, on-line education is taking root all over the country driven in large part by its cost effectiveness. Its academic effectiveness, on the other hand, is sketchy at best, even though the drive toward more cost-effective instruction model appears to be irreversible. The purpose of this talk is to propose a mechanism to address this difficulty, particularly in the mathematical writing in introductory level on-line courses.

Kaphle, Krishna *University of Maine at Fort Kent*

Elementary Statistics using Facebook

General Contributed Paper Sessions: Teaching or Learning Introductory Mathematics, Part A

The University of Maine at Fort Kent is a rural university and majority of the students are under prepared for college level math courses. Elementary statistics is a required course for most of the majors. We found using Facebook friend data for such a group of students to be challenging and interesting as well. I would like to share my experience on using Facebook in this course for a group of students with a poor prior math background.

Karaali, Gizem *Pomona College*
Lily Khadjavi, *Loyola Marymount University Los Angeles*

Mathematics and Social Justice: Perspectives and Resources for the College Classroom

Themed Contributed Paper Sessions: TCPS 15 - Democratizing Access to Authentic Mathematical Activity

In this presentation we will introduce an ongoing project which may be of interest to college faculty seeking to make mathematical connections to social justice issues. We have gathered together an eclectic group of instructors who are working to create an expansive collection of classroom materials along with a handful of thoughtful essays on the goals, methods, and possible implementation problems associated with incorporating social justice themes into the college mathematics classroom. In the presentation we will describe our own goals and aspirations for this project and offer some concrete examples to encourage others to get involved.

Karakok, Gulden *University of Northern Colorado*
Emilie Naccarato, *University of Northern Colorado*
Spencer Bagley, *University of Northern Colorado*

Exploration of Best "Flipped" Practices

General Contributed Paper Sessions: Mathematics and Technology

One current, popular use of technology in traditional learning settings is the "flipped classroom", in which course content delivery is time-shifted through the use of online video or lecture and then non-lecture based activities related to the videos are done in the classroom. The flipped (or inverted) classroom model is continuing to gain popularity, especially within undergraduate mathematics courses. Our research group has been exploring "best" implementation practices of this particular model through qualitative and quantitative research studies with instructors who have been implementing this method. Before discussing how this pedagogical practice improves student-learning outcomes or comparing it to other models of teaching, our group investigated instructors' goals of implementing this teaching method, their perception of its success on student-learning and what they think works or does not work. While research exists that describes various implementations of the flipped classroom, studies combining the instructional goals of

the teacher with details of in-class activities are lacking. In this presentation, we will share our preliminary results from qualitative interview and quantitative survey data collected from postsecondary math faculty members in US. We believe a connection between instructional goals and implementation of the flipped classroom model would help to better understand the effects of a flipped classroom. This bigger picture is necessary before any generalization can be made about the success or failure of flipped classrooms on student learning.

Karber, Kristi *University of Central Oklahoma*
Britney Hopkins, *University of Central Oklahoma*

The Existence of Positive Solutions to an Even Order Differential Equation with Right Focal Boundary Conditions

General Contributed Paper Sessions: Analysis and Other

In order to establish the existence of positive solutions to an even order differential equation with right focal boundary conditions, we make use of the Guo-Krasnosel'skii Fixed Point Theorem multiple times. Our technique involves a transformation of the even order problem into a system of second order differential equations satisfying homogeneous boundary conditions prior to applying the aforementionedfixed point theorem.

Karcher, Kelli *Virginia Polytechnic Institute and State University*

The Space of Biorders on Some Solvable Groups

General Contributed Paper Sessions: Algebra and Linear Algebra

A group is said to be biorderable if it has a total order invariant under left and right multiplication. These orders can be given a topology that is called the space of biorders on this group. There has been intensive study on the space of left-orders recently, but less on the space of biorders. I will focus on solvable groups to show that under certain conditions the space of biorders is either finite or homeomorphic to a Cantor set.

Karcher, Kelli *Virginia Tech*

What is an Orderable Group?

Graduate Student Session: Great Talks for a General Audience: Coached Presentations by Graduate Students, Part A

Sets of numbers can be ordered using relations. What do these orders look like and how can we place them on sets? We consider this question and discuss techniques for determining how many orders we can place on a set. We will end by discussing the properties of a group of orders.

Karls, Michael *Ball State University*

Validating Groundwater Flow Models

Themed Contributed Paper Sessions: TCPS 18 - Using Modeling for Teaching Differential Equations: Before, During, After

In 2009 I began a series of student research projects aimed at validating classic groundwater flow models that involve the one- and two-dimensional heat equation. The goals of these projects are to find ways to collect water well-head data, construct appropriate models, and compare the models to the data. I will report on the progress made, including both the challenges encountered and the results obtained. Portions of this work were funded by an Indiana Space Grant Consortium award.

Kashan, Sahar *Kentucky State University*

Iran and Women in Mathematics

Themed Contributed Paper Sessions: TCPS 2A - The Contributions of Women to Mathematics: 100 Years and Counting

I am an Iranian-born-and-educated woman mathematician, living in the U.S.A. I would like to talk about how it could be that such a seemingly repressive country as Iran could produce one such as Fields Medaliist Maryan Mirzakhani.

Kasube, Herbert *Bradley University*

History of Mathematics - The Illinois Connection

General Contributed Paper Sessions: History or Philosophy of Mathematics

As we celebrate the Centennial of the Mathematical Association of America we recall in what state it was first chartered. Illinois! The Land of Lincoln offers other connections with the history of mathematics that will be highlighted.

Katz, Brian *Augustana College*

Opening a Gateway to Mathematical Inquiry

Themed Contributed Paper Sessions: TCPS 15 - Democratizing Access to Authentic Mathematical Activity

I teach an introductory course called Tools of Inquiry, in which I help students learn to ask and explore their own mathematical questions. The students come to me nervous about the idea of proofs and equating mathematics with the application of algorithms; they need to leave my course believing that mathematics is a living discipline and feeling equipped to start participating in our efforts. I will discuss some of the generative mathematical phenomena that I use to empower students to ask questions as well the phenomena they choose to explore when given complete freedom. I will support claims about the student engagement with mathematical questions through analysis of their regular reflective writing in and peer-peer feedback on their Research Journals.

Kauffman, Lou *University of Illinois at Chicago*

Knots and Knot Theory

Invited Paper Sessions: MAA Invited Paper Session: Algebraic Structures Motivated by Knot Theory

Knotting and weaving has been part of all cultures for thousands of years, but this subject was not studied mathematically until the middle of the 19-th century when the scientist Lord Kelvin (Sir William Thompson) conceived the Theory that atoms were knotted vortices in the 'luminferous aether' (a hypothetical fluid that filled empty space). Kelvin convinced the mathematician Peter Guthrie Tait and his team to make a table of knots. At the same time other mathematicians were preparing the ground for actually doing mathematics with knots. By the turn of the century, the aether theory had disappeared, but the mathematical theory of knots was beginning to thrive! Knot theory is today an active part of mathematics, with many applications. We demonstrate problems and questions about knots by using rope, magic tricks and computer graphics. We will discuss tricks that illuminate the topology. This will include knots that are unknotted in surprising ways, the Dirac string trick that describes the quantum state of an electron, how to weave a braided belt and what this has to do with elementary particles, how the question of knotted vortices was resolved by the use of three dimensional printing. In the course of this, we shall discuss how knots are studied by using diagrams and how this way of thinking leads to new structures such as the Jones polynomial, Khovanov homology and virtual knot theory. The talk will be elementary and self-contained.

Kean, Debra *DeVry University*

Math = Art (or: How to Enhance Threaded Discussions)

Themed Contributed Paper Sessions: TCPS 6B - Mathematics and Art

Topics for threaded discussions in online college algebra courses typically include variations of: (i) Briefly define a term in your own words. State a real world example of it. (ii) Show your step-by-step solution for a homework problem. (III) Compare-and-contrast (e.g., three methods of graphing). (iv) Prove-or-disprove (e.g., derive the quadratic formula). The above topics address several categories in Bloom's Taxonomy of Cognitive Skills. However, students seldom explore beyond the drill-and-kill homework problems. Thus, they rarely surpass the Application level of learning in the weekly Discussions. Since mathematics can be approached outside the Discussion textbox, a challenge was issued to the students. Instead of tediously keying mathematical symbols in the weekly Discussions, they could create and submit a homework-related video, artwork, puzzle, PowerPoint presentation with audio clip, etc. Students' participation rose in the weekly Discussions. They crocheted a boutonnière, color-coded in the digits of π; produced and starred in a film noir involving systems of linear equations; recreated a three-dimensional puzzle; etc. In conclusion, students' cognitive skills in the weekly Discussions may be enhanced by providing them multiple media options.

Keene, Karen *North Carolina State University*
William Hall, *North Carolina State University*

Modeling in an Inquiry-Oriented Differential Equations Course
Themed Contributed Paper Sessions: TCPS 18 - Using Modeling for Teaching Differential Equations: Before, During, After

Interest in using differential equations to model real world content continues to grow as the use of technology becomes more embedded in our university courses, allowing us to make sense of, and not just find, solutions to differential equations that was never possible before. Additionally, dynamical systems as a way to model a myriad of non-mathematics systems in order to interpret and predict continues to drive the differential equations content more into solving time-based differential equations. In this session, we will look at using modeling with time-based differential equations as a way to improve instruction in inquiry-oriented classrooms. Particularly, we will consider linear systems of autonomous differential equations and look at how an airplane propeller can provide a conceptual model to understand the solutions to linear systems. We will look at predator-prey models as a way to develop Euler's method for systems. Finally, we will present an example from second order ODEs, where students make sense of linear systems through the development of their understanding of the spring-mass system and how this helps them reinvent the concept of eigenlines, eigenvectors, and eigenvalues, in that order. Using the models of real world situations creates a firm foundation for students to better understand solutions to linear systems of differential equations.

Kelley, Victoria *James Madison University*
Katie Sipes, *James Madison University*

JMU's AWM Adventures!
PosterFest 2015: Highlights from AWM Student Chapters

This poster will highlight the achievements of JMU's AWM Student Chapter. We will discuss our activities, including planning a Pi Day Celebration and a talk by a representative of the NSA's Women in Math Society, attending the AWM Research Symposium, taking a day trip to the NSA museum, volunteering at the JMU Expanding Your Horizons Conference, and more!

Kelly, Susan *University of Wisconsin - La Crosse*

Girls in Science: Over 15 Years of STEM Outreach for Middle School Girls
General Contributed Paper Sessions: Mentoring and Outreach

The summer of 2014 marked the fifteenth anniversary of the Girls in Science program at the University of Wisconsin - La Crosse. The program began as a partnership with faculty from the College of Science and Health and the office of Continuing Education and Extension (CEE). From the beginning, math and science faculty worked with members of the CEE office to create a weekend summer program that would offer middle school girls hands-on math and science workshops lead by faculty at the University. The program has had continued success and reaches girls from across the State and surrounding area. This talk will be given by the science director who has worked in the program since the program's conception. The talk will present the design and goals of the program. Practical matters such as advertising and budgeting will also be discussed. Sample workshops both in math and other sciences will be given along with some student perspectives of these workshops. Several other outreach STEM programs will also be briefly presented. Girls in Science has already reached about 600-700 girls and we hope this early outreach draws more young women into math and science fields.

Kennedy, K. Grace *Wentworth Institute of Technology*
Emma Smith Zbarsky, *Wentworth Institute of Technology*
Amanda Hattaway, *Wentworth Institute of Technology*
Joan Giblin, *Wentworth Institute of Technology*

Implementing Learning Labs as Instructional Support for Freshman Calculus
Themed Contributed Paper Sessions: TCPS 17 - Curriculum and Course Development to Support First Year STEM Students

As a department, we have been working on developing additional support for first year students for four years. We started seven new engineering and technical majors which require students to start college in engineering calculus. There were over 560 students taking engineering calculus 1 last fall, about 40% of the entering class. Approximately

half of those students took calculus in high school and half did not. To support our students, we have one-on-one peer tutoring available daily and a weekly three hour math facilitated study group presided over by a professor and two to three undergraduate teaching assistants. Review of our records has found that the marginal students most in need of support do not avail themselves of these activities, however, so we have been experimenting with alternative forms of peer tutoring support that have evolved into Learning Labs. During the fall of 2014, we had five tutors embed themselves in calculus courses and hold weekly hour-long recitation sessions outside of class hours. In the spring of 2015, as a partnership with the Wentworth Learning Center we piloted a Learning Lab structure with two tutors in engineering calculus 1 and three tutors in engineering calculus 2 attached to different sections. I will discuss the features and perceived benefits of integrated Learning Labs on student success as well as the changes we intend to make for our full rollout in engineering calculus 1 for the fall 2015 semester.

Kenney, Emelie *Siena College*

Making Her Mark on a Century of Turmoil and Triumph: A Tribute to Polish and Polish-American Women in Mathematics

Themed Contributed Paper Sessions: TCPS 2A - The Contributions of Women to Mathematics: 100 Years and Counting

New starts, frustration, doubt, excitement, overcoming difficulties, and positive outcomes are familiar to most mathematicians. To the women who are the focus of this talk, however, new beginnings may include relocating to a different continent, difficulties may include having to learn and teach in secret, and positive outcomes include not only generating results, but changing the way mathematics is taught in her country, popularizing mathematics much more extensively than had ever before been seen, and being free to investigate mathematics to whatever extent she chooses. This talk introduces the particular experiences and accomplishments of Anna Zofia Krygowska, Zofia Szmydt, Edith Luchins, and Helena Rasiowa, and acknowledges the contributions of mathematicians whose work in the U.S. is ongoing and significant.

Kent, Deborah *Drake University*

The Annals of Mathematics: From the Fringes of Civilization to the University of Virginia, 1873-1883

Themed Contributed Paper Sessions: TCPS 1M - Special Session in Honor of Karen Parshall

Most nineteenth-century attempts to produce mathematical periodicals in the U.S. hinged on editorial efforts and financial backing from a few dedicated individuals. In 1873, Joel Hendricks founded The Analyst (later renamed The Annals of Mathematics) in the unlikely location of Des Moines, Iowa. Before its transfer to the University of Virginia – and, later, world renown as The Annals – this publication was the longest-running privately-funded mathematical journal in nineteenth-century the U.S.. The Analyst illustrates the challenges of specialized publication intended for an audience of nineteenth-century mathematical practitioners in America.

Khan, Muhammad *University of Calgary*

Cover the Spot' and Homothetic Covering of Convex Bodies

Themed Contributed Paper Sessions: TCPS 5B - Recreational Mathematics: New Problems and New Solutions

Cover the spot is an ancient game, which made its way from Mongolia to American carnivals in over two thousand years. The objective is to cover a large circular spot completely by 5 smaller circular disks. This raises two questions: (i) how large the disks must be, and (ii) where should they be placed in order to cover the spot. K. Bezdek answered both these questions in 1983 by finding a covering of a circle by 5 homothetic copies having the same smallest possible homothety ratio. In this talk, we investigate a generalization of this problem, namely, what is the smallest homothety ratio needed to cover a convex body by m smaller positive homothets. This leads to the notion of covering index of a convex body, which was recently introduced by Bezdek and the speaker [The covering index of convex bodies, arXiv:1503.03111v2 [math.MG] (28 April, 2015)]. Intuitively, the covering index measures how well a convex body can be covered by a relatively few smaller positive homothets. We compute the covering index of a number of planar and 3-dimensional convex bodies including triangles, squares, hexagons, circles, cubes, circular cylinders and triangular prisms. Several interesting problems of a recreational nature are posed such as what is the covering index of a pentagon, an octagon, a ball and a tetrahedron? We also discuss connections with the famous Hadwiger Covering Conjecture (1955) of combinatorial and convex geometry.

Khovanov, Mikhail *Columbia University*

What is Categorification?

Invited Paper Sessions: MAA Invited Paper Session: Algebraic Structures Motivated by Knot Theory

This talk will be an introduction to the idea of categorification. In categorification, numbers are lifted to vector spaces, while vector spaces equipped with integral lattices become Grothendieck groups of categories. Linear operators between vector spaces are lifted to functors. The talk will include several examples to motivate and illustrate categorification.

Kidwell, Peggy *Smithsonian Institution*

Charter Members of the MAA and the Material Culture of American Mathematics

Themed Contributed Paper Sessions: TCPS 1A - History of Mathematics

In the early twentieth century, growing use of numbers, combined with burgeoning high school enrollments and expanding technical education, encouraged the expansion of college mathematics teaching in the United States. It was an era when like-minded educators banded together in professional associations. In 1915, mathematicians met to establish the Mathematical Association of America. Physical objects associated with several charter members of the MAA survive in the collections of the Smithsonian's National Museum of American History. They well represent the diverse concerns of the early membership. These ranged from research on prime numbers to creating geometric models in and for the classroom to encouraging recreational mathematics to exploring aspects of the history of mathematics.

Kiihne, Pat *Illinois College*

Statistics and Japan: Bringing Themes into Elementary Statistics Courses

General Contributed Paper Sessions: Probability or Statistics

This talk focuses on modifications related to Japan and environmental science that were made to an elementary statistics course. I will include both the benefits and challenges of bringing a theme into a statistics course. I will also show some computer lab activities, group activities on interpreting statistics in scholarly and popular media articles, and demonstration problems.

Kim, Minsu *University of North Georgia*

System-wide Co-requisite Pedagogical Approaches for Learning Support Mathematics Students

Themed Contributed Paper Sessions: TCPS 16 - Curriculum Development to Support First Year General Education Mathematics Students

The purpose of this study is to examine the effectiveness of the co-requisite College Algebra courses, which consist of a lecture and lab component, regarding student achievement, success, perspective, and engagement. The co-requisite College Algebra is to motivate Learning Support math students to succeed in the gateway mathematics courses, help them be well-prepared for upper-level mathematics courses, and encourage them to graduate on time. As a mixed method research design, this study has conducted from the Fall 2014 to the Spring 2015 with about 220 students in 8 sections for College Algebra at a university. This study employed pre-and posttests, questionnaires, and semi-structured interviews. The results of this study will contribute to the knowledge of co-requisite mathematics courses and promote student retention, success, and mastering College Algebra materials.

Kim, Myungchul *Suffolk County Community College*

Increase Student Engagement by Using Clickers and Smart Phones

General Contributed Paper Sessions: Mathematics and Technology

The use of classroom response systems can help student learning, engagement and perception during the class. They provide each student a chance to think about and respond to a question before hearing other students' answer. Also, it can enlighten the instructor to sources of student difficulties. In this talk, the effective use of clickers and smart phones, when teaching math courses — statistics and calculus — will be presented.

King, Raena *Christian Brothers University*

Mathematics of Fez

Themed Contributed Paper Sessions: TCPS 8 - Mathematics in Video Games

Fez is a game whose plot and gameplay are clearly influenced by mathematics. The protagonist, Gomez, is presented with an artifact that lets him rotate his 2D perspective of a 3D world. This talk will discuss the geometry, group theory, and graph theory in the game Fez.

Kleiner, Alexander *Drake University*

The Interplay of "Hard" and "Soft" Analysis in the History of Summabiliy Theory: Preliminary Report

Themed Contributed Paper Sessions: TCPS 1R - History of Mathematics

If x is a sequence and T is a sequence to sequence transformation then T is said to sum x if $T(x)$ converges. T is called a summability method. For example, if A is an infinite matrix and $T(x) = Ax$, then T (or A) is a matrix method of summability. The study of such transformations is called Summability Theory. Starting in 1911, L. L. Silverman, Otto Toeplitz and others developed basic results that transformed (matrix methods of) summability from a collection of special methods used in other areas into a general area of study. Two decades later, Stefan Banach's use of the Uniform Boundedness Principle to prove the Silverman-Toeplitz conditions represented a whole new approach. Thereafter both classical and functional analysis techniques were used to develop and prove new results. This paper will discuss the use of these two approaches in the development of several theorems that clarified the structure of the space of sequences summed by a particular matrix.

Kloefkorn, Tyler *University of Arizona*

Introducing Technology to a Vector Calculus Course

Themed Contributed Paper Sessions: TCPS 10 - The Scholarship of Teaching and Learning in Collegiate Mathematics

Vector Calculus at the University of Arizona is a rigorous semester-long course that starts with vectors and ends with Stokes' Theorem. Due to strong enrollment in mathematics, engineering, and other physical science programs, Vector Calculus is a popular course; approximately 450 students enroll in the course each semester. Currently, the curriculum does not include the use of technology. We seek to show that the student experience in Vector Calculus will greatly improve if students use technology to gain better intuition and understanding of calculus on curves and surfaces. During the spring 2015 semester, twelve iPads were introduced into two out of eleven sections of Vector Calculus. Students used iPads and graphing calculator software in class to study curves, surfaces, tangent planes, contour diagrams, 3D coordinate systems, and vector fields. In this talk we will discuss the implementation of technology and the student experience. We will also report data gathered from the spring 2015 Vector Calculus common final exam.

Klyve, Dominic *Central Washington University*
Olivia Hirschey, *Central Washington University*

Euler and Phonetics: The Untold Story of the Mathematics of Language

Themed Contributed Paper Sessions: TCPS 1E - The Mathematics of Euler

It is well known that Euler made seminal contributions to a wide range of fields. Recent scholarship demonstrates that he contributed to as least one other which has not been described in the literature. In this paper we will describe two fascinating contributions to the field of articulatory phonetics. First, it was Euler who convinced the St. Petersburg Academy to make the nature of the vowels an annual prize question, leading directly to one of the most influential works in the history of phonetics, the Tentamen of Kratzenstein. Second, Euler himself wrote a short work, the Meditatio de formatione vocum, which, as an article on articulatory phonetics, strikingly presages 20th-century work in vowel classification. Euler's rather mathematical treatment of vowels as existing in two-dimensional "vocal space" was two centuries ahead of its time. This talk will survey Euler's work in this area.

Knotts-Zides, Charlotte *Wofford College*

Resequencing Calculus I & II

Themed Contributed Paper Sessions: TCPS 19A - Innovative Approaches in the Calculus Sequence

The math department at Wofford College implemented a resequencing of the topics in Calculus I and II to better address three issues: the increased number of students who took AP Calculus in high school, the types of majors taking

Calculus I but not Calculus II, and the desire to promote more critical thinking and less rote memorization. Topics in Calculus I now include limits, derivatives, basic integration including substitution and parts, and applications; however, we moved the theory behind these topics to Calculus II. This gave us an opportunity to create a calculus class where derivatives and integrals are introduced almost simultaneously. For example, shortly after we discuss the product rule for a derivative, we introduce integration by parts as its partner for antiderivatives. The result is a course that is refreshingly new to students who had Calculus in high school, demonstrates applications of both derivatives and antiderivatives even to students who only take Calculus I, and provides us the opportunity to more deeply address the issue of rigor in Calculus II with students who are more interested in math. In this talk, I'll describe the new sequence of topics, discuss the planning that went into the change, and talk about its successes and pitfalls.

Knox, Steve *National Security Agency*

Extending Pairwise Element Similarity to Set Similarity Efficiently

Invited Paper Sessions: MAA Invited Paper Session: The Non-Traditional "Traditional NSA Mathematician"

A fundamental question in data analysis is: "how much is this like that?" Often "this" and "that" are aggregates which can be viewed as sets of atomic items. In any given context, specialist knowledge may suggest a reasonable way to measure the similarity between any pair of items. Ad hoc extension of similarity of items to similarity of sets can — and usually does — lead to measures with peculiar properties, such as sets being arbitrarily dissimilar to themselves. Such measures ought not to be used if there is a better alternative. This talk presents a method, called Saga, of extending any similarity measure of items to a similarity measure of sets of items. Saga set similarity has several good, provable theoretical properties and is also fast to compute. Saga is illustrated by measuring the similarity of intelligence sources based upon the similarity of intelligence reports which cite them, and other NSA mission-management applications.

Kofman, Victoria *Quality Engineering Education, Inc.*

From 100s in a Number to 100 Squares on a 10x10 Checker Board (Or Are There More?)

Themed Contributed Paper Sessions: TCPS 3 - Math Circle Problems Involving the Number 100 in Honor of the MAA's 100th Anniversary

Organizing information is an important problem solving skills. It can be developed when teaching students several topics starting from second grade material and finishing by algebra level problems. In second grade, many students have difficulties with finding the quantity of tens or hundreds in large numbers. At Vika School, students learn this material by solving problems where tens are represented as rectangles and hundreds as triangles. Using our triangles-rectangles model, The flag of Great Britain, a rectangle with a vertical line, a horizontal line, and two diagonals, represents 1,690. The exercise not only helps students understand tens and hundreds, but teaches them strategies for organizing information. The next topic that can be used to foster skills of organizing information is probability: drawing "trees" based on well organized structures helps in calculating number of combinations. On Algebra level, the students might be proposed to find a total number of squares on a 10x10 international checkers board. If a student can solve this problem using more than one approach, the student has mastered the skill of organizing information.

Kose, Emek *St. Mary's College of Maryland*

Undergraduate Research, Outreach and Student Activities for a "Fair" Mathematical Experience

Themed Contributed Paper Sessions: TCPS 15 - Democratizing Access to Authentic Mathematical Activity

In this talk, we will present various forms of undergraduate research, outreach and classes we utilize for community building, recruiting and retaining, and simply for increasing participation to authentic mathematical experience by students. We will share course development ideas, research programs, as well as student activities.

Kosiak, Jennifer *University of Wisconsin-La Crosse*
James Sobota, *University of Wisconsin-La Crosse*
Robert Hoar, *University of Wisconsin-La Crosse*
Maggie McHugh, *La Crosse School District*

FastTrack: A Collaborative Effort to Support STEM students

Themed Contributed Paper Sessions: TCPS 17 - Curriculum and Course Development to Support First Year STEM Students

The FastTrack Summer Math Program is a bridge program designed to enhance the mathematical skills of incoming freshman interested in a STEM major who have placed into a developmental mathematics course. FastTrack students

participate in a 6-week online program prior to coming to campus for a one week, face-to-face session with mathematics faculty and student support staff. Specifically, this talk will address the success of the program, now in its fourth year, in preparing STEM students for their first college credit-bearing mathematics course as well as their persistence in STEM related field through longitudinal data. We will also discuss how the FastTrack model has been replicated at other universities, growing from 38 students to over 300 students across the University of Wisconsin system.

Koss, Lorelei *Dickinson College*

Differential Equations in Music, Dance, and the Visual Arts

Themed Contributed Paper Sessions: TCPS 6A - Mathematics and Art

We investigate a number of differential equations models that have been used to create artistic works in music, dance, and the visual arts. Many of these examples can be used in a standard introductory course in differential equations, and we present a number of ways in which these models have been incorporated into the classroom.

Kostadinov, Boyan *City Tech, CUNY*

Simulating and Animating the Spatial Dynamics of Interacting Species Living on a Torus-shaped Universe

Themed Contributed Paper Sessions: TCPS 4 - Undergraduate Research Activities in Mathematical and Computational Biology

The goal of this paper is to present a student research project in computational population biology, which aims at creating a computer simulation and animation of the spatial dynamics of interactions between two kinds of species living on a torus-shaped universe. The habitat for spatial interactions is modeled by a 2D lattice with periodic boundary conditions, which wrap the rectangular grid into a torus. The spatial interactions between the species have two components: 1. Population dynamics modeled by the classical Nicholson-Bailey two-parameter family of models for coupled interactions between species, extended to incorporate space and 2. Two-parameter migration dynamics, modeled by the weighted average of the current population density and the average inflow of migrating species from the nearest 8-neighbor migration zone, applied to any given cell in the inner core of the grid (inside the reflecting boundary layer). All simulations are coded using the high-level programming language R, which allows for very compact code that can be quickly developed by using functional, matrix-based, programing. This programming approach allows the entire model dynamics to be coded in less than 50 lines of code, making it ideal for student projects. The presentation will conclude with a video, animating the spatial interactions between the two species living on a torus, based on the given population and migration dynamics, initial conditions and parameter values. The resulting beautiful spatial wave patterns, produced by the interfering waves of the spatial population density, visualize the fluctuating abundance of the species in their torus-shaped universe over time.

Kraft, Kent *Trinity Washington University*

Eliminating Pre-Foundational and Comprehensively Redesigning First Year General Education Mathematics Courses at Trinity Washington University

Themed Contributed Paper Sessions: TCPS 16 - Curriculum Development to Support First Year General Education Mathematics Students

Trinity Washington University has had success with students who complete our one semester, four credit hour pre-foundational mathematics course. For instance, the Fall 2013 semester saw a pass rate of 84% for students who completed the course. When you focus on the students originally enrolled in the course, the pass rate drops to 52% which can be explained in part by a 59% completion rate. One of our second tier math courses at Trinity saw a completion rate of 72% and pass rate of 64% of all enrolled students for the Fall 2013-Spring 2014 school year. Based on student assessments and evaluations, one of the motivating differences is an application based approach making math more relevant to the students. Based on current research and best practices and the outcomes of one restructured math course, a comprehensive redevelopment is underway at Trinity. We are eliminating the pre-foundational mathematics course and transitioning our three traditional "first year" math courses from three credit hours and two meetings per week to four credit hours and three meetings per week. All three courses will be application driven and tailored more to the math topics relevant to the student interest based on "metamajor" choice, while incorporating support systems from our pre-foundational course that proved successful with our student population. This discussion will focus on the collective reasoning for this change as well as why an application driven approach has seen success at Trinity.

Kraut, Gertrud *Southern Virginia University*

Inverting an Introductory Statistics Course
General Contributed Paper Sessions: Probability or Statistics

The inverted classroom allows more in-class time for inquiry-based learning and for working through more advanced problem-solving activities than does the traditional lecture class. The skills acquired in this learning environment offer benefits far beyond the statistics classroom. This paper discusses four ways that can make the inverted classroom successful in an introductory statistics class: how to motivate students to prepare for each class, how to move the teaching of technology out of the classroom, how to balance student classwork, and how to create a mindset for learning.

Kronholm, William *Whittier College*

Integration By the Wrong Parts
General Contributed Paper Sessions: Teaching or Learning Calculus

Integration by parts is a standard technique for determining antiderivatives for functions. Typically, students learning this technique are encouraged to make the "right" choice of parts. In this talk we explore what happens when the "wrong" choices are made. Perhaps surprisingly, making the "wrong" choices can still lead to closed form solutions to antiderivatives for some elementary functions.

L

Lagarias, Jeffrey *University of Michigan*

The Arithmetic of the Spheres
Invited Addresses: AMS-MAA Joint Invited Address

Beginning with historical remarks on the harmony of the spheres, this talk tours two topics at the interface of number theory and dynamical systems. The first concerns the Farey tree, Ford circles and the Minkowski question-mark function. The second concerns Farey fractions, radix expansions and the Riemann zeta function.

Lamagna, Edmund *University of Rhode Island*

Puzzles + Games = Mathematical Thinking
Themed Contributed Paper Sessions: TCPS 11A - Cultivating Critical Thinking through Active Learning in Mathematics

Puzzles and games provide a rich environment for acquiring critical mathematical thinking skills through active learning. The presenter has designed and taught a section of a "liberal arts" math course using puzzles and games. Most students enrolled are non-STEM majors using the class to fulfill a general education requirement. Puzzles and games provide a way to "level the playing field" among students with vastly different mathematical backgrounds. Furthermore, students enjoy mathematical puzzles, and will put more effort into them than routine exercises. The course is taught without lectures. Students spend most of a class period working in small groups (2-4 individuals) solving several related puzzles or playing a game with a mathematical theme. Toward the end of class, students present and discuss their solutions with guidance from the instructor. Students individually write solutions to selected problems, sometimes including ones not solved in class. Good writing and careful presentations are expected. The solutions are revised based on feedback, and compiled into a solutions manual submitted at the end of the term. The in-class presentations and the writing assignments help students to sharpen their reasoning and to develop an ability to communicate mathematical ideas. Topics studied include sequential movement puzzles, probability, mathematical logic, basic number theory, summation and proofs without words, algorithms, recursion and induction, and graphs. The talk includes examples of several class activities, and discusses the critical reasoning they cultivate.

Landquist, Eric *Kutztown University*

Logarithms are Hot Stuff and a New Rating Scale for Chili Peppers
Themed Contributed Paper Sessions: TCPS 5A - Recreational Mathematics: New Problems and New Solutions

Have you ever wondered what makes a hot pepper hot and why some peppers are hotter than others? The piquancy of a pepper is caused by the chemical *capsaicin*, among other so-called *capsaicinoids*. Currently, the hotness of a pepper

is measured using the Scoville scale, which is proportional to the concentration of capsaicinoids, and ranges from 0 to 16,000,000. The hottest pepper in the world, the Carolina Reaper, measures up to 2,200,000 on this scale. Such large numbers can make the Scoville scale a little cumbersome for a label on a bottle of hot sauce or for the average chili pepper enthusiast. Trigonometry and Calculus students were challenged to create a more palatable rating system for chili peppers using oft-dreaded logarithms, using the familiar Richter Scale as a motivational example. Calculus students had the added challenge of making their scale a smooth piece-wise function of the Scoville rating. In this talk, we present the results from their endeavors, both with the proposal of a new and simple chili pepper rating scale and with anecdotes of how this activity has helped students better understand logarithms. As such, results will span from the sudden realization that log(0) doesn't exist to why we might rate that Carolina Reaper an 8.56.

Landry, Elaine *University of California, Davis*

Mathematical Structuralism and Mathematical Applicability

Themed Contributed Paper Sessions: TCPS 1J - Special Session on Philosophy of Mathematics

I argue that taking mathematical axioms as Hilbertian is not only better for our account of mathematical structuralism, but it yields a better account of mathematical applicability. Building on Reck's [2003] account of Dedekind, I show the sense in which, as mathematical structuralists, we ought to dispense with metaphysical/semantic demands. Moreover, I argue that it is these problematic demands that underlie both the Frege/Hilbert debate and the current debates about category-theoretic structuralism. At the heart of both debates is the metaphysical/semantic presumption that structures must be constituted from/refer to some primary system of elements, either sets or collections, platonic places or nominalist concreta, so axioms, as truth about such systems, must be prior to the notion of structure. But what we ought have learned from Dedekind [1888] and Hilbert [1899], respectively, is that we are to "entirely neglect the special character of the elements", and so axioms are but implicit definitions, and, consequently "every theory is only a scaffolding or schema of concepts together with their necessary relations... and the basic elements can be thought of in any way one likes... [A]ny theory can always be applied to infinitely many systems." The first thing to note is that no primitive system is necessary, the second is that any system, be it mathematical or physical, can be said to have a structure. Thus, applicability is just the claim that a physical system has a mathematical structure, i.e., that it satisfies the axioms, in certain respects and degrees for certain physical purposes.

Lane, Dick *University of Montana*

Online Homework Can Provide Desirable Difficulties for Learning Mathematics

General Contributed Paper Sessions: Mathematics and Technology

Many science textbooks are structured with a sequence of topics where presentation is followed by examples, exercises, and problems involving that topic. A student working on tasks in section 5.3 has an important clue: USE IDEAS IN SECTION 5.3 — such a clue will not appear on a test nor will it be available in a real-life situation. A variety of experiments have demonstrated improved learning by rearranging a sequence of tasks: having each study session involve several topics and having those topics shuffled. For example, after studying topic E — instead of working on a collection of 'eeeeEEE' tasks, a student is presented with an assignment involving several recent topics (A to E) and in a scrambled order (DBEAECDCED instead of ABCCDDDEEE). R & E Bjork coined the phrase "desirable difficulties" for this type of organization which slows short-term learning in exchange for improving its long-term effectiveness. Some work has investigated application of those ideas to math ("The shuffling of mathematics practice problems improves learning", Rohrer & Taylor, 2007). I will report work using an online homework system (WeBWorK) to implement this strategy for precalculus and calculus.

Lane-Harvard, Liz *University of Central Oklahoma*

Two Intersection Sets and Paley Graphs

General Contributed Paper Sessions: Graph Theory

Due to Delsarte's work, we know there are connections between two intersection sets and strongly regular graphs. Utilizing this connection, we construct two intersection sets in PG$(5, q)$, q odd, whose associated strongly regular graphs have the same parameters as, but are not isomorphic to, Paley graphs.

Langley, Christy *University of Louisiana at Lafayette*
Julie Roy, *University of Louisiana at Lafayette*

Achieving a Successful Active Learning Environment in an Online Math/Stat Undergraduate Course
Themed Contributed Paper Sessions: TCPS 11B - Cultivating Critical Thinking through Active Learning in Mathematics

This talk summarizes the benefits and obstacles in creating an active learning environment in online undergraduate courses. Our goal is to share with you what we have learned and the experiences we benefited from while creating and implementing fully online undergraduate math/stat courses. The different audiences we service include high school dual enrollment students, traditional on campus students and true distance learners. Each audience introduces its own challenges that must be met. We will address the shift in expectations and responsibilities for an online course of both the instructor and student compared to a traditional face to face class. This talk explores the shift in work load for both instructor and student through the timeline of a course. We will discuss the many types of communication needed for a successful online course. Finally, we will share our experiences with different types of delivery and assessments and how each of these topics affects the evolution of our active learning environment for students.

Lazowski, Andrew *Sacred Heart University*

Nested Sequences of Triangles in Non-Euclidean Spaces
General Contributed Paper Sessions: Geometry

For a given triangle, sequences of nested triangles obtained by iterative procedures have been examined in Euclidean space. The limiting behavior of sequences is known under certain conditions. We will provide an overview of such results and discuss generalizing the results to non-Euclidean spaces.

Leahy, Andrew *Knox College*

William Brouncker's Rectification of the Semi-Cubical Parabola
Themed Contributed Paper Sessions: TCPS 1C - History and Philosophy of Mathematics

One of Jackie Stedall's contributions to the history of mathematics was drawing attention to the work of William Brouncker. Though Brouncker is relatively unknown today, he was a mathematical collaborator of John Wallis and the founding President of Britain's Royal Society. Mathematically, he is perhaps best remembered for his work on continued fractions, but if you look carefully at his portrait in the National Portrait Gallery in London he appears to be pointing to a diagram showing his rectification of the semicubical parabola. Brouncker wasn't the first to solve the rectification problem, but his work, which followed immediately after William Neile's original result, is arguably much more algebraic and easier to understand than Neile's original proof. In this talk we will look at the details of Brouncker's solution to the rectification problem.

Lee, Duk-Hyung *Asbury University*

Wonders of 11 Stars: Mathematical Cultivations through Paper Folding
Themed Contributed Paper Sessions: TCPS 11A - Cultivating Critical Thinking through Active Learning in Mathematics

Kazuo Haga, a biology professor in Japan, discovered geometrical patterns and mathematics through paper folding exercises, called "origamics". He used paper folding as means of mathematical explorations. This talk gives a glimpse of Haga's effort in making mathematics more interactive and will discuss ways to make our classrooms more hands-on and inquiry-based learning environment.

Lee, Perry *Kutztown University of Pennsylvania*
Padraig McLoughlin, *Kutztown University of Pennsylvania*

An Assessment of Student-Centered Learning Across Multi-Sections of 'Large' College Algebra Classrooms: An On-Going Study
General Contributed Paper Sessions: Teaching or Learning Devlopmental Mathematics and Assessment

For the past four semesters, an active learning strategy using both the Flipped (or inverted) and the Inquiry-Based Learning (IBL) methods, or the F/IBL method, has been implemented into one of the author's 'large' College Algebra classrooms. During this past 2014/15 academic year (both the Fall 2014 and Spring 2015 semesters), student-learned

outcomes were assessed to determine the effectiveness of this F/IBL approach in his 'large' College Algebra classrooms compared to multi-sections other 'large' College Algebra classrooms that were taught using the traditional lecture-style methods. In these large multi-section classrooms, student scores were collected by prescribing two assessments during each of the Fall 2014 and Spring 2015 semesters: the pre-assessment and the post-assessment using Educational Testing Service's (ETS) standardized Elementary Algebra Skills Assessments (EAS). The presentation will highlight how this F/IBL method is implemented and managed into his 'large' classrooms. Also, a summary of assessment data based on student learned outcomes from those multi-sections of College Algebra classrooms that participated in the assessment study is presented.

LeVan, Mike *Transylvania University*

Pedagogical Strategies for Quantitative Reasoning, Literacy, and Writing for Non-Science Majors

General Contributed Paper Sessions: Teaching or Learning Introductory Mathematics, Part B

Mathematics classes for non-science majors (general education courses) tend to have high drop or withdrawal rates. The success rate for students has also been shown to be lower in these classes when compared to other math courses. While most students do not necessarily have to know how to take the derivative of a function to participate in every day life, every student needs the basic concept of Quantitative Reasoning (QR), Literacy (QL), and Writing (QW) to become an informed and effective citizen. These are the skills that need to be shown to non-science majors to finally answer their question of, "When will I ever use this?" or "What is this good for?" By presenting the material in a format in which non-science majors will be more comfortable, this leads to a higher appreciation of the skills needed in QR, QL, and QW. The material is taught to the students in such a way that the skills acquired can and should also be useful in classes across the curriculum. Topics include social justice, environmental science, and other topics that are accessible to students. This presentation will review various pedagogical strategies employed to introduce students to these skills. Some assessment shall be presented to show the effectiveness of the strategies.

Levine, Alan *Franklin and Marshall College*

A Surprisingly Simple Integral

General Contributed Paper Sessions: Teaching or Learning Calculus

In most calculus classes, students are taught to evaluate definite integrals by the Fundamental Theorem of Calculus. There are, however, many integrals for which this approach is either quite messy or impossible. We will look at one such example, for which there is a surprsingly simple solution.

Levine, Lionel *Cornell University*

Circles in the Sand

Invited Paper Sessions: AMS-MAA Invited Paper Session: The Arithmetic of the Spheres

I will describe the role played by an Apollonian circle packing in the scaling limit of the abelian sandpile model on the square grid $\mathbb{Z}^2$. The sandpile solves a certain integer optimization problem. Associated to each circle in the packing is a locally optimal solution to that problem. Each locally optimal solution can be described by an infinite periodic pattern of sand, and the patterns associated to any four mutually tangent circles obey an analogue of the Descartes Circle Theorem. Joint work with Wesley Pegden and Charles Smart.

Lewis, Albert *Educational Advancement Foundation*

"Another Big Book": I Grattan-Guinness as Editor and Organizer

Themed Contributed Paper Sessions: TCPS 1Q - Special Session in Memory of Ivor Grattan-Guinness

Grattan-Guinness's first large work was the three-volume *Convolutions in French mathematics, 1800-1840* (1990) while another was *The Norton history of the mathematical sciences: the rainbow of mathematics* (1998). As solo productions these showed his ability to carry out major projects on his own. However, he also had the ability to marshal the talents of other historians in collaborating on even larger projects. This required not only a certain degree of authority, but also the capability of effectively selecting and working with experts across the full range of history of mathematics. His techniques for garnering this cooperation, and his way of operating with publishers, resulted in the *Companion encyclopedia of the history and philosophy of the mathematical sciences* (2003) and *Landmark writings*

in Western mathematics 1640–1940 (2005). These skills were undoubtedly sharpened earlier by his experience as the editor of the journal *Annals of Science* from 1974 to 1981.

Lewis, Blair *Weber State University*

Geometry in Paintings: Where Two Dimensional Becomes Three Dimensional
Themed Contributed Paper Sessions: TCPS 6B - Mathematics and Art

In this presentation we will discuss the appearance of art in geometry focusing on paintings and drawings. Even though it is two dimensional art we perceive it as a three dimensional masterpiece. It is not just a matter of where to put a square, triangle or circle, but how they all interact together to grab our eyes (called emphasis). To drag our attention to the correct location and to make us see what is and is not there. We will discuss geometric techniques used in art such as: symmetry, scaling, optics, projection, and perspective.

Libertini, Jessica *Virginia Military Institute*

Coloring Inside the Lines: My Experiences Adding Modeling to an Existing DE Curriculum Without Sacrificing Content
Themed Contributed Paper Sessions: TCPS 18 - Using Modeling for Teaching Differential Equations: Before, During, After

As a required course for many scientists and engineers, DE courses often have a laundry list of "must-do" topics that fill the semester with little room to add anything let alone something as demanding as mathematical modeling. However, this presentation will showcase a counterexample - a DE course that took our school's existing (and full) schedule of topics and added modeling without subtracting a single topic. We found that modeling gave additional meaning and motivation to our otherwise traditional methods-based course. We also found that adding modeling did not require us to rush or reduce content; instead we were able to increase both the depth and breadth of material covered relative to the original course. In this presentation, we will share the story of our journey, our syllabus and teaching model, and student and faculty reflections. We will also encourage the audience to think about ways to add modeling to their own DE courses while still coloring inside the lines.

Lindsey, Chuck *Florida Gulf Coast University*

Doing Arithmetic in Medieval Europe
Themed Contributed Paper Sessions: TCPS 1C - History and Philosophy of Mathematics

The period between roughly 500 CE and 1000 CE is still a fairly obscure time in the development of mathematics in Western Europe. We will survey what is known about European mathematics during this interval, especially in terms of the development and dissemination of techniques for arithmetical calculation. Finally, we will look at the contributions of Gerbert d'Aurillac in the context of other contemporary developments in the art of calculation on the abacus and the influence of Gerbert's methods in the 11th and 12th centuries.

Liu, Sijie *University of Alabama*

A New Directed Interval Arithmetic
General Contributed Paper Sessions: Applied Mathematics

Interval arithmetic is an approach to provide us rigorous bounds in the presence of round of errors in mathematical computation. But one big drawback of interval arithmetic is overestimation because of the dependency problem. In order to improve the quality of computing enclosures of the range of functions, we address a new directed interval arithmetic. In an application, the new arithmetic is experimentally compared with the standard version of Interval arithmetic and the inner interval arithmetic.

Liu, Yaping *Pittsburg State University*

The Right Pascal's Triangle
General Contributed Paper Sessions: Geometry

We'll discuss the history of Pascal's triangle and various ways the triangle can be displayed. While the equilateral triangle display is pleasing to the eye, the right triangle display represents the combinatorial relations correctly. Dis-

playing the triangle in a coordinate system lends itself to the study of many interesting infinite sequences and the discovery of new patterns.

Lorch, Crystal *Ball State University*

Redesigning a Liberal Arts Math Course for Student Performance

Themed Contributed Paper Sessions: TCPS 16 - Curriculum Development to Support First Year General Education Mathematics Students

We discuss the recent large scale pedagogical redesign of Ball State University's liberal arts mathematics course, Mathematics and Its Applications (MAP). Given that MAP is the last collegiate math course many students take, and that on-time graduation plays such a significant role in Indiana funding metrics for its state universities, there is significant interest on the part of both faculty and university administration in improving student performance in MAP. Efforts to improve performance in MAP focused on increasing student engagement with higher-level course material, peers, and faculty. Flipping the classroom is a prominent feature of the redesigned course. In this presentation we describe the redesign process, the resources we have amassed for student use outside of class, the materials developed for in-class use, and how students are assessed for both preparation and understanding. We also provide a data-driven summary of the success of this redesign.

Luca, Magdalena *MCPHS University*

Supporting Students in Health Sciences

Themed Contributed Paper Sessions: TCPS 17 - Curriculum and Course Development to Support First Year STEM Students

At our university, students are enrolled in a variety of health sciences programs, from pharmacy and premed to dental hygiene, nursing, and physical therapy. Most mathematics courses are taught in the first two years by faculty in the School of Arts and Sciences. In the last decade, new courses were designed and significant curriculum changes were successfully implemented in all programs in order to address general student retention, motivation to do mathematics and success in obtaining professional licenses. This presentation will describe program-specific initiatives undertaken by the mathematics faculty: the development of several new courses such as "Math for Nurses", "Biostatistics", and "Business Math and Computer Applications"; the redesign of the Statistics course; and the creation of a Math & Physics Center. In addition, data supporting our students' improvement within first year mathematics courses and our nursing students' success in taking board exams will also be presented.

Lucas, Jason *Purdue University*

Loops and Operads: An Introduction

Graduate Student Session: Great Talks for a General Audience: Coached Presentations by Graduate Students, Part A

Why is a beach ball different from an inner tube? One obvious difference is that an inner tube has a hole in the middle, while a beach ball does not. This is easy to see just by looking at the two, but we can't always rely on pictures in mathematics. We need a rigorous way to define the idea of a "hole in an object". The basic way we do this is by drawing circles, or "loops", in these objects. If every loop we draw can be filled in with a solid disc without leaving the object we're considering, then it must not have any holes. This turns out to be a powerful idea in mathematics. In fact, loops of these kind have an entire algebra built around them. In this talk, we'll examine the question of detecting holes in objects. This will then tell us when two things, like a beach ball and an inner tube, are the same or different. To do this, we'll take a closer look at this algebraic structure of loops.

Ludwick, Kurt *Salisbury University*

Counting Melodies with Fibonacci Polynomials

General Contributed Paper Sessions: Interdisciplinary Topics in Mathematics and Modeling or Applications

In this talk we will consider the problem of enumerating all melodies of a specified length. Our main result is the discovery of a family of polynomials, $H_n(x)$, which gives us the number of melodies of length n beats with notes selected from a set of x pitch classes, where each note's duration is assumed to be a whole number of beats. The family $H_n(x)$ is generated via recursion, and is closely related to the family of Fibonacci polynomials.

Ludwig, Lewis *Denison University*

How You Too Can Join the 3D Printing Craze!

Themed Contributed Paper Sessions: TCPS 9 - What Can a Mathematician Do with a 3D Printer?

In November 2014 I saw a presentation on 3D printing by Laura Taalman and was immediately hooked. With next to no experience, by January 2015, I was leading a seminar of 12 students in a one-credit hour 3D Printing and Design class. In this presentation I will discuss the process of bringing a 3D printer to our campus, the freeware software used by my students, several of our successful and unsuccessful design projects, and some of our lessons learned. This presentation is accessible to anyone interested in 3D printing or designing a 3D printing class.

Luo, Qinghua *Marian University*

Identification Problem for Klein-Gordon Equation

General Contributed Paper Sessions: Applied Mathematics

We consider a damped Klein-Gordon equation with a variable diffusion coefficient of the form

$$u_{tt}(t,x) + \alpha u_t(t,x) - \nabla(\beta(x)\nabla u(t,x)) + \delta g(u(t,x)) = f(t,x)$$

where the diffusion coefficient $\beta(x)$ is Lipschitz continuous. The goal is to derive necessary conditions for the optimal set of parameters minimizing the objective function J. First, we show that the solution map is continuous. Then the solution map is shown to be weakly Gateaux differentiable on the admissible set P, implying the Gateaux differentiability of the objective function. Finally we study the Frechet differentiability of J and optimal parameters for these problems. Unlike the sine-Gordon equation, which has a bounded nonlinear term, Klein-Gordon equation requires stronger assumptions on the initial data.

Lynch, Frank *EWU*

Leaf Hydraulic Conductance: Modeling Geometry

Themed Contributed Paper Sessions: TCPS 4 - Undergraduate Research Activities in Mathematical and Computational Biology

The total hydraulic conductance in the tank bromeliad *Guzmania lingulata* can be characterized as having axial and radial components. This work aims to decompose a measured value of total hydraulic conductance into its axial and radial components. We examine a modified model which accounts for the geometry of the leaf. The desired decomposition requires the solution of a second order initial value problem where an unknown parameter is selected to satisfy a third boundary condition. The unknown parameter is used to characterize the ability *G. lingulata* to conduct water through its radial pathway. A portion of this research was completed with undergraduates.

M

Ma, Yanping *Loyola Marymount University*

Interdisciplinary Teaching: The Mathematical Component of Ecology of Homelessness

PosterFest 2015: A Poster Session of Scholarship by Early Career Mathematicians and Graduate Students

Students were exposed to the diversity of the homeless population in America in an attempt to educate beyond the stereotypes of homelessness, and were engaged in computational laboratory and fieldwork experiences that simulated research in community health science and urban ecology. Mathematical sessions prepared students in modeling. Group projects used math/stat tools and created solutions for local services facilities, such as food and service map (Voronoi tessellation), data for volunteer program (regression analysis) and epidemiology.

Mabrouk, Sarah *Framingham State University*

Reflection Paper, Poster, and Presentation: A Unique Final Examination Experience for a Liberal Arts Mathematics Course

General Contributed Paper Sessions: Teaching or Learning Introductory Mathematics, Part B

At Framingham State University, MATH 119 Mathematics for the Liberal Arts is a general education mathematics course commonly taken by students who are not required to enroll in a specific mathematics course for their major.

Many of the students taking the course do not like mathematics, and most view mathematics as serving little or no purpose in their program of study, future career, or life. In a semester during which I taught both sections of the course using group projects and an assortment of topic-related assignments, I used a reflection paper, poster, and presentation in place of a traditional final examination. In this presentation, I will discuss the requirements for each component of this alternate final examination experience, student outcomes and surprises, and instructor challenges and delights as well as share pictures from the reflection presentation and poster sessions.

Mak, Matthew *ACS Independent*
Suling Lee, *ACS Independent*

A New Approach to Chinese Chess Knight's Tour Using Gauss' Area Formula

Themed Contributed Paper Sessions: TCPS 5A - Recreational Mathematics: New Problems and New Solutions

The Knight's Tour has been a recreational muse for many mathematicians throughout history. Leonhard Euler was the first to make an attempt to write a mathematical paper analyzing Knight's Tour in 1759. Subsequently, the highly popular Warnsdorff's Rule was then presented in 1823. This paper presents a Chinese Chess Knight's Tour using Gauss' area formula, or commonly known as shoelace algorithm. Tie-breakers as well as differences between this simple new approach and the Warnsdorff's Rule will be analyzed and presented in the paper.

Malec, Sara *Hood College*

Problem Exists Between Keyboard and Chair: Filling in the Gaps in Online Homework

General Contributed Paper Sessions: Teaching or Learning Introductory Mathematics, Part B

Online homework systems sometimes allow students to skip steps in their development of conceptual understanding. In particular, a multiple-choice question asking a student to select the graph of a function may not necessarily require them to correctly analyze the first and second derivatives of the function in order to answer correctly. In a finite math and calculus class designed primarily for business majors, a series of paper assignments was introduced to encourage better habits without requiring significant additional grading time. I will discuss the results of adding these assignments on student understanding, as measured through analyzing student responses to common final exam questions.

Manafu, Alexandru *IHPST Paris*

Does the Indispensability Argument Leave Open the Question of the Causal Nature of Mathematical Entities?

Themed Contributed Paper Sessions: TCPS 1J - Special Session on Philosophy of Mathematics

Colyvan has claimed that the indispensability argument leaves open the question of the causal nature of mathematical entities (2001, p. 143). He defended this position by arguing that not all explanations are causal, and that some mathematical entities may play important explanatory roles even though they are causally idle in the ontology (in the sense that they do not interact with the particulars posited by that ontology). I argue that Colyvan cannot maintain such an open attitude. I formulate an argument which shows that even if one grants the existence of mathematical entities which are explanatorily indispensable but causally idle in the ontology, Colyvan's conclusion still doesn't follow. If sound, the argument I offer shows that the question of whether the indispensability argument delivers causally active entities becomes settled. This result rehabilitates an argument offered previously by Cheyne and Pigden (1996). References Cheyne, C., and Pigden, C. (1996) Pythagorean Powers or a Challenge to Platonism, Australasian Journal of Philosophy, 74(4): 639-645. Colyvan, M., 2001, The Indispensability of Mathematics, New York: Oxford University Press

Mansour, Hassan *El Centro College*
Mike Panahi, *El Centro College*
Dale Pearson, *El Centro College*

Initial Condition and Stability of Differential Equations

General Contributed Paper Sessions: Applied Mathematics

Existence and uniqueness, and sensitivity of the solution of an initial value problems is a fundamental issue in theory of differential equations. When a differential equations is been used to model the real world problem the exact initial value(s) is generally an unknown factor. Instead, we may have to use a small rang of possible initial values. It is

important to know whether the solution that are near each other at initial point remain close together at neighborhood. We examine these issues using a numerical approach and MATLAB.

Mantell, Abraham *Nassau Community College*

Coordinating a State-Wide Math Contest

Themed Contributed Paper Sessions: TCPS 3 - Math Circle Problems Involving the Number 100 in Honor of the MAA's 100th Anniversary

The particulars of coordinating the New York State Mathematics Association of Two-Year Colleges Math League will be addressed. Several past problems will be presented, particularly those involving the number 100, in honor of the MAA's centennial celebration.

Marciniak, Malgorzata *CUNY*

Elementary Approach to End Compactifications

General Contributed Paper Sessions: Analysis and Other

Ends, originally introduced by Freudenthal in 1931, found a number of applications, for example in analysis or graph theory. Recently they were of interest for nonstandard analysis as an interpretation of "remote points". During my talk I will present an elementary way of seeing ends and end compactifications.

Maritato, Kevin *Suffolk County Community College*

Gender and the Pursuit of Mathematics: An Examination of the Participation Gap in Math Careers

Themed Contributed Paper Sessions: TCPS 2B - The Contributions of Women to Mathematics: 100 Years and Counting

Despite the fact that the performance gap between males and females in mathematics has been closing in recent decades, due in large part to efforts to improve the equality of educational opportunities for boys and girls in STEM fields at young ages, there remains a large participation gap between adult men and women in mathematical fields. This gap first becomes noticeable at the post-secondary level, with the difference in numbers between male and female mathematics majors, and grows at each level of the academic pyramid, spanning through math masters and PhD programs to non-tenured and finally tenured math research faculty. There are many possible explanations for the disparity in the numbers of male and female mathematicians, most of which are based in the stereotyping of mathematics as a male field. We will discuss several of these explanations, as well as potential steps that might be taken to mitigate the influence of stereotypes and help keep more female students interested in pursuing careers in math.

Maroncelli, Dan *Concordia University St. Paul*
Jesus Rodriguez, *North Carolina State University*

Periodic Behavior of Nonlinear 2nd Order Discrete Dynamical Systems

General Contributed Paper Sessions: Analysis and Other

In this work we provide conditions for the existence of periodic solutions to nonlinear, second-order difference equations of the form $y(t+2)+by(t+1)+cy(t)=g(t,y(t))$ where $c \neq 0$, and $g:\mathbb{Z}^+\times\mathbb{R}\to\mathbb{R}$ is continuous and periodic in t. Our analysis uses the Lyapunov-Schmidt reduction in combination with fixed point methods and topological degree theory.

Marquis, Jean-Pierre *Université de Montréal*

Designing Mathematics: the Role of Axioms

Themed Contributed Paper Sessions: TCPS 1J - Special Session on Philosophy of Mathematics

The use of axioms in mathematics was more or less reintroduced in the 19th century and became a central tool at the end of that century and at the beginning of the 20th century. Already during this period, axioms had different functions. For Hilbert, it is first a tool for conceptual clarification and then, a more general tool for conceptual analysis. The American postulationists used axioms as logical knives and cutters. Noether and others introduced the axiomatic method and a way of abstracting, unifying and simplifying large portions of mathematics. My claim in this talk is that some mathematicians started using the axiomatic method not only in a new context, namely the context of categories, but that they also put the axiomatic method to a new usage. I will concentrate on Grothendieck's introduction of a

host of types of categories, e.g. abelian categories, derived categories, triangulated categories, pretoposes, toposes, etc., in his quest to prove Weil's conjectures. In Grothendieck's head, the abstract character of the concepts involved is taken for granted and the purpose of the axiomatic method is primarily to construct the proper context for some tools, namely cohomological theories, to be used properly. Although Grothendieck's work marks a radical shift in mathematical style and some might even want to talk about a paradigm shift, he was soon followed by others who showed how this could be done for other problems. I will argue that this usage of the axiomatic method must be seen as an instance of *conceptual design*. The latter expression underlines the artifactual dimension of these parts of mathematics, as emphasized by Grothendieck himself, and allows us to contrast mathematical knowledge from scientific knowledge.

Marshall, Susan *Monmouth University*

Quaternions in Action

Themed Contributed Paper Sessions: TCPS 8 - Mathematics in Video Games

Quaternions, discovered in the mid-19th century, are a four-dimensional generalization of the complex numbers. Their interpretation as three-dimensional rotations leads to many modern applications in areas such as spacecraft flight, CGI animation, and the computer graphics in modern video games. We'll explore how to introduce students to quaternions in a range of courses (such as complex analysis or abstract algebra), using the motivating factor of video games.

Martin, Andy *Kentucky State University*

A Small Adjustment to the Definition of the Limit of a Function

Themed Contributed Paper Sessions: TCPS 19B - Innovative Approaches in the Calculus Sequence

We all remember how, with some functions, the determination of a delta in answer to a given epsilon required the clunky, "Well, if epsilon is greater than 19, then...". Since the essence of the limit is in epsilon's smallness, it is irritating that large values must be pointlessly examined. In this talk I will present an alternative definition avoiding this digression. I will also provide proof that this new definition is equivalent to the traditional Weierstrassian one.

Martin, Andy *Kentucky State University*

Euler's OTHER Constant

Themed Contributed Paper Sessions: TCPS 1E - The Mathematics of Euler

The base of the natural logarithm is the most commonly used constant which might fairly claim Euler as its eponym. But what of the constant γ (gamma), also laughably referred to as Mascheroni's constant? This talk will describe Euler's earliest published discussion of gamma, and explain how Lorenzo M. got his name in the history books.

Martin, Julia *SUNY Oswego*

Bats, Ecology and Public Health

PosterFest 2015: A Poster Session of Scholarship by Early Career Mathematicians and Graduate Students

In 2000 the Bats in the Bedroom policy changed to having all bats caught in the home while someone was in the room were to be taken and tested for rabies. What is the probability that a bat caught and tested had rabies and what is the transmission rate from bat-to-human related to these results? And has this policy change been effective? In 2006/2007 the bat population began to struggle with white nose syndrome in New York State. By 2009 this disease decreased the bat population by 90% from the 2006 estimates. How has this decrease in population affected rabies testing and results?

Martin, Susan *Kentucky Employers' Mutual Insurance*

Polygonal Numbers from Fermat to Cauchy

Themed Contributed Paper Sessions: TCPS 1P - History and Philosophy of Mathematics

In 1638, Fermat conjectured that every positive integer is a sum of at most three triangular numbers, four square numbers, five pentagonal numbers, and, in general, n n-gonal numbers. This talk will focus on the eventual proof by Cauchy in 1813, which promoted the conjecture to a theorem.

Massell, Paul *U.S. Census Bureau*

Using the Mathematical Sciences to Protect Data

General Contributed Paper Sessions: Probability or Statistics

Using the Mathematical Sciences to Protect Data Federal statistical agencies and many other organizations are interested in learning about various populations, e.g., of people, households, and companies. They collect data about these populations in various ways, e.g., via surveys (paper or online), or from administrative forms. The goal of the organization is often to create statistical information of use to itself, other organizations, researchers, or the public. In most cases the organization wants to protect the confidentiality of the data; i.e., not disclose individual-level information. This has led to a subject called statistical disclosure control. An interesting aspect of this subject is that it uses techniques from several of the mathematical sciences. For decades, simple ideas from probability and statistics have been used, e.g., in methods such as adding noise to actual data. Noise can be generated with a standard random number generator or by using Markov matrices. Methods from operations research, such as linear and integer programming, are often used for protecting sensitive cells in magnitude data tables. In the past decade, privacy protection has become a 'hot' topic among computer scientists. They have added some sophisticated approaches and methods (ref1: C. Dwork and A. Roth) to those developed by statisticians. Courses on statistical disclosure control are now being developed that discuss all these approaches (ref2: P.B. Massell). References: 1. www.cis.upenn.edu/~aaroth/Papers/privacybook.pdf 2. apps.ep.jhu.edu/course-homepages/3494-625.468-statistical-privacy-protection-in-large-datasets-massell

Masuda, Shigeru *Kyoto University*

The Derivative Productions of Classical Heat Analyses

General Contributed Paper Sessions: History or Philosophy of Mathematics

We discuss the derivatives of classical wave/heat analyses, based on the books : Prévost 1792, Physico-Mechanical Researches of the Heat, Fourier 1822, Analytic Theory of the Heat, and Poisson 1835, Mathematic Theory of the Heat and finally Poincaré 1895 Analytic Theory of Propagation of Heat. In this 18–19 century, the conception of continuum is introduced at first by Laplace, many mathematician challenge the physico-mathematical problems. One in Prévost's essay on heat is the communication theory of heat, which becomes Fourier's main and initial motif in his scholar life. After Laplace, Fourier and Navier, et al. participate in these studies, and Fourier puts forth the trigonometric series in the process of building the heat theory, including communication theory and the theory of heat motion in fluid. Navier establishes the equations of hydrodynamics. In the rivalry with Fourier, Poisson puts forth with his personality independent of Fourier, the digressions on the mathematics : these are his characteristic, namely, on the mathematical analysis of the integral, the partial equations, and the trigonometric series. Poisson traces many historical facts of the origins of the wave equations including the trigonometric series by the trailblazers such as Euler, Lagrange, Laplace, Fourier, etc. Dirichlet follows up the Fourier's problem, and Sturm- Liouville follow up Poisson's problems. Poincaré puts forth many conceptions of pure analysis from the viewpoint of up-to-date mathematical physics. In these current of developments, many derivatives are brought out, namely the trigonometric series, concept of eigenvalue and eigenfunction of Hilbert, etc. We talk about these derivatives of wave/heat problems.

Matsko, Vincent *University of San Francisco*

Fractals, Linear Algebra, Python, and Sage: A Linear Algebra Course for Computer Science Majors

General Contributed Paper Sessions: Teaching or Learning Introductory Mathematics, Part B

At the University of San Francisco, undergraduate computer science majors take a course entitled "Linear Algebra and Probability." Using Sage as a platform where the geometry of linear transformations can be dynamically illustrated using iterated function systems is effective in engaging CS majors in learning linear algebra. In addition, having students modify Python programs to produce their own two- and three-dimensional fractals allows CS majors to see a visual application of concepts in linear algebra.

Matsko, Vincent *University of San Francisco*

Randomness and Structure in Computer-generated Art and Design

Themed Contributed Paper Sessions: TCPS 6B - Mathematics and Art

Pseudo-random number generators allow for the creation of random elements in computer-generated art and design. Too much randomness, however, results in work which is disconnected and incoherent. In this talk, we explore several ways to control the use of randomness in computer-generated work.

Mauch, Elizabeth *Bloomsburg University*

Rural STEM Model

General Contributed Paper Sessions: Mentoring and Outreach

Bloomsburg University of Pennsylvania (BU) sits in the heart of "coal country" in central Pennsylvania. The region has been ravaged by the lack of opportunities for big business to thrive since the collapse of the coal industry nearly half a century ago. Today, many of the school districts are small and while they have challenges, those challenges do not mirror those on the national stage. Many students are not challenged in math or science classes because there simply are not enough resources in any given school district to engage students in such a way that would give them the skills they need to succeed in a STEM major in college. BU has partnered with eleven local school districts where junior and seniors from their local school districts come together to take STEM courses at the university, where they can be challenged by their peers. Students are also given additional assistance with study and coping skills. Local businesses act as mentors to the students.

McHugh, Maggie *La Crosse School District*
Jennifer Kosiak, *University of Wisconsin-La Crosse*

Active Learning through Formative Assessments

Themed Contributed Paper Sessions: TCPS 11B - Cultivating Critical Thinking through Active Learning in Mathematics

Active learning strategies have been shown to be effective in both enhancing the engagement of the learner and the learner's content understanding. This talk will specifically focus on active learning through the use of formative assessments. From Frayer models to commit and toss, we will share numerous strategies to engage students enrolled in any level of mathematics courses. Student work samples will highlight the use and effectiveness of these learning strategies in promoting conceptual understanding and procedural fluency.

McLeod, Jillian *U.S. Coast Guard Academy*
Naiomi Cameron, *Lewis & Clark College*

On the Number of Hills Among Generalized Dyck Paths

General Contributed Paper Sessions: Graph Theory

It is well known that Dyck paths without hills (that is, ground level subpaths of the form UD) are counted by the Fine numbers, with generating function $F(z) = \left(1 - \sqrt{1-4z}\right)\left(3z - z\sqrt{1-4z}\right)^{-1}$ [**?**]. The main object of study in this paper is a generalization of the Fine number sequence. We let $F_t(z)$ denote the generating function for the number of generalized Dyck paths without hills (that is, minimal length subpaths of the form $U^{t-1}D$). When $t = 2$, $F_t(z)$ corresponds to the Fine number sequence and when $t = 3$, $F_t(z)$ gives the number of ternary paths with no hills; that is, paths from $(0,0)$ to $(3n,0)$, using steps of the form $U(1,1)$ and $D(1,-2)$, never going below the x-axis and having no hills. We consider a question posed by L. Shapiro circa 2009: "What is the asymptotic proportion of Dyck paths having an even number of hills?" We provide an answer to this question for generalized Dyck paths, finding in the case when $t = 3$ that the probability of a ternary path having an even number of hills approaches $125/169$ as path length approaches infinity. We give a limiting distribution for the number of hills among generalized Dyck paths. We also consider a generalization of the following identity: $(2z + z^2)F^2(z) - (1 + 2z)F(z) + 1 = 0$, for which a combinatorial proof was provided in [Cheon]. We generalize the result to $F_t(z)$ in the following way $1 + zF_t^t(z) = \sum_{k=0}^{t-1}\left[\binom{t-1}{k} + \binom{t}{k+1}z\right](-1)^k z^k F_t^{k+1}(z)$ and explore various combinatorial interpretations of the results.

McSweeney, John *Rose-Hulman Institute of Technology*

Teaching Quantifiers via Map Coloring

General Contributed Paper Sessions: Teaching or Learning Advanced Mathematics

A common stumbling block for students in post-calculus mathematics is understanding the abstraction inherent in statements with quantifiers. Indeed, the main reason why rigorous epsilon-delta definitions of limits are not routinely taught in introductory calculus is the difficulty in untangling the multiple quantifiers that such precise statements require. When introducing quantifiers in a discrete math course, I expected that epsilon-delta limit definitions would

be a natural motivation, but many students got lost in the combination of logic and algebra and did not have the necessary intuition to work through the problem. Map coloring, however, is an idea that all students can grasp, and the fundamental coloring theorems inevitably involve statements with multiple quantifiers, such as "for all maps m, there exists a 4-coloring of m such that for all pairs (x,y) of neighboring countries of m, x and y have different colors". Exercises involving modifying or negating such statements then follow easily on a very intuitive level.

Meade, Douglas *University of South Carolina*
George McNulty, *University of South Carolina*
Nieves McNulty, *Columbia College*

Spinout, The Brain, Gray Code, and 100

Themed Contributed Paper Sessions: TCPS 3 - Math Circle Problems Involving the Number 100 in Honor of the MAA's 100th Anniversary

Spinout and the Brain are two classic puzzles with a common theme: both are based on Gray codes. This presentation focuses on the Gray code, including its history and applications (not just fun puzzles) in a format suitable for use with a Math (Teachers') Circle. In recognition of the MAA's 100th anniversary, we will certainly learn that 100 is the 5th number in Gray code; we might even find some time to determine how to determine the 100th number in the Gray code.

Meadows, Alex *St. Mary's College of Maryland*
Casey Douglas, *St. Mary's College of Maryland*

What Isn't an Ellipse?

General Contributed Paper Sessions: Geometry

A multifocal ellipse is a set of points in the plane whose average distance to n focal points is a given constant ($n = 1$ and $n = 2$ giving circles and ellipses). In this talk we explore general ellipses whose foci are given by arbitrary sets. With this generalized definition, we attempt to answer the question, "Is there anything that is not an ellipse?"

Meadows, Leslie *GSU - Dept. of Mathematics and Statistics*

Iteratively Regularized Gauss-Newton Method for Applied Inverse Problems

General Contributed Paper Sessions: Applied Mathematics

We are examining the Iteratively Regularized Gauss-Newton Method for solving nonlinear inverse problems. We are particularly interested in utilizing this technique for unstable application problems. Classical algorithms tend to be divergent for these types of problems and, therefore, special methods of numerical analysis are necessary.

Mealy, J. *Austin College*
Malin Pappas, *Austin College*

Angle-of-Parallelism Spectra in Non-Homogeneous Geometries

General Contributed Paper Sessions: Geometry

Though the dynamics of parallels in the classical homogeneous geometries E^2, H^2, and S^2 are well known, we re-engage these ideas in the context of some new language. After said language is established, we undertake a study of parallelism in various non-homogeneous geometric systems. Specifically, we consider in detail a particular 'double cone point' system; a natural foliation of the space stemming from this new language is illustrated. We also consider systems described, for example, via staircase metric geometry. Further directions in the work are outlined.

Mei, May *Denison University*

Product and Process: Writing Portfolios and Feedback in Introduction to Proof Techniques

Themed Contributed Paper Sessions: TCPS 12 - Improving Undergraduate Math Writing

Denison University adopted a new writing program in 2013. One of the tenants of the program is that students "regard writing as both a product and a process." That is, they recognize that the goal of writing is not only the written product at the end but also the process of editing and revision. In this talk, we discuss adapting an Introduction to

Proof Techniques class, taught with the Book of Proof, to include weekly feedback meetings and repeated revision culminating in a proof portfolio.

Melville, Duncan *St. Lawrence University*

Approaches to Computation in Third Millennium Mesopotamia

Themed Contributed Paper Sessions: TCPS 1N - History and Philosophy of Mathematics

Mesopotamian mathematics was profoundly computational. The goal was always to compute some quantity. How the processes to achieve those goals were conceived, and how scribes approached different kinds of computations in different domains has been a topic of recent scholarly debate. In this talk we will discuss what is known about computational techniques at various points in the development of abstraction of the concept of number during the third millennium.

Merchant, Sandra *University of British Columbia*
Wesley Maciejewski, *University of Auckland*

Assessing the Cognitive Levels of Exam Problems in Mathematics: A Comparison Across Years

Themed Contributed Paper Sessions: TCPS 10 - The Scholarship of Teaching and Learning in Collegiate Mathematics

Since its original publication in 1956, Bloom's taxonomy has become the predominant tool for analyzing the cognitive demands of educational tasks. In this project, we used Bloom's taxonomy to categorize problems appearing on final exams, for a large selection of mathematics courses at all year levels. We found that, compared to lower-division courses, upper division (300 and 400-level) exams included more problems that required higher-level cognitive skills. In addition, in comparison to 100-level exams, there was greater variability in the distribution of cognitive levels, both between-exams and within-exam, for upper division courses. First-year courses consisted of problems almost exclusively at the "apply" cognitive level, whereas upper-division exams contained more problems both at lower ("remember" and "understand") and higher ("evaluate" and "create") levels. We also present some preliminary work that attempts to link these findings to individual instructors' goals when constructing final exams.

Michael, T. S. *United States Naval Academy*
Val Pinciu, *Southern Connecticut State University*

How to Add Guards to an Art Gallery

General Contributed Paper Sessions: Geometry

The floor plan of an art gallery is a polygon with n vertices. We want to post stationary guards (or security cameras) so that every point in the gallery is visible to at least one guard. The art gallery theorem asserts that we never require more than $n/3$ guards. We obtain a similar theorem for the situation in which some guards are already in place – perhaps in inefficient locations – and we want to post as few additional guards as possible.

Mickens, Ronald *Clark Atlanta University*

"The Teacher and the Mentor: A Combination that Instills Mathematical Greatness"

Invited Paper Sessions: Special Session: "Notes of a Native Son": The Legacy of Dr. Abdulalim A. Shabazz (1927-2014)

What are the characteristic attributes of a great teacher? What is an effective mentor? In this talk, we will examine these and related issues through the lens of the life and career of Professor Shabazz. We will share the influence he had (and still has) on his many students and colleagues who have now gone on to enhance the mathematical horizon.

Mihalisin, James *JedMDesigns*

"iFlakes": Interactive Line Designs for iOS

Themed Contributed Paper Sessions: TCPS 6B - Mathematics and Art

The free iOS app "iFlakes" interactively produces 6-fold symmetric designs. (Available on the App Store for your iPhone or iPad, just search on "iFlakes".) I'll briefly describe the inspiration for these compass and straight edge designs from the string art of the 70's through Dale Seymour's excellent text "Line Designs". We'll then talk about the plane geometry basis for the designs and the combinatorial possibilities for various iFlake bases.

Mihram, G. Arthur *University of Southern California*

More of 1915: Why is Mathematics Continually Deemed So Essential to Science?

General Contributed Paper Sessions: History or Philosophy of Mathematics

Science is that human activity devoted to the search for the very explanation for (i.e., for the truth about) any particular naturally occurring phenomenon. Investigating the titular question is initiated well with Quinn [AMS NOTICES, January 2012]: Mathematics is not Science since their criteria for validity differ: respectively, internal vs. external (to the presentation/model). A student appreciates that mathematics yields statements/conclusions which are true (We add: are irrefutably true.); yet, classroom assessment techniques serve to ask students whether mathematics is either (A) sufficient or (B) necessary for Science. (A) At our MAA's Centenary's outset, More (Dean, Arts/Sciences, Cincinnati University) noted that the language of mathematics is not [sufficient for] Science since it "deals with abstractions and ignores concrete phenomena" [LIMITATIONS OF SCIENCE, N.Y.: Holt, 1915]. (B) Neither is mathematics necessary for Science: e.g., Darwin and, notably, Nobel Laureate KZ Lorenz [NATURWISSENSCHAFTEN, January 1973]. But, isn't mathematics one alternative language for the presentation by a scientist of his/her explanation/model? Conclusion: The longstanding requirement for mathematics in the secondary/tertiary curriculum is, importantly, a modern-day recognition of the ancient Greeks' own appreciation of the value of mathematical education: viz., to discipline the mind of the adolescent to reach logical, hopefully irrefutable, conclusions throughout life.

Miller, J. Lyn *Slippery Rock University*

"Reverse Engineering" to Strengthen Critical Thinking for Pre-Service Teachers

General Contributed Paper Sessions: Teaching or Learning Introductory Mathematics, Part B

In mathematics content courses for future elementary teachers, problem styles are often modeled on those given to elementary school children. But such encounters are frequently algorithmic, which can inhibit or skew the opportunity to think critically about the concepts. Methods-based work-arounds can be premature for freshman or sophomore level teacher candidates. Another option is to challenge them with "reverse problems": problems that ask the future teachers to analyze or construct "input" necessary to arrive at a desired "answer" to a somewhat standard problem. Examples involving place value, statistics, probability, arithmetic properties, and number sentence terminology will be presented.

Mimbs, Debra *Lee University*

Integrating Mathematics and Biology Through Mathematical Modeling

Themed Contributed Paper Sessions: TCPS 4 - Undergraduate Research Activities in Mathematical and Computational Biology

Mathematical modeling is a useful tool for integrating mathematics and biology. Through offering a course in Mathematical Modeling which satisfies an upper division requirement for both mathematics majors and biology majors, we have been able to encourage collaboration among students between the two divisions. The structure and results of this course will be discussed. Additionally, this course has a research requirement, through which we have had multiple students present their research at regional and national conferences. Notable research topics and results will also be discussed.

Mishra, Vikash *University of Arkansas*
Craig Mclean, *University of Arkansas*

Unique Algebraic Structure to Connect Nanoscale Instance from Mesoscale Material Behavior

General Contributed Paper Sessions: Interdisciplinary Topics in Mathematics and Modeling or Applications

The prediction of mesoscale material behaviour using nanoscale structure is a critical aspect to the advancement of many science and engineering disciplines. However, the contemporary methods used to determine these properties require extensive computational resources. To overcome this difficulty, we have attempted to elucidate this information by algebraic means. We have proposed a unique group representative to a material's structure, in which the instances of the group interacted amongst each other. This group contains a mapping set binary operation acting on the instances that mathematically relate the physical aspects of the system. Later, finite element methods were used to build the collective interaction network to predict mesoscale properties.

Mohr, Austin *Nebraska Wesleyan University*

Introducing the Pi-Base: An Interactive Encyclopedia of Topological Spaces

General Contributed Paper Sessions: Mathematics and Technology

Is every first countable, separable space also second countable? The Pi-Base currently produces twelve topological spaces that contradict this seemingly plausible claim. Standing on the shoulders of Lynn Arthur Steen and J. Arthur Seebach, Jr.'s superb text "Counterexamples in Topology", the Pi-Base offers users powerful search, automated deduction, and collaboratively-edited proof. The purpose of this presentation is to demonstrate the features of the website and reflect upon how it can enrich your course in general topology. Even if you cannot attend, we hope you will sign up for a free account at http://topology.jdabbs.com to see how you and your students can learn from and contribute to the project.

Molinsky, Michael *University of Maine at Farmington*

Some Original Sources for Modern Tales of Thales

Themed Contributed Paper Sessions: TCPS 1N - History and Philosophy of Mathematics

There are many recent history of mathematics books written for general audiences that provide information and anecdotes about the ancient Greek mathematician, astronomer and philosopher Thales of Miletus, and in some cases these books even include quotations which are ascribed to Thales. But these general resources do not always include citations to the ancient sources from which these stories are being drawn. This talk will provide a brief outline of some stories about Thales that appear in modern publications, tracing each item back to much older, existing sources.

Molitierno, Jason *Sacred Heart University*

Analyzing Distributions by Visualization in a Probability and Statistics Class

General Contributed Paper Sessions: Probability or Statistics

In a Probability & Statistics class for math majors, students learn about various discrete and continuous distributions such as binomial, negative binomial, Poisson, exponential, normal, and some joint distributions. In this talk, I discuss Excel projects in which students must graph each distribution with several different parameters. Students are then asked to analyze, in light of the graphs, how the parameters affect the graphs and why this is so. I will discuss both the successes and failures associated with this project and improvements I am making.

Montgomery, Aaron *Baldwin Wallace University*

Extracting Mathematical Pedagogy from Video Games

Themed Contributed Paper Sessions: TCPS 8 - Mathematics in Video Games

Most video games have specialized sets of rules that define how the player interacts with the surrounding objects and environments. In order to explain how to play the game (ideally without large blocks of text), game designers employ pedagogical tactics to convey the necessary mechanics. These teaching tactics are applicable well beyond the artificial constructs of the video games, and many of them can be directly applied to the art of mathematical instruction. In this talk, we will explore some of these tactics and will discuss how to borrow pedagogical elements from games like Portal, Braid, and Super Meat Boy to improve our undergraduate mathematics classrooms.

Moore, Angela *Yale University*

Beal's Conjecture vs. "Positive Zero", Fight

General Contributed Paper Sessions: Number Theory and Logic or Foundations

This session hopes to prompt a mathematical discussion concerning a prospective solution to the Beal Conjecture. It deconstructs one of the most challenging equations in the world and pushes participants to challenge the basic foundation of Number Theory. In particular; it incorporates basic Computational Number Theory, benefits from the number one's lack of prime factors and provides an in-depth analysis of signed zero in-order to present a prospective disproof of the Beal Conjecture.

Moreno, Luis *SUNY Broome Community College*

Where Is the Hypergeometric Distribution Used (Besides Card Games)?
General Contributed Paper Sessions: Applied Mathematics

Statistical quality control is a rich source of applied mathematics that is hardly known to the undergraduate STEM student. We will describe how the hypergeometric probability distribution is perfectly suited to the question of deciding whether or not a lot of N items should be accepted from a supplier. The problem is that there is always an unknown number of defective items lurking somewhere in the lot. We will also discuss how to grapple with huge numbers when N is large.

Morgan, Frank *Williams College*

What's It Like to Be Editor-in-Chief of the Notices of the American Mathematical Society?
General Contributed Paper Sessions: Mentoring and Outreach

I'm about to find out (starting with the January 2016 issue). I'd like to express some of my hopes for interesting, readable articles and an online comments blog, and I'd like to hear your concerns and suggestions.

Morrow, Margaret *SUNY Plattsburgh*

From Scratch to Proof: Preliminary Report
Themed Contributed Paper Sessions: TCPS 10 - The Scholarship of Teaching and Learning in Collegiate Mathematics

In my Inquiry-Based-Learning Abstract Algebra class, all students are required to submit "scratch-work" for proofs the day prior to presentation in class; I provide feedback (electronically) within a few hours to try to assist the students in structuring their final proofs. This study explores the difficulties that students have in constructing proofs (as revealed in this scratch-work) as well as the subtleties of providing effective feedback to the students. Difficulties students have include issues related to logic and concepts, as well as the difficulty of transforming the "key idea" of a proof into a well-written mathematical proof. I will present examples of scratch-work submitted by students, analyze some of the difficulties, and consider the kinds of prompt that were and might be given as feedback. A major goal of the study is to ultimately gain evidence-based insight into what kinds of prompts would most effectively promote student progress.

Moss, Erin *Millersville University of Pennsylvania*

Promoting Student Understanding of Properties of Logarithms
General Contributed Paper Sessions: Teaching or Learning Introductory Mathematics, Part A

Many students in introductory mathematics courses lack interest in the subject matter and the understanding of how to effectively learn mathematics. Traditional lecture-style teaching allows the opportunity for them to mentally disengage from the material. To help these students become active participants in their learning, I experiment with class activities that require students' focused attention and provide less opportunity to zone out. One area of struggle for college algebra and pre-calculus students is correctly applying the properties of logarithms. Even if the properties are memorized flawlessly, or even provided for the students, I repeatedly come across several common errors in their work — for instance, rewriting $\log_a(u+v)$ as $\log_a u + \log_a v$. In this presentation, I share an activity designed to engage students in looking more critically at these properties via an investigation of examples worked by students from a previous semester. They must work in small groups to decide which of the given examples are equivalent and justify their responses. Having students look critically at other students' work can help them develop a discerning eye regarding whether applying a particular property is appropriate. Even the strongest students find the task to be a significant challenge.

Mou, Libin *Bradley University*

Area Bounds of Covers of Unit Arcs
General Contributed Paper Sessions: Geometry

One of the Moser's worm problems is to determine the least area of a cover of unit arcs, which is a convex region that contains an isometric copy of any arc of length 1. While finding the exact least area is still an open problem, many attempts are made to estimate its lower and upper bounds. The current best lower and upper bounds are .23223 and

.27091. In this talk, we will discuss an area estimate for the convex hull of simple curves and then apply it to improve the bounds of the least area of covers of unit arcs.

Mouser, Christina *William Paterson University*
Amitabha Bose, *New Jersey Institute of Technology*
Farzan Nadim, *New Jersey Institute of Technology*

Understanding the Role of Voltage Dependent Electrical Coupling in a Neuronal Network
General Contributed Paper Sessions: Interdisciplinary Topics in Mathematics and Modeling or Applications

Neuronal networks are made up of an intricate collection of synaptic connections. Understanding the effects of these synapses is crucial in determining what role they play in generating and maintaining network oscillations. We explore the role of a rectifying, bi-directional electrical synapse in a subnetwork of the Stomatogastric Nervous System. A mathematical model consisting of a set of coupled differential equations is derived and phase plane analysis is performed in order to understand the role of the electrical coupling and how it works in conjunction with the chemical synapses of the network. It is shown that the electrical coupling provides an additional mechanism for the generation of oscillations and helps the network operate in an optimal manner.

Moyer, Nathan *Whitworth Univesity*

Generating Combinatorial Identities via Walk Counting
General Contributed Paper Sessions: Graph Theory

There are numerous available methods of combinatorial proof designed to verify identities. This talk will introduce a method of proving certain combinatorial identities associated with second order recurrence relations of the form $a_k = ma_{k-1} + a_{k-2}$. These relations can be generated by a simple 2×2 matrix which can be viewed as the adjacency matrix for a graph. By establishing a count of the number of closed walks on these graphs, one can demonstrate a correspondence that yields certain families of identities. This method will be used to verify the well-known Fibonacci identity $F_n = \sum \binom{n-k}{k}$ as well as others.

Mummert, Amanda *Washington & Jefferson College*
Katie Linthicum, *Washington & Jefferson College*
Kadie Clancy, *Washington & Jefferson College*

Social Security Benefit: Now or Later?
Themed Contributed Paper Sessions: TCPS 7 - Financial Mathematics

Social Security benefit is a topic that every American reaching the retirement age must consider. While there is no perfect time to start claiming your Social Security benefit, there are questions to consider that will help maximize your total return. In this talk, we present a continuous model using a differential equation for a single American to start claiming Social Security benefit at three different ages: 62, 66 and 70, and investing their earnings thereafter. The parameters used in this model include the tax rate, the investment return rate, and the annual benefit depending on the beginning retirement age. From this model we can determine the balance of the retirement account at any year during retirement. This will allow us to find the catch-up point between two retirement accounts with different starting retirement age. The result can be used in conjunction with other personal factors such as health, spending habits and pre-retirement income to aid a person in starting Social Security benefit at the ideal time.

Murray, Margaret *University of Iowa*

American Women Mathematics PhDs of the 1940s and 1950s
Themed Contributed Paper Sessions: TCPS 2A - The Contributions of Women to Mathematics: 100 Years and Counting

In this talk, I'll present a comprehensive picture of the roughly 200 women who earned PhDs in mathematics from American institutions during the years 1940–1959. I'll describe recent research—building significantly on my book Women Becoming Mathematicians (MIT Press 2000)—that reveals a complex picture of the women mathematicians of this generation. I'll explain what makes this generation so pivotal to our understanding of the history of American women in mathematics.

Myers, Kellen *Farmingdale State College*

Computing New Ramsey-Theoretic Quantities

PosterFest 2015: A Poster Session of Scholarship by Early Career Mathematicians and Graduate Students

In Ramsey theory, to any equation E we can associate a quantity called a Rado number. This is the smallest N such that any coloring of 1, 2, ... N contains a solution to E of the same color. This N depends on E as well as the number of colors. For example, the 3-color Rado number for $x + y = z$ is 14. I will present a few new results concerning Rado numbers for a few families of equations, including some linear and nonlinear equations.

N

Najeem, Lateef *University of South Africa*

A Critical Reflection on the Development and Promotion of Constructivist-Learning Environment in Mathematics at the Intermediate Phase in South Africa

General Contributed Paper Sessions: Teaching or Learning Devlopmental Mathematics and Assessment

This paper outlines how radical constructivist theory and research has facilitated the development of an authentic learning model in promoting constructivist-learning environment in Mathematics at the intermediate phase. The paper traces how radical constructivist theory has developed and employed within the South African contexts with special focus on teaching and learning of mathematics. It went further examine the optimal engendering of more viable models that could help to address existing complexities around the teaching and learning mathematics at the intermediate phase of learning in South African Schools. Based on existing evidences from the literature, the paper argued that authentic learning Model in action research promote constructivist learning , as it developed and progresses, supports teachers to be more effective. The paper concludes with a critical overview of the Implications of radical constructivism as the potential to influence practice.

Nakamura, Kei *University of California Davis*

Geometry and Number Theory of Integral Sphere Packings

Invited Paper Sessions: AMS-MAA Invited Paper Session: The Arithmetic of the Spheres

Classical Apollonian circle packings are constructed from a quadruple of pairwise tangent circles on a plane by successively inscribing circles into the triangular interstices. We consider variations of this construction, and study other circle packings and sphere packings of higher dimensions. Remarkably, just as in the classical Apollonian circle packings, there are a few circle/sphere packings in which the bends of constituent circles/spheres are integers, giving rise to fascinating questions on the Diophantine properties of the set of bends. We describe examples of integral circle/sphere packings in terms of hyperbolic geometry, Coxeter groups, and quadratic forms, and discuss the "local-global principle" for the set of bends that arise in this context.

Nakane, Michiyo *Nihon University Research Institute of Science and Technology*

Yoshikatsu Sugiura: A Good Japanese friend of Paul Dirac

Themed Contributed Paper Sessions: TCPS 1H - History and Philosophy of Mathematics

After finishing his Dr. Thesis, Paul Dirac started as a researcher at Bohr's Institute in Copenhagen in September of 1926. At that time, several Japanese research workers were also staying at the institute. Dirac moved to Göttingen at the end of January 1927. About four months later, one of the Japanese physicists who had been staying at Bohr's institute, Yoshikatsu Sugiura (1895-1960), moved to Göttingen. He worked under Born's supervision and stayed at the Cario family house with Dirac and Oppenheimer. As a pioneering Japanese quantum physicist, Sugiura wrote several good papers on experimental and theoretical physics during his stay in Europe from 1924 to 1927. His most famous work, the completion of the Heiter and London calculation, was performed in Göttingen. Sugiura's recollection of the fruitful days in Göttingen showed that Dirac, Oppenheimer, and Sugiura established a close friendship that continued after World War II. Just after coming back to Japan, Sugiura gave a public lecture on the new quantum mechanics in 1928. In this lecture, Sugiura introduced Dirac's latest work involving the delta function, which led to confusion among Japanese physicists. Often referring to the works of Dirac and Oppenheimer, Sugiura continued his work and lectures on the new quantum mechanics in Japan during the period of time from 1928 to 1935. Although Yoshio Nishina, who

had met Dirac in Copenhagen, arranged to invite him to Japan with Heisenberg, it is not doubted that Dirac's best Japanese friend was Sugiura.

Narayan, Jack *SUNY Oswego and WebAssign*

Improving Students' Learning by Integrating Effective Learning and Teaching Strategies and Instructional Learning Management Systems

General Contributed Paper Sessions: Mathematics and Technology

Increasing students' success in STEM disciplines remains a major challenge for educators. Research in the cognitive science of learning offers explanations of why this situation exists and suggests strategies that educators could implement to improve learning. This research requires students to make major changes in their study habits, which, for the most part, have proved to be counter-productive. "Naturally occurring" study strategies such as rereading, highlighting, and focusing on already understood material, as well as "massed practice," are deemed to be ineffective. Faculty should help students by developing practices that will facilitate concepts of memory retrieval, reflection, elaboration, and generation of ideas in ways that enable students to experience some improved level of success. Frequent quizzing is one effective strategy for retrieval practice. Quizzing should be cumulative, interleaved, and spaced. By interleaving, we mean not just including a variety of topics, but deliberately alternating among them so that students have to process, with some effort, each type of problem/topic prior to solving it. Interleaving is a good example where students' intuition about the right way to study leads them in the wrong direction. We will show how these recommendations can be implemented by using the data analytics capability of WebAssign, an instructional technology system that provides new opportunities for teaching, learning, and educational research.

Nelson, Sam *Claremont McKenna College*

Enhancements of Counting Invariants

Invited Paper Sessions: MAA Invited Paper Session: Algebraic Structures Motivated by Knot Theory

Quandle counting invariants form an infinite family of knot invariants which as easy to define and compute. Enhancements are stronger knot invariants defined using the quandle counting invariants as a base. In this talk we will see some examples of enhancements of quandle counting invariants.

Neus, Jordan *Suffolk County Community College*
Maria Alzugaray, *Suffolk County Community College*

Outcomes Assessment Using Item Response Theory

PosterFest 2015: A Poster Session of Scholarship by Early Career Mathematicians and Graduate Students

Item Response Theory (IRT) is based upon a statistical framework that models the odds of a test-taker answering a test question correct as a function of his or her "ability" or level of achievement. While these two variables were originally linked via a a simple one-parameter logistic function, modern computational methods allow iterative estimation of a three-parameter probit-linked model, with item ("item" being the psychometrician's term for test question) difficulty, item discrimination, and even a guessing parameter, which estimates the likelihood that a test-taker will guess on a particular question. This presentation will highlight some advantages of using IRT in the context of outcomes assessment with multiple-choice questions to assess the lower levels of Bloom's taxonomy.

Newton, Jeremy *Lee University*
Debra Mimbs, *Lee University*

10,000 Ways to Count a Truncated Tetrahedron

General Contributed Paper Sessions: Number Theory and Logic or Foundations

Arising from Eike Hertel's paper, *Reguläre Dreieckspflasterungen konvexer Polygone*, we discuss tiling a regular tetrahedron with unit tetrahedrons and octahedrons. Ordering the tetrahedral constructions by size produces the sequence of tetrahedron numbers, which represents the number of unit tetrahedron volumes in a tetrahedral construction, which is the sequence of cubic integers. Truncating a tetrahedron by cutting away its corners, we discover a new sequence of integers. The sequence can be understood from various mathematical perspectives. Further explorations would include proving a surjection from the sequence to the natural numbers and finding the largest element of the new sequence's complement.

Nguyen, Hieu *Rowan University*

The Digital Binomial Theorem
General Contributed Paper Sessions: Number Theory and Logic or Foundations

This talk will make complete a triangle of connections between the binomial theorem, Pascal's triangle, and Sierpinski's triangle via a one-parameter family of Sierpinski matrices. These matrices are expressed in terms of the sum-of-digits function and encodes a digital version of the binomial theorem.

Nicholas, Mike *Colorado School of Mines*

The Everyday Examples in Engineering (E3) Program in a Scientific Computing Course
Themed Contributed Paper Sessions: TCPS 14 - Projects, Applications and Demonstrations to Enhance a Numerical Analysis or Computational Mathematics Course

Everyday Examples in Engineering (E3) is one part of the NSF's Engnge in Engineering project. As a participant in E3, I interviewed engineering faculty to collect examples of numerical methods used in research. These applications have been incorporated into numerical methods classes as motivating examples and as homework problems. I will show some of the examples and will discuss student reactions to them.

Nichols, Janet *Colorado State University - Pueblo*

Building Learning Communities for Students and Instructors in Introductory and Intermediate Algebra
Themed Contributed Paper Sessions: TCPS 16 - Curriculum Development to Support First Year General Education Mathematics Students

Pass rates at Colorado State University - Pueblo in Introductory and Intermediate Algebra increased when we instituted on-line homework and met with all instructors to agree on test questions. Now, ten years later, we have seen a decline. Enrollment in these two classes is around 600 every fall. Last summer, we redesigned our Introductory Algebra class to include building a learning community in the classroom where lectures were brief and students worked on worksheets and presented their work on the board. Discussion will include how the classroom learning community was supported, my pass rate of 85%, and plans for the Intermediate Algebra class.

Nicolas, Carlos *Ferrum College*

What Should be the Content of a Developmental Algebra Class?
General Contributed Paper Sessions: Teaching or Learning Devlopmental Mathematics and Assessment

In this talk I will describe the impact that successive content revisions have had on our one-semester developmental algebra class. The setting is a four-year liberal arts college with very inclusive admissions. I will argue that the content selection is probably the most important factor affecting the outcome of an algebra class, and yet it seems to receive less attention than the methodological aspects. I will try to discern the different forces from outside and inside the mathematical community that affect, often negatively, the content of a typical intermediate algebra textbook.

Nita, Bogdan *Montclair State University*

On the Equilibrium Configurations of Flexible Fibers in a Flow
General Contributed Paper Sessions: Applied Mathematics

We discuss the equilibrium configurations of fibers, of different length and orientation, clamped to a spherical body and immersed in a flow. Experimental and numerical results are presented and the effects of flow speed and positioning of the fiber upon the equilibrium configuration are investigated. Our results reveal that the orientation of the fiber and its length have a significant impact upon its bending and drag experienced by the sphere-fiber system.

Northshield, Sam *SUNY Plattsburgh*

Infinitude of Primes
General Contributed Paper Sessions: Number Theory and Logic or Foundations

There are perhaps hundreds of proofs that there are infinitely many prime numbers. Among the most famous is a "topological" proof by Furstenberg. We present a version of this proof without the topology! Then, for something completely different, we present a probabilistic proof based on the impossibility of choosing an integer at random.

Noussi Kamdem, Hubert *Roger Williams University*

Predator-Prey Modeling

Themed Contributed Paper Sessions: TCPS 18 - Using Modeling for Teaching Differential Equations: Before, During, After

Students have an opportunity to model the interactions between two species where one species preys the other. M&M candies could be used to represent the prey population and squares made out of paper could be used as predators. Students will then simulate the encounters between the species and record the data. Depending on the assumptions students should describe the population dynamics and draw conclusions.

Nowrouzi-Kashan, Fariba *Kentucky Sytate University*

Where Can We Use Abstract Algebra?

General Contributed Paper Sessions: Teaching or Learning Advanced Mathematics

When I started to teach Abstract Algebra for the first time, a student challenged me with the question of what is the practical use of the subject. In this talk I would like to share some of the applications I have found with others who may hope to teach the course.

O

O'Neil, Cathleen *Johnson County Community College*

Eisenhower, the Binomial Theorem, and the $64,000 Question

Themed Contributed Paper Sessions: TCPS 1B - History of Mathematics

At MathFest 2013, Robert Rogers shared a letter with SIGHOM from President Eisenhower to his son, John Eisenhower, thanking John for his letter that gave the President the clue he needed about how the "quiz lad" answered a mathematical question. With the help of Kevin Bailey, a reference archivist at the Eisenhower Presidential Library, we have been able to recover the letter that John wrote to his father, which contains a simple explanation of the Binomial Theorem. By following newspaper stories and TV Guide articles of the 1950's, as well as lucky guesses on the Internet, I have been able to positively identify the quiz lad. With his help I have been able to make a good guess about the nature of the question he was asked on the quiz show and how President Eisenhower happened to be watching.

O'Neill, Christopher *Texals A&M University*
Roberto Pelayo, *University of Hawaii at Hilo*

How Do You Measure Primality?

PosterFest 2015: A Poster Session of Scholarship by Early Career Mathematicians and Graduate Students

In commutative monoids, the omega-value measures how far an element is from being prime. This invariant, which is important in understanding the factorization theory of monoids, has been the focus of much recent study. In this poster, we provide detailed examples and an overview of known results on omega-primality, including several recent and surprising contributions in the setting of numerical monoids. As many questions related to omega-primality remain, we provide a list of open problems accessible to advanced undergraduate students and beginning graduate students. The work presented here is based on a survey article appearing in the American Mathematical Monthly.

Oberbroeckling, Lisa *Loyola University Maryland*

The Many Lessons in Fractals

Themed Contributed Paper Sessions: TCPS 6A - Mathematics and Art

Fractals are what many people think of when they think of Mathematics and Art. Fractals are rich with lessons in basic and advanced mathematics, along with computer programming techniques. This talk will demonstrate a few assignments using fractals in a course in which mathematics and basic programming is covered. Students program fern fractals to demonstrate affine linear transformations and programming techniques. The basic geometry of complex numbers are introduced to program variations of the Chaos Game. Complex numbers are again used in line replacement fractals such as Gosper Island and the Koch Snowflake. The students also review geometric sequences in this

assignment. These assignments can easily be adapted to accommodate any programming level of the student and the course.

Orona, Cynthia *University of Arkansas*

Graduate Certificate in STEM Education

Themed Contributed Paper Sessions: TCPS 13 - Successful STEM Programs for Elementary Education Majors

The University of Arkansas offers a graduate certificate in Science, Technology, Engineering, and Mathematics (STEM) education. With a thriving emphasis on STEM fields, students in the elementary Masters of Arts in Teaching degree program are encouraged to choose STEM as a sub-specialty area. Research shows that by third or fourth grade, children have decided the fate of STEM fields in their future. Therefore, children need to be introduced to STEM fields at an earlier age and see their relevance to real-life. This certificate helps close that gap by preparing future elementary teachers to introduce STEM earlier and in a non-threatening manner while continuing to meet state and national standards in their classrooms. The primary method of content delivery in these courses is through project-based learning which is then carried into elementary classrooms. The course sequence allows for each discipline to be the focus, but also requires an integration of the other disciplines to remain true to providing an integrated STEM curriculum. In the mathematics problem-based learning course, students are challenged to extend their thinking about how to incorporate mathematics in the elementary classroom through real-world projects. Students are required to create integrated STEM lessons that highlight the mathematics involved. The objective is to think outside of the box and create engaging lessons where the disciplines are integrated as opposed to teaching them in isolation.

Ortiz-Albino, Reyes *University of Puerto Rico-Mayaguez*

Topics in $\tau_{(n)}$-Number Theory

General Contributed Paper Sessions: Number Theory and Logic or Foundations

The notion of a τ-factorization or τ-products in the general theory of (nonatomic) factorization was defined in 2006. Since, several results have been done in general, but there is been a small interest study such factorizations when considering the set of integers as the integral domain and τ as the equivalence relation modulo n. This subject was studied by Hamon(2007), Ortiz (2008), Florescu(2011), and several Ortiz's students(2010-present). We introduce the divisibility properties, as done in the usual number theory, present examples and give their characterization when $\phi(n) \leq 4$. Also, we will show where does the problem gets more complicated.

Oscarson, William *Cornell*

Using Binomial Coefficients to Prove Oppermann's Conjecture

General Contributed Paper Sessions: Number Theory and Logic or Foundations

We express the two parts of Oppermann's conjecture as binomial coefficients of the form $n^2!/((n^2-n)!n!)$ and $((n)(n+1))!/(((n)(n+1)-n)!n!)$ where n is a positive integer > 1. We propose two constraints which allow us to monitor how the integers behave in the division process, which leads toward a confirmation of Oppermann's conjecture and strongly suggests how other non Oppermann primes are formed.

Oster, Andrew *Eastern Washington University*
Paul C. Bressloff, *University of Utah*

Pattern Formation in the Developing Visual Cortex - The Joint Development of CO Blobs and Ocular Dominance Stripes

General Contributed Paper Sessions: Interdisciplinary Topics in Mathematics and Modeling or Applications

In this talk, we will introduce the architecture of the visual system in higher order primates and cats. Through activity-dependent plasticity mechanisms, the left and right eye streams segregate in the cortex in a stripe-like manner, resulting in a pattern called an ocular dominance map. We introduce a mathematical model to study how such a neural wiring pattern emerges and extend it to consider the joint development of the ocular dominance map with another feature of the visual system, the cytochrome oxidase (CO) blobs, which appear in the center of the ocular dominance stripes. Since cortex is in fact comprised of layers, we introduce a simple laminar model and perform a stability analysis of the wiring pattern. This intricate biological structure (ocular dominance stripes with 'blobs' periodically distributed in their centers) can be understood as occurring due to two Turing instabilities combined with the first-order dynamics

of the system. We show recent numerical simulations showing how monocular deprivation during development can dramatically alter the ocular dominance pattern, while leaving the CO blob distribution nearly unaltered.

Overbay, Shannon *Gonzaga University*

Book Thickness of Zero-Divisor Graphs of Commutative Rings
General Contributed Paper Sessions: Graph Theory

An n-page book consists of a line in 3-space (the spine), together with n half-planes (the pages), joined together at the spine. A graph G is embedded in a book by placing the vertices along the spine and assigning each edge to a single page of the book so that no two edges cross each other or the spine. The book-thickness of a graph, $bt(G)$, is the smallest number of pages needed to embed G in a book. If we let R be a commutative ring with identity, we form the zero-divisor graph of R, denoted by $\Gamma(R)$, by taking the nonzero zero-divisors of R as the vertices. Two vertices, x and y, are joined by an edge in $\Gamma(R)$ if and only if $xy = 0$. We classify the book thickness of all planar zero-divisor graphs for commutative rings and investigate the book thickness of nonplanar zero-divisor graphs for such rings.

Owad, Nicholas *University of Nebraska - Lincoln*

Exploring Visualizations: An Overview of a Seminar in 3D Modeling and Printing
Themed Contributed Paper Sessions: TCPS 9 - What Can a Mathematician Do with a 3D Printer?

During the 2014-15 academic year, the presenter organized and ran a workshop with the goal of introducing attendees to the basics of 3D modeling and printing, focusing on how mathematical ideas can be relayed. The software used was Rhinoceros 5. Projects in the workshop, that succeeded and failed, will be explained, with an emphasis on what can be improved upon based on attendees observations. The projects ranged from building a castle out of basic shapes to writing python scripts to graph saddle points and estimate the integral.

P

Panaggio, Mark *Rose-Hulman Institute of Technology*
Steve J. Bacinski, *Davenport University*
Timothy J. Pennings, *Davenport University*

Elvis Lives: An Exploration of Greedy and Global Path Optimization in a Game of Fetch
Themed Contributed Paper Sessions: TCPS 5A - Recreational Mathematics: New Problems and New Solutions

Elvis, the Welsh corgi who "knew" calculus, became famous when he found the quickest route down the beach and through the water to his ball. It was later discovered that Salsa, the Labrador, could achieve the same result by using a "greedy" approach — moving toward the ball as quickly as possible at each instant in time. Why would these two disparate strategies yield identical results? In this talk, we consider a generalized game of fetch in which the dogs' speeds depend on their position. We will demonstrate that when speed is continuous the greedy path is always a beeline straight to the ball, while the optimal path seldom is. Only when the speed is discontinuous along the shoreline does Salsa's short term thinking result in her taking the optimal path.

Panofsky, Ellen *Temple University*
Maria Lorenz, *Temple University*

Teaching Focused at a Research University: Temple University Mathematics
General Contributed Paper Sessions: Teaching or Learning Introductory Mathematics, Part B

High school students have a big decision to make when choosing a college or university. One question often pondered is, "should I be looking at an institution which is more research focused or teaching focused?" Students in Temple University's Mathematics Department get the best of both worlds. We are a research institution, but we also have a focus on teaching. University wide programs such as the Provost's Teaching Academy and the STEM Teaching Circle help faculty improve their teaching, and departmental programs such as Talking About Teaching allow us to focus on issues specifically in mathematics. In this talk we will present information about these programs which we have participated in as well as discussing Temple University's Teaching in Higher Education Certificate which teaches future faculty (graduate students) how to be more teaching focused.

Pantano, Alessandra *University of California, Irvine*
Li-Sheng Tseng, *University of California, Irvine*
Andres Forero, *University of California, Irvine*

Seeding Mathematical Interest in Inner-City Latino Students

Themed Contributed Paper Sessions: TCPS 15 - Democratizing Access to Authentic Mathematical Activity

The UCI Math Circle initiated a pilot program to work with a group of about 30 middle school Latino students from a low-performing public school in nearby Santa Ana, CA. During the 2014–2015 academic year, we ran 16 sessions of mathematical explorations on a variety of topics including algebra, number theory and geometry. The program is open to all the students interested in mathematics, with no regards to their mathematical abilities. We will describe our experience working with students in grade 6–8 with a wide range of math background, and share our insights in creating educational material that increases both the students' mathematical competence and their interest in "doing math".

Parshall, Karen *University of Virginia*

1894–1919

Invited Paper Sessions: MAA Invited Paper Session: Generations of Monthly Gems

In 1894, Benjamin Finkel, former secondary school mathematics teacher and then Professor of Mathematics at Drury College in Kidder, Missouri, began the publication of *The American Mathematical Monthly* to fill what he saw as the need to stimulate and encourage mathematics teachers in both the high schools and the normal schools. His thinking went that the teachers, and by association their students, would benefit from the challenges presented by a problems-and-solutions department as well as by articles of both a mathematical and an historical nature dealing with the subject matter presented in their classrooms. This defined the *Monthly's* mission until 1913, when Herbert Slaught of the University of Chicago, George A. Miller of the University of Illinois, and Earle R. Hedrick then of the University of Missouri, officially took over the journal's editorship. They saw the *Monthly* more explicitly as a vehicle for the professionalization and more formally the legitimization of the teaching of collegiate mathematics. This was also the goal of the Mathematical Association of America, formed two years later in 1915 with the Monthly as its official publication. This talk will examine the first twenty-five years of publication — 1894–1919 — of the *Monthly* in the context of the evolving American mathematical community.

Parshall, Karen *University of Virginia*

MAA Centennial Lecture 5 CSHPM Kenneth O. May Lecture "We Are Evidently on the Verge of Important Steps Forward": The American Mathematical Community, 1915-195

Invited Addresses: MAA Centennial Lecture

The American mathematical community experienced remarkable changes over the course of the thirty-five years from the founding of the Mathematical Association of America (MAA) in 1915 to the establishment of the National Science Foundation in 1950. The first fifteen years witnessed not only the evolution of the MAA with its emphasis on the promotion of mathematics teaching but also the "corporatization" and "capitalization" of the American Mathematical Society as mathematicians worked to raise money in support of research-level mathematics. The next decade, one characterized by the stock market crash and Depression, almost paradoxically saw the building of mathematics departments nationwide and the absorption into those departments of European mathematical refugees. Finally, the 1940s witnessed the mobilization of America's mathematicians in the war effort and their subsequent efforts to insure that mathematics was supported as the Federal government began to open its coffers in the war's immediate aftermath. This talk will explore this period of optimism in which the American mathematical community sensed, as Roland Richardson put it, "we are evidently on the verge of important steps forward."

Parson, James *Hood College*

Prehistory of the Outer Automorphism of S_6

Themed Contributed Paper Sessions: TCPS 1R - History of Mathematics

The symmetric group S_6 is unique within the family of the groups S_n in admitting automorphisms that do not come from conjugation by elements of the group, so-called outer automorphisms. Otto Hölder is generally credited with the discovery of outer automorphisms of S_6 in a paper published in 1895. In this talk, we discuss the prehistory of Hölder's observations, both in the tradition of the Lagrangian theory of equations and in Sylvester's *tactic*.

Patterson, Catherine *University of Iowa*
Kevin Gerstle, *University of Iowa*

Group-Based Learning in the TILE Environment

PosterFest 2015: A Poster Session of Scholarship by Early Career Mathematicians and Graduate Students

At the University of Iowa, the Transform, Learn, Interact, Engage (TILE) Project supports the goals of increasing student success by changing the way the classroom functions. As student enrollment increases, it becomes increasingly important to give students a learning environment in which they are able to learn both effectively and efficiently. TILE classrooms were designed to pursue these goals. Through use of round tables for collaborative learning and technology such as laptops and multiple projectors, students are able to work in a unique environment, one in which active learning is carried out through the TILE approach. This approach serves as a new educational pedagogy in which student-centered learning is of utmost importance. In this poster, we will share our experiences teaching students about exponential and logarithmic functions in a TILE setting. We designed our activities around collaborative, guided discovery of the properties of exponential and logarithmic functions, emphasizing the application of prior knowledge to these functions. By adapting our lessons to the TILE environment, we were able to produce a richer educational experience for our students.

Patterson, Catherine *University of Iowa*

Histomorphometry-Based Modeling and Simulation of Multiple Myeloma Bone Disease

Graduate Student Session: Great Talks for a General Audience: Coached Presentations by Graduate Students, Part A

Cancer is a lot like a hurricane; you can see it coming, but you don't know exactly where it will go or how much damage it will do. However, by combining a partial differential equations (PDE) model with patient data, we can predict how a patient's cancer will develop. My research focuses on multiple myeloma, a plasma cell cancer that disrupts the bone remodeling process. In multiple myeloma patients, bone destruction outpaces bone replacement, producing bone lesions. During this presentation, I will introduce my model of multiple myeloma's impact on the bone, show some computational results, and discuss the data available to validate the model.

Paudel, Lokendra *New Mexico State University*

The Sources Jeremiah Day Used in his 1823 Algebra Book

General Contributed Paper Sessions: History or Philosophy of Mathematics

Jeremiah Day (1773–1867), an American professor of mathematics and natural science and president of Yale from 1817–1846, wrote An introduction to algebra: Being the first part of a course of mathematics adapted to the method of instruction in the American Colleges in 1814. It went through many editions including one in 1823 and was a popular book. His preface states that he used as sources for it Newton, Maclaurin, Saunderson, Simpson, Euler, Emerson, Lacroix, and others. I have matched parts of his text to selections from algebra books by some of these authors, and to some others such as Bonnycastle. But in many cases, as was noted by Cajori (1890), Day's content is simplified. Example: Simpson (1809): Extract the square root of $a^4 + 4 * a^3 * x + 6 * a^2 * x^2 + 4 * a * x^3 + x^4$; Day: Find the square root of $x^4 - 4 * x^3 + 6 * x^2 - 4 * x + 1$ (Here, Day substitutes the value -1 for a.) Such simplifications make the content accessible to less experienced readers. I will discuss the contents of Day's book and the matches I found, together with the content (especially definitions and axioms) that he seems to have created on his own. I will also discuss why his book made such a unique contribution to algebra in the United States in the 19th century, and why it was so popular. References Cajori, Florian (1890). The Teaching and History of Mathematics in the United States. Washington: Govt. Printing Office Day, Jeremiah (1823). An Introduction to Algebra. New Haven: Howe & Spalding

Paul, Stepan *California Polytechnic State University*

Elements of the Successful Calculus Computer Lab Assignment

Themed Contributed Paper Sessions: TCPS 19B - Innovative Approaches in the Calculus Sequence

A well-planned computer lab assignment can be a fantastic opportunity for students to engage deeply in many topics in calculus. Manipulable graphics and expressions along with the right guiding questions can give a visceral environment in which students can build conceptual understanding and intuition. In this talk, I will give a demonstration of computer lab activities I have used, and use this as a vehicle to discuss some considerations for faculty thinking of incorporating

computer labs into a their classes. In particular, I will talk about the process of selecting good topics, interactions, and questions for a lab, and the practical problem of finding the right format for different classroom situations. I will also give some tips for finding and adapting others' computer labs and for sharing your own.

Paynter, Bradley *University of Central Oklahoma*

The Impact of Student-Selected Projects on Operations Research Education - An Initial Report

PosterFest 2015: A Poster Session of Scholarship by Early Career Mathematicians and Graduate Students

Operations Research, when taught in a mathematical context, can be one of the few times that a mathematics student encounters the direct application of in-class content to real world problems. This is especially effective due to the low entry requirements (usually just Linear Algebra) which allows the course to be taken as a Junior or even earlier. This impact can be highly leveraged by requiring students to do an applied project. We have extended this even further by requiring the students to develop their own topic too. Initial results, challenges faced, and ideas for the future are presented.

Perry, David *National Security Agency*

The Coming of Enigma

Invited Paper Sessions: MAA Invited Paper Session: The Non-Traditional "Traditional NSA Mathematician"

Prior to and during World War II the Germans used a cryptodevice called "Enigma"that was thought by everyone to provide unbreakable encryption. We will see how the device worked and why it was thought to be unbreakable by taking a whirlwind trip through the history of cryptography. Attendees will have the opportunity to see an Enigma machine in operation.

Petillo, Alice *Marymount University*
Nicole Ferree, *Marymount University*

Impact of 2015 National Math Festival on Undergraduate Mathematics Students

General Contributed Paper Sessions: Mentoring and Outreach

This session will share results from an IRB-approved research project designed to describe the impact of the National Math Festival (NMF) in Washington DC on participating undergraduate students and mathematics department faculty from Marymount University (MU) in Arlington, VA. Approximately 40 MU students and faculty attended the NMF on April 18th, 2015. Mathematics majors interacted with festival-goers as they built a Zometool hyperbolic star on the Ripley Center concourse. Other students, mostly undergraduates enrolled in liberal arts mathematics classes, volunteered at stations like Ring of Fire, Funny Faces, Mirror Morph or logistics. Mathematics department faculty, along with some family members, joined the students. Additional MU students came to attend the festival, some bringing young relatives. Events like this have large opportunity costs in terms of time investment on the part of faculty and students. What outcomes were there? How was student thinking changed by this experience? Would they come to an event like this in the future? Findings from this research may increase the capacity of mathematics departments to promote interest in mathematics among undergraduate students, and provide insights on how to incorporate informal learning opportunities outside the classroom.

Petito, Lucia *UC Berkeley*
Nicholas P. Jewell, *UC Berkeley*

An Exploration into Grouped Current Status Data

General Contributed Paper Sessions: Probability or Statistics

Grouped testing has long been used as a method to reduce costs when estimating the prevalence of a binary characteristic based on a screening test of k groups that include n independent individuals in total. In some applications, the individual binary response corresponds to whether an underlying "time to incidence" variable T is less than an observed screening time C. This data structure at the individual level is known as current status data. Given sufficient variation in the observed Cs, it is possible to estimate the distribution function F of T non-parametrically using the pool-adjacent-violators algorithm (Ayer et al., 1955). Here, we consider similar nonparametric estimation of F based on group tested current status data for k groups where the group tests "positive" if and only if any individual unobserved T is less than its corresponding observed C. We consider potential cost savings and its relationship to precision

over the support of F, and investigate the effect of misclassification of the pooled tests. We consider potential applications to testing for the presence of various diseases from pooled samples where interest focuses on the age at incidence distribution.

Phan-Yamada, Tuyetdong *Glendale Community College*
Walter M. Yamada, *III, Children's Hospital Los Angeles*

Lefty-Righty Experiment: A Group Project for An Individual Grade

General Contributed Paper Sessions: Probability or Statistics

A pedagogical hurdle of many hybrid approaches for teaching statistical testing using statistical programs such as SPSS, SAS, JMP, or R, and also of traditional textbooks is that theory and practice are disjointly presented. We have written statistical apps that concurrently demonstrate how to do essential statistical calculations and why these tests work. Our apps take advantage of the graphical and calculation tools of GeoGebra, but they do not require students to know GeoGebra. Like GeoGebra, our apps are free and work on all major personal computing platforms. Our apps combine data entry, calculation of basic statistics, and dynamic visualization of the sampling distribution function, to allow lesson plans for simultaneous learning theory and practice of statistical testing. In this paper we will present a statistics project in which students infer the percentage of left-handed people in the general population from a convenience sample of people carrying out a digital manipulation task using their right or left hand. This dataset allows for testing other hypothesis, for example how fast right- or left-handed people write. We also present how instructors can measure each individual work through this group project.

Piercey, Victor *Ferris State University*

Linked Math and English in an Active Learning Classroom

Themed Contributed Paper Sessions: TCPS 11B - Cultivating Critical Thinking through Active Learning in Mathematics

There are two variables that are easy to neglect when implementing active learning strategies. One is the sense of community among the students, and the second is the space in which the learning takes place. We addressed these variables by linking a year-long inquiry-based quantitative reasoning course for business students with courses in writing and research. The linked courses met in an "active learning classroom" - a room designed to facilitate collaboration and inquiry. In this talk, we will describe how we used the space, what we learned from our experience, and the gains that students made in critical thinking and questioning compared to students in an unlinked section of the same math course in a traditional classroom.

Piercey, Victor *Ferris State University*

What Evidence Do You Have? Data-Based Investigations into Contemporary Race Relations in a General Education Math Class

Themed Contributed Paper Sessions: TCPS 15 - Democratizing Access to Authentic Mathematical Activity

In the wake of racial events such as the Ferguson protests, it has become apparent that our discussions about sensitive issues are elevated when informed by data. A general education math class provides an opportunity to develop the habit of demanding and assessing data-based support for claims. In this talk, I will share a project in which students examined and critiqued the evidence for claims in a scholarly book regarding contemporary race relations, formulated questions inspired by the book, and sought data to address their questions which they presented in a public poster session.

Pilgrim, Mary E. *Colorado State University*
Sue Doe, *Colorado State University*
Hilary Freeman, *Colorado State University*
Kate Kiefer, *Colorado State University*

Engaged Learning Through Writing: A Faculty Development Project

Themed Contributed Paper Sessions: TCPS 10 - The Scholarship of Teaching and Learning in Collegiate Mathematics

Beginning in the fall 2014 semester, we were provided with funding to develop a Writing to Learn (WTL) program in the College of Natural Sciences at Colorado State University. The first year of the program has been devoted to

developing faculty understanding of WTL, to the development of WTL activities — specifically in Mathematics and Physics, and to exploring the importance and best approaches to giving meaningful feedback. The ultimate goal of the program is to address the student experience in gateway courses across the College of Natural Sciences. The first year of the program has been focused not only on the mechanics of writing for engagement but also on faculty identification of the central disappointments with student math understanding that our WTL program hopes to address. Preliminary results indicate that students who participate in writing activities that are incorporated in the classroom as well as outside of the classroom perform better on exam questions. In this presentation we will provide the framework of the WTL program, provide prompts that emerged from our processes, share sample student responses, and provide preliminary results.

Pleasant, Kendra *Howard University*

Coloring your World: An Introduction to Ramsey Numbers

Graduate Student Session: Great Talks for a General Audience: Coached Presentations by Graduate Students, Part C

Suppose you are throwing a dinner party. Although you know all of your guests, you want some of your company to know each other to ensure a successful sit down. How many people do you need to invite to guarantee that a certain amount of people are already associated? In 1928, Frank Plumpton Ramsey, a well-known English mathematician and philosopher, first presented a solution to this problem through the Ramsey number. We will explore how to use MATLAB to determine bounds on Ramsey numbers.

Poet, Jeffrey *Missouri Western State University*
Laurie J. Heyer, *Davidson College*
Todd T. Eckdahl, *Missouri Western State University*
A. M. Campbell, *Davidson College*

Ten Years of Math/Bio Research Collaboration with Undergraduates

Themed Contributed Paper Sessions: TCPS 4 - Undergraduate Research Activities in Mathematical and Computational Biology

Math and biology faculty at Missouri Western State University and Davidson College have collaborated for ten years to conduct research with undergraduates at both institutions in the area of synthetic biology. The group pioneered early efforts in bacterial computing, designing and constructing living cells to solve simple math problems. This talk will provide an overview of the team's NSF-funded projects from The Burnt Pancake Problem through Programmed Evolution.

Ponomarenko, Vadim *San Diego State University*
Cody Allen, *San Diego State University*

Winning Moves in Fibonacci Nim

Themed Contributed Paper Sessions: TCPS 5A - Recreational Mathematics: New Problems and New Solutions

Fibonacci Nim is a takeaway game with one pile of counters, where each player in turn removes at least one token and at most twice what the previous player removed in the immediately preceding turn. Whoever removes the last token is the winner. A winning strategy for playing this game is known; it is based on the (unique!) representation of the number of counters in the pile as a sum of nonconsecutive Fibonacci numbers. Our contribution is to determine all winning strategies, and thereby to estimate the probability that an untrained opponent may accidentally play optimally.

Posta, Filippo *Grand Canyon University*

Blended Delivery and Asynchronous Active-Learning Strategies in Developmental Math: a Case Study

Themed Contributed Paper Sessions: TCPS 11B - Cultivating Critical Thinking through Active Learning in Mathematics

Developmental Math courses are characterized by high dropout rates and poor performance. These outcomes are often due to disconnect between students interests/aspirations and course content. A common effort to bridge this gap is by emphasizing the application of mathematical concepts to real-life problems. We built two Blended Developmental Mathematics course with the idea of promoting the mathematical competencies of the course through asynchronous

self-discovery. We choose a blended setup with $2/3$ face-to-face and $1/3$ asynchronous. The synchronous portion of the course focused on traditional lectures explaining the mathematical procedures. The online portion consisted of Asynchronous Learning Experiences that required the students to apply the concepts learned in the classroom to problems related to their future careers. We present asynchronous active learning strategies that use data collection and spreadsheet based data analysis as a link between course assignments, the workplace, and students' personal interests. We discuss our results in general and present some specific case studies to illustrate assignment designs and assessments, as well as integration of the active-learning assignments with an existing assignment platform (such as MyMathLab). This integration is probably the most important and definitely the most overlooked aspect of "real-life assignment" design. Students need to be engaged on the "real-life assignment" while also progressing with their more standard course assignments such as homework problems, quizzes, and tests.

Posta, Filippo *Grand Canyon University*

Studying Habits in Developmental Math: What Can Be Learned from Analysis of Assignments Data

PosterFest 2015: A Poster Session of Scholarship by Early Career Mathematicians and Graduate Students

Technology-based educational systems are becoming the norm for assessment in Mathematics courses. These systems have obvious advantages: cater to a technology savvy student population, provide immediate feedback to the user, automate most of the grading, and allow for asynchronous assessment. They also introduce new challenges to faculty and curriculum developers, such as setting up the system correctly (there are usually many parameters that can be turned on/off) and most importantly making sure that students accomplish their learning objectives. The latter is becoming a hot topic because of the many on-line tools that are readily available (often for free) to perform complicated mathematical calculations. We analyzed data that can be obtained from MyMathLab with the goal of detecting learner's studying habits and determine best practices to encourage productive learning habits and discourage unproductive ones. We present our findings and suggestions on best practices for setting-up and monitoring courses that use on-line assessment tools.

Previato, Emma *Boston University*

Boston University AWM Student Chapter

PosterFest 2015: Highlights from AWM Student Chapters

The poster presenters are the founders of the Boston University (BU) AWM studnet chapter. The poster will include: A feature on our sponsor, a curriculum development company that awarded us memberships funding to establish the chapter (2013–2014); A series of vignettes on our activities, ranging from A Conversation with Past AWM President Prof. Ruth Charney, to a Workshop entitled Mathematics in Motion: Modelling Poi Flowers with Parametric Equations and GeoGebra, by Prof. Eleanor Farrington (Massachusetts Maritime Academy), to stress-coping sessions sponsored by bakery Insomnia Cookies, to informal meetings for students to present research conducted in their classes, and staffing a table at Freshman Orientation, bringing our mission message to the whole student body and collecting an e-mail list; Our main projects: We created a public multimedia ePortfolio, which we hope will be a clearinghouse of opportunities, consisting of sections such as Announcements of Conferences for Women in STEM, Community Service projects to provide tutoring in the Boston Area Public School System, Tips on Mentorship, Presentations by our Chapter Members, Contacts and Literature on Research and Organizations on Women in STEM, Internships for Students; We planned a searchable, BU-supported Open-Access archive, sustained by research in the Digital Humanities, which will profile the Women of Mathematics and Statistics at BU, since its foundation in 1839; This year, we will be co-hosting an NSA-sponsored research conference titled "R.D.M. Accola's Work: In Memoriam", spanning two days: our Chapter will be involved in day-one activities, reaching out to other AWM Chapters in the Greater Boston Area and to Speakers in the AWM Student Chapter Speaker Program.

Price, Candice *United States Military Academy, West Point*

Application of Knot Theory: Using Knots to Unravel Biochemistry Mysteries

Themed Contributed Paper Sessions: TCPS 2B - The Contributions of Women to Mathematics: 100 Years and Counting

In mathematics, a knot is defined as a closed, non-self-intersecting curve that is embedded in three dimensions and cannot be untangled to produce a simple loop. You can think of this as simply tying your shoelaces and the fusing

together the ends to create a continuous loop. While the mathematical properties of knots have been studied for close to 100 years, fairly recently the mathematics of knots have been shown to have application in various sciences including physics, molecular biology and chemistry. In this discussion, we will view some of the mathematical properties of knots as well as their applications to molecular biology.

Puhl, Maria *University of Tulsa*

William Coberly, *University of Tuls*

Comparing Methods of Sparse Discriminant Analysis Applied to fMRI Data

PosterFest 2015: A Poster Session of Scholarship by Early Career Mathematicians and Graduate Students

It has been shown that resting state fMRI functional connectivity features can be used to distinguish between groups of subjects such as Autism Spectrum Disorder (ASD) and Neuro-Typical (TD). Resting state functional connectivity is typically represented as a dense network consisting of highly interconnected nodes, or seed regions of the brain. Correlations or partial correlations, derived from rs-fMRI, act as connectivity weights between the seed regions. The resulting discriminant problem is one of very high dimension, where the number of variables is significantly greater than the number of subjects, p>>n. We compare two discriminant analysis methods. The first is Logistic Regression using LASSO (Least Absolute Shrinkage and Selection Model), a regularization method that reduces the number of predictor variables through an L1-norm penalty term, then classifies the data. The second is SDA (Sparse Discriminant Analysis) that reduces the number of predictor variables and classifies the data at the same time, using L1-norm and L2-norm penalty terms. We apply these techniques to approximately 3600 pairwise partial-correlations of 86 seed regions in the brain to find group differences between ASD and TD subjects.

Q

Quertermous, Katie *James Madison University*

Elizabeth Arnold, *James Madison University*

Expanding Your Horizons at James Madison University: Math and Science Outreach to Middle and High School Girls

General Contributed Paper Sessions: Mentoring and Outreach

The Expanding Your Horizons Conference at James Madison University is an annual math and science outreach event for young women in grades 6-10 that involves hands-on workshops, speakers, and opportunities for participants to interact with college students who are STEM majors. It started in 2008 with approximately 40 student participants, and, this year, approximately 190 girls and 80 adults attended. The program was funded in part by a MAA Tensor Women and Mathematics grant in 2009-2014. In this talk, we will give an overview of the conference activities and share helpful tips we have learned that can be used by others who are interested in starting a math outreach event or are already involved in a similar program.

Quinlan, James *University of New England*

Typesetting Homework in LaTeX: Best Practices that Support Teaching and Learning in Post-Calculus

Themed Contributed Paper Sessions: TCPS 12 - Improving Undergraduate Math Writing

Typesetting with LATEX can strengthen mathematical communication, organization and proper notation required by the language of mathematics. In a recent study, we required the students in three post-calculus courses to typeset homework assignments using LaTeX. The results show that the majority of students became comfortable with the markup, perceived an increase in their ability to communicate mathematically, and felt a sense of pride in the final product. In this presentation we present some of these results and discuss practical tips for incorporating LaTeX into post-calculus undergraduate mathematics courses based on our experience and reflections.

R

Raphael, Louise *Howard University*
Andrea E. Ekey, *Howard University*
Ahmed Tadde, *Howard University*

Cancer Classification of Gene Expression Data by Top Scoring Pairs, Consensus Clustering and Support Vector Machines

Themed Contributed Paper Sessions: TCPS 4 - Undergraduate Research Activities in Mathematical and Computational Biology

Cancer classification of NIH* gene expression data using supervised and unsupervised methods will be presented. Methods include top scoring pairs [TSP] of genes [which may not be cancer markers], consensus clustering and support vector machines. *T.A. Wallace, S. Ambs, et al. Tumor immunobiological differences in prostate cancer between African-American and European- American men in "Cancer Research", 68 (3), 927-936. Confusion matrices for TSP classification of all prostate cancer profiles yielded sensitivity between 0.9275 and 0.9420 and specificity = 0.95. In comparison confusion matrices for TSP gene pairs show TSP was more effective [sensitivity = specificity = 1] for classifying prostate cancer in African-American males than in European-American males [sensitivity $>$ 0.94 and specificity = 1]. Two of the authors are undergraduates at Howard University.

Rault, Patrick X. *SUNY Geneseo*

A Taste of Research

Alder Awards: Alder Awards

Research experiences in undergraduate mathematics develop critical thinking and intellectual independence, but relatively few students have the opportunity to participate. We will discuss the Inquiry-Based Learning (IBL) teaching style, which can bring a taste of these experiences to the rest of our students. Such active learning strategies have gained significant endorsements in recent years, most notably from the NSF with a 2014 press release titled "enough with lecturing." A comprehensive and high-impact study published last year states that these tastes of research significantly improve grades and reduce failure. It may now be time to stop asking "should we transition to an active classroom?" and start asking "what kind of active classroom should I create?" The Greater Upstate New York IBL Consortium provides a model to support making the transition at a regional level.

Reddy, Alison *Univeristy of Illinois*

The University of Illinois Math Placement Program: A Retrospection on 8 Years and 75,000+ Students

General Contributed Paper Sessions: Teaching or Learning Devlopmental Mathematics and Assessment

In 2007 the Department of Mathematics at Illinois began a new placement program. This talk will be a retrospection on 8 years and 75,000+ students, in particular we will compare program data from Fall 2009 to 2014. The data will show continued and consistent success rates in Calculus I since the inception the placement program. Students arrive at the University of Illinois with diverse mathematical backgrounds. This results in a diversity of mathematical knowledge, augmented by the fact that what constitutes precalculus at the various institutions varies greatly, as do grading procedures used by different high schools, confounding traditional indicators of students' mathematical knowledge and maturity. Getting students started in the appropriate math class important for their mathematical success and success on campus in general. Thus there is a great need to evaluate preparedness precisely and implement placement policies effectively.

Rehm, Megan *Millersville University of Pennsylvania*
Cynthia E. Taylor, *Millersville University of Pennsylvania*
Ximena Catepillan, *Millersville University of Pennsylvania*

An Animation of the Maya Tzolkin Calendar

General Contributed Paper Sessions: History or Philosophy of Mathematics

The ancient Maya civilization, which began ca. 1200 BC, had a long history divided into three periods. These people were sophisticated astronomers who developed a positional number system with base twenty along with the concept of zero. The Maya used this system to build their roads, construct monumental architecture, carry out astronomical

computations, and keep track of time through a remarkable calendar system. In this presentation we explain the mathematics involved in the Tzolkin calendar, which depends upon the concept of modular arithmetic and least common multiple, using an array of animations.

Reiser, Elana *St. Joseph's College*

Teaching Calculus Using Movies and Television Shows

Themed Contributed Paper Sessions: TCPS 19B - Innovative Approaches in the Calculus Sequence

Learn how to grab your students' attention by motivating calculus lessons with movies and television shows. A series of thought-provoking activities to use in a calculus classroom will be provided. Participants will be introduced to a mathematical topic through a clip from a movie or television show. Then background information will be provided, followed by a discussion on how to use the activity in a classroom.

Renault, Marc *Shippensburg University*

The Periods of Fibonacci Sequences mod m

General Contributed Paper Sessions: Number Theory and Logic or Foundations

Any integer sequence G satisfying the recurrence relation $G_n = G_{n-1} + G_{n-2}$ must be periodic when taken modulo m, and its period modulo m is denoted $\pi_G(m)$. It is known that $\pi_G(m) \mid \pi_F(m)$ where F is the standard Fibonacci sequence, and in this talk we describe the possible values of $\pi_F(m)/\pi_G(m)$. Additionally, we provide formulas that, for a fixed modulus m, count the number of sequences G that produce these different values.

Rice, Adrian *Randolph-Macon College*

"Same Time Next Week?": Ivor Grattan-Guinness as a Ph.D. Advisor

Themed Contributed Paper Sessions: TCPS 1Q - Special Session in Memory of Ivor Grattan-Guinness

In addition to his work as a researcher, editor, and university lecturer, Ivor Grattan-Guinness also served as a Ph.D. advisor during his career at Middlesex University. Between 1975 and 2007, he successfully supervised nine doctoral dissertations on the history of mathematics, on topics ranging from Niccolò Guicciardini's study of the 18th-century development of the Newtonian fluxional calculus to Abhilasha Aggarwal's survey of higher mathematics education in British India. This talk will include a brief overview of these dissertations, a discussion of their impact on Ivor's own research trajectory, and an account – based on personal experience – of just what it was like to work with the man himself.

Riley, Kyle *South Dakota School of Mines & Technology*

Assessing Student Motivation in a Numerical Methods Class

Themed Contributed Paper Sessions: TCPS 14 - Projects, Applications and Demonstrations to Enhance a Numerical Analysis or Computational Mathematics Course

One crucial component of student success is their motivation to learn the material. The Motivated Strategies for Learning Questionnaire (MSLQ) was used in a numerical methods class that was largely comprised of Mechanical Engineering majors. The MSLQ was administered to the class online at the start of the semester and a portion of the survey was administered to the class at the conclusion of the semester online. Discussion will review the results and the planned adjustments to the course for subsequent offerings.

Rivers, Yevgeniya *University of New Haven*
Joshua Goss, *University of New Haven*

The Emporium Teaching Model and Its Effect on Students' Conceptions of Mathematics, Metacognitive Awareness and Course Performance

Themed Contributed Paper Sessions: TCPS 10 - The Scholarship of Teaching and Learning in Collegiate Mathematics

The University of New Haven adopted an emporium model, the Math Zone, for teaching four developmental math courses in the fall of 2013. The technology used to support this model was and continues to be Pearson's My Math Labs. The initial model relied on self-pacing. Student learning was supported by a staff of undergraduate, graduate and professional tutors. The first year of a multi-year research project studying students' conceptions of mathematics,

mathematics proficiency, metacognitive awareness, and issues of equity began this past spring. A mixed-methods approach was used, with data collection including two previously validated instruments, pre- and post- results on a common assessment, and student interviews. Findings related to student conceptions, along with preliminary results on the affect on students' metacognitive awareness are included, along with a discussion on potential directions to take the model to allow for a more student-centered approach.

Robbins, Hannah *Roanoke College*
Adam Childers, *Roanoke College*
Jan Minton, *Roanoke College*
Kristin Emrich, *Roanoke College*
David Taylor, *Roanoke College*

Curing the High DFW Rate in First Year Calculus

Themed Contributed Paper Sessions: TCPS 10 - The Scholarship of Teaching and Learning in Collegiate Mathematics

Our department recently restructured our first calculus course to address the fact that it has perennially had one of the highest DFW rates at the college. Our solution was to offer both a one semester and a two semester version of calculus 1. Both versions cover the same calculus material as our previous calculus 1 course, and the two semester version also contains just-in-time algebra review. We use a placement test, along with SAT math scores and high school GPAs, to place students into the appropriate version. Additionally, we allow students to switch from the one semester version back to the two semester version after the first test. The goal of our study is to see how successful this new course structure is in helping students succeed in first year calculus. We collected and analyzed students' grades, placement test scores, and final exams in this first year of the restructured course, and compared them to data from the last year of our old version of calculus. In this talk, we will give details about implementing this new calculus curriculum and discuss the preliminary results of our assessment.

Roberts, Lila *Clayton State University*

I Can Touch the Math!

Themed Contributed Paper Sessions: TCPS 9 - What Can a Mathematician Do with a 3D Printer?

3D printers are becoming more affordable and at least one 3D printer manufacturer has declared that there should be "A 3D Printer in Every School." What mathematics can we create using a 3D printer and how hard is it to do? This presentation will focus on how one can get started with 3D printing and show some of the tactile objects that can enhance mathematics teaching and learning using enhanced visualization and touch.

Roberts, Siobhan *Freelance Writer, Math & Science Journalist, Biographer*

John Horton Conway: Certainly a Piece of History

Themed Contributed Paper Sessions: TCPS 1B - History of Mathematics

Wherein the author of the forthcoming biography "Genius At Play, The Curious Mind of John Horton Conway" (Bloomsbury, July 2015) recounts her subject's own penchant for history – specifically revisionist history, Conway being *the most* unreliable narrator of his own life – with the loops of expository tales he tells about his myriad contributions to the mathematical canon, surveying the Conway groups, the aptly named surreal numbers, the Game of Life, as well as tangents touching upon the likes of Thomas Cromwell, Georg Cantor, Stephen Hawking, John Bunyan, Salvador Dali, Germaine Greer, and Kurt Gödel, among others...

Rohatgi, Ranjan *Indiana University*

Tiling the Bathroom Floor: An Exercise in Counting

Graduate Student Session: Great Talks for a General Audience: Coached Presentations by Graduate Students, Part C

You need to tile your square bathroom floor, measuring 4 feet on each side. If I give you rectangular tiles, each measuring 2 ft. by 1 ft., how many different ways can you tile the floor? What if the bathroom had sides that were 6, 8, or even $2n$ feet? Let's design a hexagonal bathroom next, measuring n feet on each side. We obviously can't tile it

with rectangles, but we can using tiles shaped like rhombi (interior angles 60 and 120 degrees), called lozenges, with each side 1 foot. We can again ask about the number of ways to tile this floor or, equivalently, the number of lozenge tilings of this hexagon. While there are nice formulas for the number of tilings of the square and hexagon, no formulas are known for most regions. I will provide historical context for tiling problems and present new results for some very weirdly-shaped bathrooms!

Romik, Dan *University of California Davis*

Pythagoras Meets Euclid: A Euclidean Algorithm for Pythagorean Triples

Invited Paper Sessions: AMS-MAA Invited Paper Session: The Arithmetic of the Spheres

It was first discovered by Berggren in 1934 that primitive Pythagorean triples can be arranged in a ternary tree having the "fundamental" triple (3,4,5) at its root, in which each triple appears precisely once; thus to each triple there corresponds a word over a 3-letter alphabet encoding its position on the tree. I will discuss this curious phenomenon, which has at its heart a kind of Euclidean algorithm, explain how this algorithm can be used to define a dynamical system on the positive quadrant of the unit circle analogous to the Gauss continued fraction map, and mention possible extensions of these ideas to other diophantine equations.

Rosado, James *Rowan University*
Tom Osler, *Rowan University*

The Marriage of Two Series: An Exciting Approach to Obtaining Definite Integral Solutions.

PosterFest 2015: A Poster Session of Scholarship by Early Career Mathematicians and Graduate Students

Imagine solving the integral $\int_{-\pi}^{\pi} e^{rcos(\theta)}cos(rsin(\theta))cos(n\theta)d\theta$ by finding the antiderivative. It would undoubtedly prove to be quite a challenge, if not impossible, to find a simple antiderivative for this function. As a result standard techniques for determining the antiderivative are not helpful. Instead, we begin with a function and two different forms of its infinite series expansion, then with algebraic manipulation a solution for the integral magically appears! This is an exciting approach because our technique not only illustrates how two different infinite series expansions of a function are connected, but also permits the solutions of two more related integrals.

Rosado, James *Rowan University*
Tom Osler, *Rowan University*

The Marriage of Two Series: An Exciting Approach to Obtaining Definite Integral Solutions

Graduate Student Session: Great Talks for a General Audience: Coached Presentations by Graduate Students, Part B

Imagine solving the integral $\int_{-\pi}^{\pi} \left[e^{r\cos\theta}\cos(r\sin\theta)\cos(n\theta)\right] d\theta$ by determining the antiderivative. It would undoubtedly prove to be quite a challenge, if not impossible, to find a simple antiderivative for this function. As a result standard techniques for determining the antiderivative are not helpful. Instead, we begin with a function and two different forms of its infinite series expansion, then with algebraic manipulation a solution for the integral magically appears! This is an exciting approach because our technique not only illustrates how two different infinite series expansions of a function are connected, but also permits the solutions of two more related integrals.

Rosenhouse, Jason *James Madison University*

Nonclassical Logic Puzzles

Themed Contributed Paper Sessions: TCPS 5B - Recreational Mathematics: New Problems and New Solutions

Logic puzzles have long been a mainstay of recreational mathematics. Non-classical logics are currently a topic of great interest among researchers in mathematics, computer science, and philosophy. Perhaps, then, it is time to give some thought to what logic puzzles might look like if they were based on non-classical logics. We shall give a brief history of the use of logic in recreational mathematics, focusing especially on the work of Lewis Carroll and Raymond Smullyan. Then we shall consider examples of knight/knave puzzles (that is, puzzles about liars and truthtellers), that are based on three-valued and fuzzy logics.

Roth, Kimberly *Juniata College*
Erika Ward, *Jacksonville University*

Mathematics of Ingress
Themed Contributed Paper Sessions: TCPS 8 - Mathematics in Video Games

Ingress is an alternate reality game in which locations in the real world become portals that teams want to control and link together to form triangular control fields (in the game fiction to protect humanity from or enhance the influence of alien Shapers). Players earn action points (AP) for claiming portals, establishing links, and creating fields. The question of how to amass the most AP in a given area arises naturally in the game, and raises interesting mathematical questions. At a basic level, it's an application of planar graphs and triangulation of point sets, but slightly more powerful tools are needed to consider the optimization questions: How many links can be made? How many fields? We explore the mathematics that let us answer these questions.

Runnion, Paul *Missouri S&T*

Thinking On Your Feet Does No Harm
Themed Contributed Paper Sessions: TCPS 17 - Curriculum and Course Development to Support First Year STEM Students

During the 2014–2015 academic year, the Department of Mathematics and Statistics at Missouri University of Science and Technology introduced interactive labs into selected sections of Calculus I as part of a comprehensive, four-year calculus redesign initiative. Preliminary data shows that the redesigned labs have had little (if any) effect on the success rates of the course, but this is not surprising - we only anticipate seeing measurable improvements after the new labs are combined with other key features of the multi-faceted project. This talk will give an overview of the new labs, including some preliminary data, and look at how the new labs will fit into the larger structure of our ongoing redesign.

Russ, Steve *University of Warwick*
Katerina Trlifajova, *Centre for Theoretical Studies, Prague*

Bolzano's Measurable Numbers: Are They Real?
Themed Contributed Paper Sessions: TCPS 1F - Special Session in Memory of Jackie Stedall

Bolzano's measurable numbers: are they real? Bolzano's work on measurable numbers has had a chequered history. It was roughly 130 years before it was published in 1962 by Rychlík as Theorie der reellen Zahlen. Since that time there have been more than a dozen papers or books which have included some assessment of his work but with little consensus. They range from sustained criticism (van Rootselaar) to enthusiastic endorsement (Laugwitz, Spalt) with the most recent judgements from Bolzano scholars Sebestik and Rusnock being decidedly cautious and qualified. We shall explain some of the background to this variety of opinion and also describe a new way of showing how Bolzano's introduction of measurable numbers, as numbers permitting arbitrarily close approximation, can be described in terms of sequences of nested closed intervals with lengths converging to zero. We show that equivalence classes of such 'nets' can be mapped directly onto Dedekind cuts, and also onto the equivalence classes of Cauchy sequences used in Cantor's theory. Some commentators have suggested that because measurable numbers included infinitesimals Bolzano should be hailed as a forerunner of non-standard analysis. We claim that while infinitesimals allowed him to have a mathematical description of a richer continuum than that of the later 19C, they could not have been adequate to provide a foundation for analysis in the manner of modern non-standard analysis. We conclude with some remarks on the relationship between Bolzano's work, the so-called 'alternative set theory' due to the Czech mathematician Vopěnka, and some of the ideas associated with phenomenology.

Russell, Heather *Washington College*

Knot Coloring: A Diagrammatic Approach to Algebraic Invariants
Invited Paper Sessions: MAA Invited Paper Session: Algebraic Structures Motivated by Knot Theory

A knot is a circle properly embedded in three-dimensional space. A central issue in knot theory is determining when two knots are the same where same means ambiently isotopic. There are many ways to algebraically tackle this question, and when we are lucky, there is a convenient diagrammatic framework encoding the algebra. As an example, we will explore how the combinatorial rules of knot coloring encode dihedral representations of the fundamental group

of the knot complement. We will discuss Fox coloring as well as the much less extensively explored notion of Dehn coloring with a focus on advantages of Dehn coloring.

S

Sachs, Robert *George Mason University*

Multivariable Calculus Reordered and Rethought
Themed Contributed Paper Sessions: TCPS 19A - Innovative Approaches in the Calculus Sequence

The multivariable calculus course can be reordered by introducing scalar and vector functions of several variables early. This permits line integrals to be done earlier (aiding those in physics concurrently), visualization of gradient fields, partial derivatives of vector-valued functions, and more familiarity with vector fields.

Salaam, Lifoma *Howard University*

Counting Mutations and Anti-Chains in Binary Trees and Motzkin Trees
General Contributed Paper Sessions: Applied Mathematics

The Fundamental Theorem for Rooted Trees gives us the basic relationship between the vertex and leaf generating function in a class of trees. We distinguish a vertex in each tree and identify it as a mutator. We then use an extension the Fundamental Theorem to decompose each tree and to count mutated vertices. Additionally, we count mutated anti-chains in both Motzkin Trees and Complete Binary Trees.

Samples, Brandon *Georgia College & State University*

Creating a Meaningful Undergraduate Research Project
General Contributed Paper Sessions: Mentoring and Outreach

Our majors participate in a year-long research project under the direction of a faculty member, which leads to a written report and a presentation at our annual capstone day. Aligning with our two mathematics major tracks, students choose to present research in the areas of pure and applied mathematics or mathematics education. Creating a challenging project suitable for the undergraduate background takes some careful planning on the part of the faculty mentor. In this talk, we will discuss some strategies for creating meaningful undergraduate research projects in either track as well as provide some examples of past projects.

Samuels, Jason *City University of New York*
Aaron Wangberg, *Winona State University*
Brian Fisher, *Lubbock Christian University*

An Innovative, Three-Dimensional Approach to Multivariable Calculus Instruction
Themed Contributed Paper Sessions: TCPS 19A - Innovative Approaches in the Calculus Sequence

Multivariable Calculus presents a unique challenge for both instructors and students, as the objects of study can no longer be properly represented on a flat page. We have designed an innovative curriculum for Calculus III in which students use plastic surfaces, measurement tools, and group activities in order to explore and uncover many of the key ideas and formulas of multivariable calculus. The curriculum was implemented by 38 instructors around the country in the past year. In this talk we will give an overview of the project and share some initial results from students and instructors. This research is part of the project Raising Calculus to the Surface, funded by the National Science Foundation DUE

Saunders, Bonita *National Institute of Standards and Technology*

Cutting Edge Information Technology Applied to the NIST Digital Library of Mathematical Functions
General Contributed Paper Sessions: Mathematics and Technology

In 1964 the National Bureau of Standards, predecessor of the National Institute of Standards and Technology (NIST), published the Handbook of Mathematical Functions with Formulas, Graphs, and Mathematical Tables edited by Abramowitz and Stegun. This book became a valuable resource for many mathematical, physical and engineering scientists using high level special functions in their day to day work. In 2010 NIST completed a huge project to update

and modernize the handbook, replacing it with a freely available website, the NIST Digital Library of Mathematical Functions (DLMF) and its print companion, the NIST Handbook of Mathematical Functions. This talk focuses on the technological makeup of the NIST DLMF website. We look at the use of MathML (Mathematical Markup Language) and metadata to enhance the display and understanding of math content, briefly explore the mathematical search engine, and show a small sample of the site's 200 interactive 3D visualizations of function surfaces. The talk will include a short demo with tips to help users take advantage of the various features discussed.

Savina, Frank *Charles A Dana Center, University of Texas, Austin*
Stuart Boersma, *Central Washington University*

The New Mathways Project's STEM Prep Curriculum: Learning Outcomes & Example Lessons

General Contributed Paper Sessions: Teaching or Learning Calculus

The New Mathways Project (NMP) from the Charles A. Dana Center at the University of Texas at Austin has designed a mathematics pathway that prepares students beginning at the elementary algebra level to succeed in college-level calculus. NMP has completed the first draft of Reasoning With Functions I, which is the first course in this innovative STEM-Prep pathway, which spans two semesters. The STEM Prep Pathway was designed by several leading calculus education researchers and experienced two-year college mathematics faculty. The curriculum takes into account the latest research on difficulties student's face in learning calculus as well as employing intentional strategies to develop students' skills as learners. The lead authors will share the learning outcomes of the course along with examples of some of the more unique lessons.

Sazdanovic, Radmila *North Carolina State University*
Andrew Cooper, *North Carolina State University*

Art of Teaching Mathematics

Themed Contributed Paper Sessions: TCPS 6B - Mathematics and Art

While mathematics is thought to be formal, exact, objective, and the arts fluid, creative, subjective, they co-exist in the works of many famous artists and scientists. We will explore the two-way relationship between mathematics and arts and the way they are taught and learned. The visual aspect of mathematics has been recently introduced in mathematics courses as a valuable tool for motivating students as well as conveying scientific content in a clearer, more condensed way. We propose a similar use for mathematics for students interested in arts, architecture, design and similar. Mathematics provides a suite of tools–inspirational, conceptual and technological. The motto of this approach is Mathematical Literacy for Scientific and Art Literacy. A working knowledge of mathematical theory can be artistically worthwhile, by enabling artists to more effectively use 3D printers, CNC cutting, and other computer-based tools. We will use the theory of symmetry as a case study: it offers the means to analyze and compare works of all eras, from paleolithic ornaments to Dali's paintings.

Sazdanovic, Radmila *North Carolina State University*

From Jones to Chebyshev: Adventures in Categorification

Invited Paper Sessions: MAA Invited Paper Session: Algebraic Structures Motivated by Knot Theory

Categorification is a method introduced at the end of the 20th century and successfully used in many branches of mathematics. Categorification realizes various mathematical objects as shadows of new, algebraically richer objects, a perspective that often leads to beautiful and structurally deep mathematics. A famous example is the Khovanov homology, which categorifies the Jones polynomial and has led to some of remarkable recent results in knot theory. We will describe a related diagrammatic categorification of the ring of one-variable polynomials with integer coefficients. In particular, we will construct a diagrammatic algebra and use it to recover some well-known facts about the Chebyshev polynomials.

Schaefer, Jennifer *Dickinson College*

On the Structure of Generalized Symmetric Spaces of the Special Linear and General Linear Groups of Degree 2 Over Finite Fields

General Contributed Paper Sessions: Algebra and Linear Algebra

In this talk we will discuss the generalized symmetric spaces for $SL_2(\mathbb{F}_q)$ and $GL_2(\mathbb{F}_q)$. Specifically we will characterize the structure of these spaces and prove that when the characteristic of $\mathbb{F}_q$ is not equal to two the extended

generalized symmetric space is equal to the generalized symmetric space for $SL_2(\mathbb{F}_q)$ and nearly equal for $GL_2(\mathbb{F}_q)$ for all but one involution.

Schaffer, Karl *De Anza College*

The Daughters of Hypatia: A Mathematical Dance Concert Celebrating Women Mathematicians

Themed Contributed Paper Sessions: TCPS 2B - The Contributions of Women to Mathematics: 100 Years and Counting

The dance company MoveSpeakSpin based in California has been developing and performing a full-length concert performed by a cast of four female dancers and directed by the speaker that celebrates the lives, work and struggles of mathematical women throughout history. The concert employs dance, theater, multimedia, and audience interactions to bring alive the stories of mathematicians from the time of Hypatia to the present. It tells sobering yet inspiring stores beginning with Hypatia, a leading intellectual in ancient Alexandria, and later mathematicians who overcame societal boundaries placed on women, such as émilie du Châtelet, Sophie Germain, Emmy Noether, Marjorie Rice, and Vivian Malone-Mayes. The concert includes guest choreography by sarah-marie belcastro, incorporates text on micro-inequities by Sue Geller, and utilizes musical compositions by Vi Hart. We will discuss the process of developing and performing the concert, audience response, plans for the future as the show begins touring, and show short video clips.

Schaubroeck, Beth *United States Air Force Academy*

Upper Elementary Outreach Mobius Bands and Polyhedra

General Contributed Paper Sessions: Mentoring and Outreach

In this talk, I will discuss outreach activities that I have done with third and fourth grade students. The students completed activities related to finding patterns in Mobius bands and discovering Euler's formula for polyhedra. I will include details about timing, potential pitfalls, and student responses to open-ended questions.

Schiffman, Jay *Rowan University*

Exploring Two Fascinating Integer Sequences

Themed Contributed Paper Sessions: TCPS 5B - Recreational Mathematics: New Problems and New Solutions

Several years ago, a colleague of mine asked his pre-service teachers to secure all prime outputs in the following integer sequence: 9, 98, 987, 9876, 98765, 987654, 9876543, 98765432, 987654321, 9876543219, 98765432198, 987654321987, ... One easy way to view this sequence is via the deployment of an analogue clock and merely rock around the clock. My paper not only resolves this question, but secures the sequence in far greater detail. Using MATHEMATICA and modular arithmetic, we explore the prime factorizations and divisibility patterns in the sequence for over one hundred iterations and then repeat the process on the sequence reversal: 1, 12, 123, 1234, 12345, 123456, 1234567, 12345678, 123456789, 1234567891, 12345678912, 123456789123, ... Finally, I will suggest further directions including companion sequences in other number bases such as dozenal (base twelve) and hexadecimal (base sixteen) which can lead to additional stimulating research.

Schlicker, Steven *Grand Valley State University*
Feryal Alayont, *Grand Valley State University*

Active Learning in Linear Algebra Through Preview and In-class Activities

Themed Contributed Paper Sessions: TCPS 11A - Cultivating Critical Thinking through Active Learning in Mathematics

Linear algebra is usually one of the first mathematics courses in college in which students are expected to master a beautiful yet complicated web of deep mathematical concepts in addition to algorithmic fluency. Furthermore, the course draws in a mixed crowd of students from mathematics, science, engineering and other disciplines, some of whom might not have been exposed to the ideas of mathematical statements and proofs. As a result, the one-semester linear algebra course is tasked with introducing a number of algorithms needed for students' future courses, the interconnected mathematical concepts, and proofs in the context of linear algebra statements. In this talk, we will describe how we used a collection of preview and in-class activities throughout the semester to help improve student success in these course goals. With each preview activity, students were exposed to the day's material, through concrete examples of newly defined concepts or algorithms, or through questions asking them to reflect on previous concepts. In-class

activities built on students' preview work and strengthened their conceptual understanding and connections between the different topics. We will report on student feedback and our evaluation of the courses when these activities were used.

Semiyari, Hamid *James Madison University*

A Numerical Solution to Boundary Value Problems and Volterra Integrals
General Contributed Paper Sessions: Applied Mathematics

We present a new algorithm for approximating solutions of two-point boundary value problems and prove theorems that give conditions under which the solution must exist and the algorithm generate approximations that converge to it. We show how to make the algorithm computationally efficient and demonstrate how the full method works both when guaranteed to do so and more broadly. We also prove a theorem on existence of solutions of certain multidimensional Volterra integral equations and use it to show that the Parker-Sochacki method of introducing auxiliary variables, used to make the new algorithm computationally efficient, can be effectively applied to these Volterra integral equations in order to approximate their solutions by means of a Picard iteration scheme. Finally, we extend the existence theorem for solutions of two-point boundary value problems and prove that the new algorithm can be modified to approximate solutions in this case.

Shaheen, Anthony *CSU Los Angeles*

The Isoperimetric Constant of a Paley Graph
General Contributed Paper Sessions: Graph Theory

We give an upper bound for the isoperimetric constant (or expansion constant) of a Paley graph. This upper bound, combined with a known eigenvalue lower bound, provide a narrow strip that the isoperimetric constant must live in. More precisely, we show that the isoperimetric constant of the Paley graph of size p is asymptotically equal to p/4. This work was done with two undergraduates at CSULA. No previous knowledge of this area is assumed in this talk.

Shell-Gellasch, Amy *Montgomery College*

Ellipsographs: Drawing Ellipses and the Devices in the Smithsonian Collections
Themed Contributed Paper Sessions: TCPS 1A - History of Mathematics

We all learned how to draw and ellipse using two pins and a string, but there are other methods for drawing ellipses. Technical drawings created by engineers, architects, surveyors and machinists required drawing ellipse. In the 19th and early 20th centuries, various devices known as ellipsographs were used to draw these curves. The Smithsonian National Museum of American History owns several such objects. In this talk I will describe different ways to draw ellipses and showcase several of the Smithsonian ellipsographs.

Shelton, Brittany *Albright College*
Tyler VanBlargan, *Albright College*

Cracking the SafeCracker 40 Puzzle
Themed Contributed Paper Sessions: TCPS 5B - Recreational Mathematics: New Problems and New Solutions

Safecracker 40 is a wooden puzzle made up of four rotating disks containging 16 positive integers each. The object of the puzzle is to arrange the disks so that the column sums are 40. I will provide a proof of the manufacturer's claim that there is exactly one solution to this puzzle. Given such a proof, a natural question arises: What is the maximum number of solutions that a given set of positive integers can produce. In an attempt to answer this question, we analyzed smaller versions of the puzzle. We use a counting argument to provide an upper bound on the number of unique solutions.

Shepherd, Mary *Northwest Missouri State University*

Increasing Student Success in the Calculus Sequence
Themed Contributed Paper Sessions: TCPS 10 - The Scholarship of Teaching and Learning in Collegiate Mathematics

This talk will report on two years of teaching from Precalculus through Calculus 2 using a type of flipped classroom that integrates pre-reading (guided by reading guides), pre-online homework and carefully selected in-class problems. The changes in my teaching that have occurred over the two years, the questions that have arisen, and the success of

the change in teaching style will be addressed. Evidence will include the results of pre- and post- concept tests with normalized gains around 40%. This will be compared to results in previous classes that used primarily lecture and active lecture methods.

Shields, Brittany *University of Pennsylvania*

American Mathematicians Beyond the Iron Curtain: The US-Soviet Interacademy Exchange Program

Themed Contributed Paper Sessions: TCPS 1M - Special Session in Honor of Karen Parshall

Under the Lacy-Zarubin Exchange Agreement between the US and the Soviet Union established in 1958, the two countries agreed to participate in cultural, technical and educational exchanges. The US National Academy of Sciences and the Soviet Academy of Sciences served as the organizational clearinghouses for the exchange of research scientists. Under the interacademy exchange program, the mathematician Richard Courant (1888–1972) participated in a series of exchanges, including serving as chair for a delegation of two dozen American mathematicians visiting the "Science City" of Akademgorodok, about twenty miles outside of Novosibirsk, Siberia for a two-week symposium on Partial Differential Equations. This paper will consider the social and political context of Courant's visits to the Soviet Union and the ways in which mathematics was employed as an object of cultural exchange.

Shifflet, Daniel *Clarion University of Pennsylvania*

Student Centered Learning of Number Theory for Reluctant Mathematics Majors

Themed Contributed Paper Sessions: TCPS 11B - Cultivating Critical Thinking through Active Learning in Mathematics

Number Theory does not require a lot of prerequisite knowledge. Students must have a rudimentary understanding of the integers, proof, logic, and, well, that's about it. This makes the course a prime candidate in which to emphasize student centered learning. In this talk I will highlight the inquiry-based strategies that worked (or did not work) on a particularly reluctant group of mathematics majors. I will also discuss preliminary observations of student attitudes and assessment data on improvement in independent thinking over the course of the semester.

Shott, Martha *Sonoma State University*

A Watershed Year in STEM Education at Sonoma State University

Themed Contributed Paper Sessions: TCPS 17 - Curriculum and Course Development to Support First Year STEM Students

In the arena of budget freezes and cutbacks, The California State University (CSU) System is struggling to address a national shortage of STEM majors. Among students entering Sonoma State University with a declared STEM major, only about 30% obtain a STEM degree within 6 years. Even more daunting is the low graduation rates across the entire CSU, with only about half the students graduating in any discipline. The School of Science and Technology at Sonoma State University has pioneered a number of NSF supported strategies to increase the number of students obtaining STEM degrees. In particular, SSU is in its third year of offering a freshman year experience targeting prospective STEM majors; this interdisciplinary class combines biology, math modeling, and critical thinking to address issues surrounding the local watershed. In this talk we will discuss our successes and challenges thus far, with an emphasis on how we have integrated mathematical content into the course curriculum and how we have provided support for those students with weak mathematical backgrounds. Preliminary statistical analyses of the program's impact have been promising; most notably, tracking the first year's cohort shows that, two years after completing the course, our students are roughly three times as likely to have a declared STEM major as are students in a comparable control group.

Shvartsman, Mikhail *University of St Thomas*
Pavel Bělík, *Augsburg College*

Modeling Delay in Axon Circuit

Themed Contributed Paper Sessions: TCPS 4 - Undergraduate Research Activities in Mathematical and Computational Biology

We discuss an undergraduate research project at the University of Saint Thomas (supported by CSUMS funding) where various delay mechanisms were used to study changes in neuronal spike propagation for the axon potential.

Sibley, Thomas *St. John's University, College of St. Benedict*

Going to the Source

Themed Contributed Paper Sessions: TCPS 1D - History and Philosophy of Mathematics

Reading Euclid, Descartes, and others (in translation) gives students different perspective from a standard history of mathematics course. Future secondary teachers and all mathematics majors benefit from wrestling with what earlier mathematicians said and didn't say. Textbooks and secondary sources often short circuit this discernment process. The long development of algebra and geometry from roots in Babylon, Egypt, and elsewhere shows the variety of influences and ideas over 4000 years. It can also correct the misperception of the march of history leading to the "correct" (our) way to do math. I have taught history of math as two-credit independent studies and as a four-credit seminar.

Sidal, Yavuz *Işıklar Air Force High School*

An Alternative Way of Calculating Area of Closed Regions in Parabolas

General Contributed Paper Sessions: Applied Mathematics

In general integral is used to calculate the area between a polynomic parabola and a line. Riemann Sum is one of the ways of formally defining an integral.In Riemann Sum to calculate the area of a closed region,generally it is divided by rectangles. With a different approach, what if we fill the same region by triangles? Archimedes did it in his study of "Quadrature of Parabola". In addition to the study of Archimedes, in this study by means of determinant some easier formulas to calculate the area between a polynomic parabola and a line or between polinomic parabolas are presented.Furthermore some simplier approaches and tecniques are also given to calculate the area between any parabola in quadratic form and a line.

Siegfried, John (Zig) *James Madison University*
Cassie Williams, *James Madison University*

Investigating Student Learning Gains from Content Videos in a Flipped Calculus I Course

Themed Contributed Paper Sessions: TCPS 10 - The Scholarship of Teaching and Learning in Collegiate Mathematics

The flipped classroom has garnered attention in post-secondary mathematics in the past few years, but much of the research on this model has been on student perceptions rather than its effect on the attainment of learning goals. Instead of comparing to a "traditional" model, in this study we investigated student learning gains in two flipped sections of Calculus I. In this talk, we will focus on the question of determining immediate and longitudinal learning gains from delivering content via video outside of the classroom, and we will explore the strengths of different types of videos. In particular, we will compare student learning gains after watching more conceptual videos versus more calculational ones. We will share qualitative and quantitative data gathered from post-video surveys and quizzes, as well as aggregate data from exams and student work samples.

Sims, Brett *Borough of Manhattan Community College*

Dr. Abdulalim A. Shabazz: An Example of a Living Topological Isomorphism

Invited Paper Sessions: Special Session: "Notes of a Native Son": The Legacy of Dr. Abdulalim A. Shabazz (1927–2014)

This presentation is a brief look at the work of Dr. Shabazz during various aspects of his academic, administrative, religious, community, and family life. The talk emphasizes Dr. Shabazz's ability to map his way of life, based on truth and fairness, into all aspects of his work.

Singletary, Laura *Lee University*

Using a Dynamic Software Program to Develop Geometric Constructions

Themed Contributed Paper Sessions: TCPS 21 - Show Me Geometry: Geometry Software and Tablet Demonstrations

To help students engage with geometrical concepts in meaningful ways, researchers and educators have recommended the use of dynamic software programs to teach undergraduate geometry. The use of a dynamic software program in a

geometry course provides students with a digital environment to test conjectures and to develop the informal understandings necessary for students to derive general conclusions and rigorous proofs. During this interactive presentation, I will share a problem I use with my geometry students, asking them to construct a net for a truncated tetrahedron. In my class, I use construction problems such as this one to help my students build on and extend their understanding of important geometric concepts, theorems, and constructions. Using these problems with dynamic software, students are able to construct accurate and dynamic diagrams. Students are then able to interact with these dynamic diagrams, providing a means for students to deduce general properties and relationships and prove their constructions are viable. Research suggests that students' uses of such programs have the potential to improve their understandings of geometric concepts in a meaningful way.

Skorczewski, Tyler *Cornell College*
Jake Lehman, *Cornell College*
Brian Cristion, *Cornell College*
Jordan Wolfe, *Cornell College*

A New Way to Measure Competitive Balance Across Sports Leagues
General Contributed Paper Sessions: Applied Mathematics

Competitive balance, or parity, is an important aspect of many professional sports leagues, particularly in how it affects fan psychology. Fans have more hope of desirable results in leagues with greater parity, and this may affect how much time and money spent following the sport. Existing models measure competitive balance via standard deviations in the numbers of wins for each team in the league in a given season. We take broader approach here and treat teams as either in a winning or non-winning state. We then use a Markov model where transition values between winning and non-winning states function as our measure of competitive balance. We analyze data from three professional sports leagues: the NFL, MLB, and the NBA. Our results show the NFL has the most competitive balance followed by MLB and the NBA. We also show that competitive balance increases in the NFL after the onset of free agency, but decreases in the NBA and MLB, and discuss how the rules in each league may contribute to the results we find.

Smith Zbarsky, Emma *Wentworth Institute of Technology*

The Effects of Assignment Timing on Student Learning
General Contributed Paper Sessions: Teaching or Learning Calculus

This talk will describe the preliminary findings of a Fall 2014 research study on teaching calculus. We enrolled four sections of Engineering Calculus I in the study, two as controls and two as experimental groups, with several other sections acting as independent controls. The experimental sections used OpenStaxTutor for online homework using two different schedules. The independent controls used WileyPlus online homework. All other course supports stayed the same. We found a small positive effect on student learning as measured by the common final examination in our experimental group compared to both the full control group and the general control group.

Smith, Charlie *Park University*

Mathematics, Baseball and Shakespeare: What Do They Have in Common?
General Contributed Paper Sessions: History or Philosophy of Mathematics

This talk will explore these three topics and their similarities in the realms of beauty, great characters, golden moments, and dramatic endings. It will feature individuals and achievements from the history of mathematics and baseball and the plays of William Shakespeare. Mathematical examples will include the Golden Ratio, the Fibonnaci Sequence, Archimedes, Euler, Abel, Gauss, and Wiles. Examples from baseball and Shakespeare will be revealed at MathFest!

Smith, Karen *University of Michigan*

Hedrick Lecture 1
Invited Addresses: Earle Raymond Hedrick Lecture Series

Starting with a little trick I learned in third grade to check my multiplication homework, I'll share my fascination with algebra as it grew through middle school, high school, college and eventually led to research in characteristic p rings. Along the way, I'll point out the importance of many mentors and teachers who led me to eventually pursue my career in mathematics.

Smith, Karen *University of Michigan*

Hedrick Lecture 2

Invited Addresses: Earle Raymond Hedrick Lecture Series

In the second talk, I will explain how doing algebra over finite fields can deepen our understanding of geometry. Specifically, I'll discuss how understanding solutions to polynomials over finite fields can help understand the geometry of algebraic varieties defined by real or complex polynomials. Miraculously, rings of characteristic p have some very special properties that can be powerful tools in analyzing them, often replacing tools like integration for real manifolds.

Smith, Karen *University of Michigan*

Hedrick Lecture 3

Invited Addresses: Earle Raymond Hedrick Lecture Series

In the third talk, I will explain some of these recent tools in "characteristic p" algebra — specifically Frobenius splitting and related tools — which have made an impact on different areas of math, including the minimal model program for complex algebraic varieties and cluster algebras in combinatorics/representation theory. Some of this work is joint work with my PhD students and post-docs.

Sobota, James *University of Wisconsin-La Crosse*
Jennifer Kosiak, *University of Wisconsin-La Crosse*
Maggie McHugh, *La Crosse School District*
Robert Hoar, *University of Wisconsin-La Crosse*
Robert Allen, *University of Wisconsin-La Crosse*

Developmental Mathematics Remediation through an Online Summer Bridge Program

General Contributed Paper Sessions: Teaching or Learning Devlopmental Mathematics and Assessment

At a national level, there is a growing concern related to college readiness and mathematics. The FastTrack Summer Math Program is a bridge program for incoming freshmen who have been placed into a developmental mathematics course. Students in this program spend 6 weeks online in a College Readiness Math MOOC (Massive Open Online Course) environment. This course is designed to enhance conceptual understanding and procedural fluency related to key concepts needed for success in their first college-level mathematics class. Specifically, we will share the data regarding student success in retaking the placement exam, subsequent grades in a college credit mathematics course, and retention rates in college.

Sochacki, James *James Madison University*

A Novel Newton's Method Project

Themed Contributed Paper Sessions: TCPS 14 - Projects, Applications and Demonstrations to Enhance a Numerical Analysis or Computational Mathematics Course

Determining the zeroes of functions in general and Newton's Method in particular are fundamental topics in Computational and/or Numerical undergraduate mathematics courses. In this project, we show students how Newton's Method can be derived from an ordinary differential equation (ODE) by considering the minimization of a special function. We then demonstrate that a myriad of ODEs can be derived that produce the zeroes of the function of interest. We introduce the student to the concept of considering various algortihms for solving these ODEs and the importance of choosing proper parameters so that the zeroes are determined accurately and quickly. This project enforces the ideas of convergence, accuracy, error estimate, multiple solutions and why determining the zeroes of a function is important in the complicated world in which we live in.

Sondow, Jonathan *Independent Scholar*
Jean-Louis Nicolas, *University of Lyon, France*

Ramanujan, Robin, Highly Composite Numbers, and the Riemann Hypothesis

Themed Contributed Paper Sessions: TCPS 1H - History and Philosophy of Mathematics

I provide an historical account of equivalent conditions for the Riemann Hypothesis arising from the work of Ramanujan and, later, Guy Robin on generalized highly composite numbers. The first part of my talk is on the mathematical background of the subject. The second part is on its history, which includes several surprises. In particular, I will

explain how Robin avoided the fate of many mathematicians who have found that "Ramanujan reaches his hand from his grave to snatch your theorems from you." Our paper is available at http://arxiv.org/abs/1211.6944 on the arXiv.

Spardy, Lucy *The Ohio State University*
Timothy Lewis, *University of California, Davis*
Brian Mulloney, *University of California, Davis*

The Effects of Long-range Coupling on Neural Activity in the Crayfish Swimmeret System
PosterFest 2015: A Poster Session of Scholarship by Early Career Mathematicians and Graduate Students

During forward swimming, pairs of crayfish swimmerets (limbs) exhibit a robust pattern, moving rhythmically in a back to front metachronal wave with neighbors delayed by approximately 25% of the period. The mechanism responsible for this coordinated limb behavior has been explored in mathematical models representing the underlying neural circuitry as a chain of coupled oscillators. However, previous studies have only considered the effects of nearest neighbor coupling, ignoring the presence of long-range connections in the system. We address how long-range coupling affects metachronal phase locking in an oscillator chain whose architecture reflects the known neural circuitry in the swimmeret system. Using analytical arguments and numerical simulations, we show that long-range coupling tends to decrease phase differences between oscillators, and we suggest that this may maximize swimming efficiency.

Spayd, Kimberly *Gettysburg College*

Using Real Data to Study the Heat Equation
Themed Contributed Paper Sessions: TCPS 18 - Using Modeling for Teaching Differential Equations: Before, During, After

The heat equation is one of the fundamental topics discussed in any introductory Partial Differential Equations course. As a basis for student motivation, understanding and application of the mathematical model, a demonstration of the physical phenomenon was performed for the students: heating a long, thin rod with prescribed boundary conditions. The demonstration occurred at the second class meeting of the semester, before any rigorous mathematical development. Temperature data collected from the demonstration was used later in the semester for a project which included both analytical and numerical components. The demonstration set-up and execution will be discussed, along with the perceived impact on student learning.

St. Goar, Julia *University of Nebraska-Lincoln*

Green's Functions for Right Focal Boundary Value Problems in Nabla Fractional Calculus
General Contributed Paper Sessions: Analysis and Other

An Nth order right focal boundary value problem within the context of nabla fractional calculus will be considered and the uniqueness of the solution will be established. Then we will explore the conditions under which bounds on and the negativity of the corresponding Green's functions may be established.

St.Clair, Janet *Alabama State University*

One Student's Journey on the Road to Sense-Making in Algebra
General Contributed Paper Sessions: Teaching or Learning Devlopmental Mathematics and Assessment

The paper is an informal case study involving collaboration between the author and a developmental student in examining ideas related to functions and to a lesser extent, algebraic expressions. A booklet was prepared that contain readings that convey the human side of mathematicians, connect function with the real world, show that mathematics grows due to the work of a variety of types of people, and connect algebra, in general, to art and students' interests. Each reading contained activities and questions for the student to do. Examples are Egyptian Coordinate System, Maria Agnesi, and Robert Wadlow (the tallest man). The author and student met over a two weeks, engaging in rich dialogue and writing/drawing in addition to reading. The student was able to say the "right" things in class and pass traditional tests, but lacked conceptual understanding for basic ideas. The informal format helped the student's understanding and expanded their knowledge about mathematics. Over time, the student became concerned with using appropriate mathematical language, drew on prior knowledge, and was confident. The author also learned from the student, for example, the student's connection of skateboarding half-pipes with parabolas. The student's booklet with

his writings and drawings could serve as content for an algebra class or springboard for discussion. The study shows that small-group sessions are potentially beneficial and points toward using aspects of the Uri-Treisman.

Stack, Nora *Colorado School of Mines*
Monique LeBourgeois, *University of Colorado Boulder*
Cecilia Diniz Behn, *Colorado School of Mines*

Modeling Biphasic Sleep in Preschool Children

PosterFest 2015: A Poster Session of Scholarship by Early Career Mathematicians and Graduate Students

Sleep/wake behavior is governed by a network of neurons in the brainstem and hypothalamus. During early child development, physiological and anatomical changes in the brain lead to signficant changes in sleep/wake behavior. At two years old, most children exhibit a biphasic sleep pattern in which they take a daytime nap in addition to nighttime sleep. By contrast, at five years old, sleep has been consolidated to a monophasic nighttime sleep period in most children. Motivated by known changes in physiology, we adapted a differential equations based mathematical model of adult sleep/wake regulatory neuronal networks to simulate sleep/wake behavior in preschool children. After identifying a parameter set that produces biphasic sleep with realistic timing of naps and nighttime sleep, we assessed sensitivity to key model parameters and applied bifurcation analysis to systematically explore parameter dependence in transitions from biphasic to monophasic sleep patterns. This analysis predicts potential physiological changes associated with the consolidation of sleep during development.

Stange, Katherine *University of Colorado Boulder*

The Apollonian Structure of Imaginary Quadratic Fields

Invited Paper Sessions: AMS-MAA Invited Paper Session: The Arithmetic of the Spheres

Let K be an imaginary quadratic field with ring of integers OK. The Schmidt arrangement of K is the orbit of the extended real line in the extended complex plane under the Bianchi group $PSL(2, OK)$ (realised as Mobius transformations). The arrangement takes the form of a dense collection of intricately nested circles. I'll explain how the number theory of K influences the arrangement, and I'll use these arrangements to generalise Apollonian circle packings and define a new collection of thin groups of arithmetic interest.

Starbird, Michael *The University of Texas at Austin*

Teaching Elements of Effective Thinking Through Mathematics

Themed Contributed Paper Sessions: TCPS 11A - Cultivating Critical Thinking through Active Learning in Mathematics

The ultimate goal of a mathematics class, or any class, is to help students learn to think for themselves. When students work on puzzles or try to prove theorems, they get experience with success and failure. Students can learn strategies of thinking that lead them to creative insights. When students reflect on thinking strategies that did help or could have helped them, they can learn to use their minds more effectively to create concepts and meet challenges–in and beyond mathematics.

Stenger, Cynthia *University of North Alabama*
James A. Jerkins, *University of North Alabama*

A Collaborative Partnership to Teach Mathematical Reasoning Using Computer Programming (CPR2)

General Contributed Paper Sessions: Teaching or Learning Introductory Mathematics, Part B

Advanced mathematical thinking and computational thinking are terms to describe the essential mental processes required to reason about complex issues. The CPR2 team has undertaken the task of design, implementation and testing for an instructional treatment (IT) that pushes learners to build the mental framework necessary for abstract thinking. The IT uses writing computer programs for this task and then teaches the learner to write the abstractions as general expressions, using clues found in the code. In developing the CPR2 instructional treatment, close attention has been paid to the APOS theory of learning. APOSians have long employed computer programming as a means to teach conceptual understanding. In numerous studies, spanning several countries, and applied to a spectrum of mathematical topics, APOS theory has been applied to the use of computer experiences to stimulate mental processes that lead to the acquisition of mathematical concepts. It is a commonly held belief among this substantial group of researchers

that computer constructions are an intermediary between concrete objects and abstract entities. We have conducted research under the auspices of a USDE MSP Grant in conjunction with the Alabama Math, Science, and Technology Initiative. We will share results from classroom implementations at the middle, high school and undergraduate level.

Stephens, Richard *Columbus State University*

Remaining Questions on Approximating The Rate of Interest For an Annuity

Themed Contributed Paper Sessions: TCPS 7 - Financial Mathematics

Textbooks offer approximations of the effective interest rate for an ordinary annuity certain when the present value or future value is known. These approximations are poor. Much better estimates have been given by Silver, Ionascu and Stephens. However, there are serious questions remaining. Old estimates, new estimates and remaining issues will be discussed.

Stevens, Scott *Champlain College*

A Math Course for Game Programming Majors

Themed Contributed Paper Sessions: TCPS 8 - Mathematics in Video Games

At Champlain College we have a popular Game Programming major packed with industry-specific coursework. Their curriculum does not have the credit allowance for the standard sequence of five to six math courses found in a typical computer science degree. Our course, Matrices, Vectors, and 3D Math, teaches standard topics of Calculus III and Linear Algebra within the context of Game Programming applications and projects. This carefully constructed 3-credit course can have students performing moderately sophisticated mathematics by the end of the first year of coursework. What started out as a math class for game-programming majors is now a popular math course for all of our undergraduate students who want or need exposure to upper level mathematics but don't have the credit allowance for the standard sequence of math courses to get there. I will present the content/structure of the course, some student projects, and available resources for this course.

Stillwell, John *University of San Francisco*

1920–1939

Invited Paper Sessions: MAA Invited Paper Session: Generations of Monthly Gems

The 1920s and 1930s were a time of ferment in the disciplines close to mathematics, with the development of relativity and quantum theory in physics and the discovery of Gödel's theorem in logic and Turing's definition of computation. These developments were reflected in the *Monthly*, sometimes in unexpected ways. *The Monthly* also reported some interesting developments in pure mathematics, such as the publication of Ramanujan's collected works, in articles that were to have a lasting impact.

Stock, Mark *Independent Artist*

Printing Fractals: Experiences with Julia Sets and Diffusion-Limited Aggregates

Themed Contributed Paper Sessions: TCPS 9 - What Can a Mathematician Do with a 3D Printer?

Creating three-dimensional prints of fractal structures is hindered by their tendency in the wild toward infinite surface area and zero volume. Fortunately, straightforward regularization at the smallest resolvable scales makes these prints possible. We will review the mathematics of Julia Set fractals, strange attractors, and off-lattice diffusion-limited aggregation, present simple methods for effective regularization of their finest scales, discuss the strengths and limitations of common additive manufacturing technologies, and propose techniques for creating watertight triangle mesh models that will result in structurally-sound three-dimensional prints.

Strasser, Nora *Friends University*

Investigation of Geometric Theorems Using Geometer's Sketchpad

Themed Contributed Paper Sessions: TCPS 21 - Show Me Geometry: Geometry Software and Tablet Demonstrations

Many students studying Modern Geometry have difficulty understanding and visualizing the basic theorems in Euclidean Geometry. To assist students in the visualization of these theorems, Geometer's sketchpad software has been

used to create activities for the students. These activities allow students to better understand the theorems and to investigate further. These are interactive activities that require a written response by the student. After the students are familiar with the software, they are invited to create their own demonstrations. I will demonstrate the Postulate of Pasch activity that has been used by students. I will include other examples if time permits.

Stuffelbeam, Ryan *Transylvania University*

The Composite Two-Step

General Contributed Paper Sessions: Number Theory and Logic or Foundations

Let a and b be arbitrary digits. For a positive integer k, alternately append a on the left and b on the right of k. This process yields two infinite sequences of integers dependent upon which side the appending starts. We are interested in values of k that make each element of one of these sequences composite. In particular, we will discuss the search for the smallest such k.

Styer, Robert *Villanova University*
Reese Scott

Number of solutions to $a^x + b^y = c^z$

General Contributed Paper Sessions: Number Theory and Logic or Foundations

For relatively prime integers a and b both greater than one and odd integer c, there are at most two solutions in positive integers (x, y, z) to the equation $a^x + b^y = c^z$. There are an infinite number of (a, b, c) giving exactly two solutions.

Sutton, Julie *The University of Texas - Arlington*
Theresa A. Jorgensen, *The University of Texas - Arlington*

AWMUTA: A Group Engaged In Outreach

PosterFest 2015: Highlights from AWM Student Chapters

Since our formation in 2006, AWM@UTA has been a group focused on outreach and support. Through a series of grants from the AWM and the TENSOR Foundation (MAA) we have hosted numerous events at our sprawling urban campus in the heart of the Dallas-Fort Worth Metroplex with the flavor of a Sonia Kovalesky Day. Through our ongoing partnerships with local Title I public schools, we have engaged in mathematical activities and discussions with hundreds of young women in grades 5–12. More than sixty UTA students generally attend our twice monthly AWM@UTA meetings, where dynamic women from both industry and academia present inspirational stories about their lives and career paths. Funds to support catered lunch for meetings are raised through on-campus exam reviews for six highly coordinated mathematics courses.

Swanson, Rebecca *Colorado School of Mines*
Debra Carney, *Colorado School of Mines*

Society for Women in Mathematics at Mines

PosterFest 2015: Highlights from AWM Student Chapters

The Society for Women in Mathematics (SWiM) was founded by two faculty members in the spring of 2013 and became a student chapter of the AWM the following semester. The group's two main goals are: 1) to build a community for undergraduate students, graduate students, and faculty and 2) to support women in mathematics at the Colorado School of Mines. SWiM members meet monthly and invite a woman in mathematics (typically a CSM alumna) to share her "mathematical story". At each monthly meeting, SWiM sponsors a meal and members are able to talk and get to know one another during dinner. This simple act has provided us with numerous cases of informal mentoring. Additionally, the invited guest speaker gives an informal talk (about 10 to 20 minutes long) during the meeting in which she discusses how she became interested in mathematics, her career path, and how she uses mathematics in her profession. The speaker also shares any advice she may have for SWiM members. Ample time is left for discussion and questions. Through these monthly meetings SWiM members have been exposed to a variety of different career paths that different successful women in mathematics have taken. After a positive first year, SWiM members requested to meet more frequently. As a result, beginning in the fall of 2014, SWiM added a second monthly meeting devoted either to practical programming or a social activity. This additional programming has included workshops on graduate

school, the Impostor Syndrome, and salary negotiation. Additionally, social events have included a paint-your-own-pottery night, a game night social, and a celebration for graduating students.

Sward, Andrew *Augustana College*

The Bitcoin Protocol: A Detailed Look

PosterFest 2015: A Poster Session of Scholarship by Early Career Mathematicians and Graduate Students

If you would like to understand the underlying mathematics, cryptography, and computer science concepts "under the hood" of the first truly decentralized digital currency on the planet, then this poster session may be of interest to you. This poster will be a summary of the Bitcoin protocol itself, including: The underlying elliptic curve digital signature algorithm, the concept of the block-chain data structure, the underlying concept of the SHA-256 hash function, the solution to the Byzantine Generals problem, how transactions are created and verified, and how the "double-spend problem" is solved. This is a thorough preliminary research work for continued study and use of cryptographic currencies in the 21st century. Some emphasis will be placed on currently active areas of research, open problems, new (and unforeseen) applications, and future development.

Swim, Edward *Sam Houston State University*
Alacia M. Voth, *Sam Houston State University*
John G. Alford, *Sam Houston State University*

Mathematical Modeling of Continuous and Intermittent Androgen Deprivation Therapy for Advanced Prostate Cancer

General Contributed Paper Sessions: Applied Mathematics

Prostate cancer is the most prevalent type of cancer among men. It is stimulated by the androgens, or male sexual hormones, which circulate in the blood and diffuse into the tissue where they stimulate the prostate tumor to grow. One of the most important treatments for advanced prostate cancer has become androgen deprivation therapy (ADT). In this paper we present three different models of ADT for prostate cancer: continuous androgen suppression (CAS), intermittent androgen suppression (IAS), and periodic androgen suppression. Currently, many patients receive CAS therapy of ADT; however, many patients undergo a relapse after several years and experience adverse side effects while receiving treatment. Many studies have introduced IAS to delay the time to relapse, and/or to reduce the economic costs and adverse side effects. We will compute and analyze parameter sensitivity analysis for CAS and IAS which may give insight to plan effective data collection in a future clinical trial. Moreover, a periodic model for IAS is used to develop a strategy for optimizing the length of time for off-treatment periods and better predict the length of time before relapse occurs.

T

Taalman, Laura *James Madison University*

3D Printed Catalan Wireframes: Designing with Mathematica, MeshLab, and TopMod

Themed Contributed Paper Sessions: TCPS 9 - What Can a Mathematician Do with a 3D Printer?

As mathematicians, we often spend our days thinking about things that exist only in our minds. With 3D printing it is now much easier to bring those objects into reality so that we can hold them in our hands, display them on our desks, and use them in our classrooms. But how do you make the transition from mathematical information about an object to a digital file of a 3D model that is both beautiful and printable? In this talk we'll use a set of wireframes for Catalan solids as an example, and walk through the process of designing and 3D printing a full set of Catalan wireframes using a combination of Mathematica, MeshLab, TopMod, and a clever scaling factor.

Tanaka, Noriko *Toyota-nishi High School (Japan)*

Making Problem Asking the Students to Make Up Problem

Themed Contributed Paper Sessions: TCPS 11B - Cultivating Critical Thinking through Active Learning in Mathematics

"Making Problem"(asking the students to make up problem) is an active learning strategy in Mathematics. One of the aims of using this strategy is to create joyful learning experience of studying Mathematics, with their friends, and with

others. Using this strategy in the classroom helps increasing students' interest in maths, as well as they understand the usefulness of mathematics. I have initiated this innovative approach in my teaching in Japan. This strategy has been approached with two sets of learning settings - students in my classroom and students who join mathematics circle. I describe the strategy of making up the problems and share examples of my students' actual work to exhibit their engagement and mathematical learning.

Tanton, James *MAA*

100 Problems Involving the Number 100

Themed Contributed Paper Sessions: TCPS 3 - Math Circle Problems Involving the Number 100 in Honor of the MAA's 100th Anniversary

In this whirlwind of a talk we offer 100 problems each involving the number 100 that have been used to inspire mathematical musing among students, educators, and general mathematical enthusiasts and circlers.

Tapia, Richard *Rice University*

Applied Mathematics Commentary: Math at Top Speed: The Role of Mathematical Modeling in Science and in My Personal Life

Invited Paper Sessions: MAA Invited Paper Session: Improving Access to Mathematical Modeling Research

Mathematics is the modeling language of science. Euler and Newton first had to invent mathematical theory before they could exercise what was their true passion, the modeling of physical phenomena. For many years the speaker was involved in BMX bicycle racing as a supportive father for his son. In this talk the speaker will use several lively videos to identify and illustrate what he calls the Fair Lane Assignment Problem in BMX Bicycle racing. He then uses his mathematical training to mathematically model the problem and solves this problem using a computer and a mathematical algorithm. The speaker has been involved in drag racing throughout his life. In this talk the speaker uses his mathematical training to study the age old question how can a 'slow' car beat a 'fast' car. This exciting study leads him a mathematical model and in turn what he calls the Fundamental Theorem of Drag Racing.

Taylor, Ron *Berry College*
Eric McDowell, *Berry College*
Jill Cochran, *Berry College*

Roots of Polynomials with Generalized Fibonacci Coefficients

General Contributed Paper Sessions: Interdisciplinary Topics in Mathematics and Modeling or Applications

In this paper we construct sequences of polynomials whose coefficients are generalized Fibonacci numbers. These generalized Fibonacci numbers arise from the two-term recurrence $s_n = as_{n-1} + bs_{n-2}$ for arbitrary integers a and b with $s_0 = 0$ and $s_1 = 1$. These sequences have properties similar to the classical Fibonacci numbers including a relationship between the integers a and b, and the limiting value of ratios of consecutive terms of the sequence, which we call $\varphi_{(a,b)}$. The sequences of polynomials arise from considering powers of the $\varphi_{(a,b)}$ and we show that each sequence of polynomials has a subsequence whose roots converge to $\varphi_{(a,b)}$.

Taylor, Shree *Delta Decisions of DC*

The Impact of Dr. Abdulalim Shabazz on the Business Community

Invited Paper Sessions: Special Session: "Notes of a Native Son": The Legacy of Dr. Abdulalim A. Shabazz (1927–2014)

Early on during my matriculation at Clark Atlanta University, Dr. Abdulalim Shabazz had a profound and positive impact on my life. He inspired me to be a meticulous and proud mathematician. From the time I started in his Office of Naval Research (ONR) pre-freshman calculus class until today, as the owner of an analytics consulting firm, Delta Decisions of DC, his deliberate and strong teaching style remains etched in my memory and a part of my mathematical-genetic makeup! In this talk, I will discuss the impact of Dr. Shabazz on the development of my company (co-owned by Dr. Kim Barnette—another student of Dr. Shabazz) and how his quantitative training helps us solve challenging business problems.

Tedford, Steven *Misericordia University*

Getting to the Root of the Problem

Themed Contributed Paper Sessions: TCPS 1D - History and Philosophy of Mathematics

Throughout history, different cultures have found their own methods for finding the square root of a number. However, without a calculator, today's students are unable to approximate closely a square root. We will consider some methods used by a variety of cultures, including Indian, Babylonian, and Greek cultures to name a few. Additionally, we will introduce some "new" methods for approximating a square root, leading to the potential for a student research project.

Teymuroglu, Zeynep *Rollins College*

Project-Based Learning in First Year General Education Mathematics Courses

General Contributed Paper Sessions: Teaching or Learning Introductory Mathematics, Part B

Under college general education guidelines, all Rollins students are required to complete a math proficiency course (M). Students with non-Stem majors come to those courses with a big question, "Why do we have to take a mathematics course? I'll never use it in my major?". Increasing the motivation of students and breaking their mathematics phobia can be challenging. After teaching a general education mathematics course as a regular introductory-level statistics course, I decided to change my teaching approach. My recent general education mathematics courses are designed around a social theme. I encourage students to discover applications of mathematics by semester-long projects studying complexity of social and cultural issues from a quantitative perspective. First year, I collaborated with Project MOSAIC, a campus-wide interdisciplinary curricular activity by the Africa and African-American studies program. Another year, I taught a general education mathematics course with a central theme of childhood obesity. Students partnered with an on-campus facility, Child Care and Student Research Center (CDC), and explored many factors contributing to childhood obesity. In this talk, I will discuss ways to utilize such projects to increase student motivation in general education mathematics courses.

Thomley, Jill *Appalachian State University*
Sarah J. Greenwald, *Appalachian State University*

SoTLE: Assessing the Effectiveness of Moodle Glossaries

Themed Contributed Paper Sessions: TCPS 10 - The Scholarship of Teaching and Learning in Collegiate Mathematics

Educators have a variety of methods available to them to deliver mathematical content and facilitate student engagement and learning. In Moodle, a customizable open source course management system, we have been assessing the effectiveness of glossary resources. There are many recommendations for using Moodle tools to engage students (e.g., http://teachingwithmoodle.wikispaces.com/), but few of these have been systematically evaluated. Our search of prior peer-reviewed research revealed essentially nothing about the use and effectiveness of specific Moodle modules such as glossaries, which are flexible and customizable for a variety of courses. We will present the current findings of our ongoing research (Appalachian State University IRB Study).

Thompson, Derek *Taylor University*

Teaching Validity and Soundness of Arguments Using the Board Game 'The Resistance'

Themed Contributed Paper Sessions: TCPS 11A - Cultivating Critical Thinking through Active Learning in Mathematics

The primary goal of this talk is to highlight the possibilities and benefits of incorporating games into college mathematics classrooms. This is illustrated through the personal success of using the board game The Resistance to teach validity and soundness of arguments in a discrete mathematics course. Along the way, we will give some recent history of board games and rationale for incorporating them into classes. This talk is based on a recent publication of mine in PRIMUS.

Thompson, Jeremy *USAF Academy*

Sylver Coinage - An Algebraist's Investigation

Themed Contributed Paper Sessions: TCPS 5A - Recreational Mathematics: New Problems and New Solutions

Sylver Coinage is a two-player game in which the players alternate choosing natural numbers. In any turn the player cannot name a number that can be represented as linear combination of the previously named numbers using non-

negative coefficients. The player that must choose the number 1 loses. At its root, this is a game on the gaps of a numerical semigroup. A numerical semigroup is a submonoid S of the non-negative integers such that there exists a largest integer not in S. The game's namesake, James Joseph Sylvester established many foundation results about numerical semigroups including a solution to the problem of Frobenius for numerical semigroups generated by two numbers. In this talk, we investigate what is known about Sylver Coinage as well as how the study of numerical semigroups can inform our strategy.

Thompson, Patrick *Arizona State University*

Overcoming Epistemic Obstacles to Teaching Mathematical Modeling in Calculus

Invited Paper Sessions: MAA Invited Paper Session: Improving Access to Mathematical Modeling Research

Poor algebra skills is one of the commonly cited culprits behind students' poor performance in calculus. Recent research in mathematics education points to another, hidden problem that students face in learning calculus, and which contributes significantly to their 'poor algebra skills.' The problem is that students in US schools learn little about how to conceptualize, reason about, and represent relationships among quantities' values as they vary. I will share our attempt at ASU to address these problems while at the same time creating a more coherent, learnable calculus.

Thuong, Scott *Pittsburg State University*

The Bounding Problem for Infra-Solvmanifolds

General Contributed Paper Sessions: Geometry

A long standing conjecture states that every n-dimensional almost flat manifold (equivalently, infra-nilmanifold) is the boundary of an (n+1)-dimensional compact manifold. We propose the more general conjecture that every n-dimensional infra-solvmanifold bounds. The conjecture is indeed true in dimensions less than 4. Davis and Fang show that every infra-nilmanifold with holonomy group either cyclic or quaternionic bounds. We give a generalization of this result.

Tongen, Anthony *James Madison University*
James Sochacki, *James Madison University*

Geometric Modeling of Hexagonal Joints: Carving Mathematics Out of Wood

Themed Contributed Paper Sessions: TCPS 5A - Recreational Mathematics: New Problems and New Solutions

Functional wooden pliers can be constructed from a rectangular block of wood using ten cuts, with negligible loss of volume. These cuts form a hexagonal joint, with two reflectional symmetries, around which the pliers can open. A two-dimensional model describing the mechanics of the three-dimensional pliers was constructed based on the lengths of the cuts and the angles at which the cuts are placed. This model fully predicts whether or not pliers constructed with an arbitrary set of cuts can open and, if so, how far those pliers will open, based solely on the parametrization of the hexagonal joint by a characteristic length and an angle. Additionally, techniques from linear algebra and analysis are utilized to determine the set of possible pivot points and to derive a closed form solution for the maximum angle of opening, given an arbitrary pivot point.

Towers, Sherry *Arizona State University*

Engaging Students in Applied Mathematics via Experiential Learning through Research

Invited Paper Sessions: MAA Invited Paper Session: Improving Access to Mathematical Modeling Research

In recent years, at workshops for aspiring undergraduate mathematicians, and while teaching my own courses in applied mathematics, I have developed small, encapsulated research projects that have aspects which students can understand and contribute to, even at an early stage in their studies. I also ensure that the research projects are very topically interesting (usually related to current events), and likely to be publishable. As a mentor, I assist in directing their efforts, ensuring they understand the analysis, and in bringing together the final write-up of the paper. I will discuss my methodology, the overwhelmingly positive student feedback on this process, and two publications that have resulted from this process, one of which received international media attention.

Traves, Will *US Naval Academy*

When Do 10 Points Lie on a Cubic Curve?
Invited Paper Sessions: MAA Invited Paper Session: Concrete Computations in Algebra and Algebraic Geometry

David Wehlau and I found a ruler and compass construction to check when 10 points in the plane lie on a cubic curve. I'll explain our construction and how it relates to previous work by Pappus, Pascal, Cayley and Bacharach. I'll also describe a new class of problems raised by our work.

Tseng, Li-Sheng *University of California, Irvine*
Alessandra Pantano, *University of California, Irvine*

Increasing Diversity in the Classrooms: A Path towards Inclusion in Mathematics
General Contributed Paper Sessions: Mentoring and Outreach

Over the past few years the Mathematics Department at UCI has taken significant steps to increase diversity in its classrooms. In this talk, three recent successful initiatives will be presented: i) A Math Circle for middle school students from a low-performing nearby public school that is 99% Hispanic, to fuel their interest in mathematics and convince them to take more math classes; ii) A workshop for the parents of these middle school students, to encourage them to set college as a goal for their children; iii) A workshop for mathematics majors in Southern California, to inform and excite (under-represented minorities and first generation) students about opportunities in mathematics, from graduate school to the private sector. During the talk, we will discuss the implementation of these activities, share the feedback we received from students, and describe some future plans.

Tunstall, Samuel *Appalachian State University*

Pie Charts, Pearson, and the Prussian Army: Celebrating Florence Nightingale and FN David
Themed Contributed Paper Sessions: TCPS 2A - The Contributions of Women to Mathematics: 100 Years and Counting

Florence Nightingale is often hailed as the founder of modern nursing, and in light of her contributions to the medical field, few may know of her contributions to the realm of statistics. A significant aspect of Nightingale's work involved persuading the British government that nurses were needed in fighting the Prussian Army; her arguments were quite quantitative in nature, some even including novel statistical techniques of her own invention. In this talk we celebrate the life and work of Nightingale, as well as consider its influence. We will also look at the life and work of FN David, a renowned statistician named after Nightingale. David began by working as a "calculator" for Karl Pearson and finished her career as Statistics Chair at UC Riverside.

U

Underwood, Diana *Purdue University Calumet*
Catherine Murphy, *Purdue University Calumet*

An Overview of a Successful Mathematics Minor in Elementary Math Teaching at PUC
Themed Contributed Paper Sessions: TCPS 13 - Successful STEM Programs for Elementary Education Majors

We will describe the math content and pedagogy that underlies our math minor program in elementary school mathematics. We will also describe the theory of Guided Reinvention Teaching. Two undergraduates from the program will be present to share their experiences with the audience

Upadhyaya, Hari *Scholars Home Academy*

Tapestries In the Teaching Of Mathematics
General Contributed Paper Sessions: Interdisciplinary Topics in Mathematics and Modeling or Applications

Tapestries in the Teaching of Mathematics Mathematical tapestries are produced as patterns or geometrical shapes through one to one correspondence that are joined by straight line segments.The intuitive idea of tapestries are the matching patterns in Toddlers and Nursery classes like matching alphabets to words and words to object(figures). These matching ideas in the elementary grade consolidate into beautiful patterns of tapestries in the upper grades

of schooling. Tapestries in the elementary grades are introduced focusing on concentration, creativity and motivation.When a student creats different shapes of his/her own he/she become motivated to do few more. Within these simple straight line pattern there are vast masses of mathematical concepts and understandings of several kinds where tapestries may serve as essential and easiest means of manipulative in generalizing concepts.So far, I have used tapestries to teach, explain and generalize concepts in counting and development of multiplication tables, congruency, circle theorems,and trigonometry, set of ordered pairs, relation, functions and equations,sequence and series, locus and equations,transformations and symmetries of different kinds,parabolic and hyperbolic patterns,displacements and vectors, inequalities and polygonal region as the base for Linear Programming Problems, rout maps and matrices in graph theory,seating arrangements and different combinations,envelopes and curvatures. I think these are new and simplest ideas and would be worth sharing among the mathematics teachers, teacher educators and mathematicians of the world.

V

Valenzuela, Jose *Arizona State University*
Komi Messan, *Arizona State University*

Two Strategy Dispersal on Predator-Prey Systems

PosterFest 2015: A Poster Session of Scholarship by Early Career Mathematicians and Graduate Students

The purpose of this research is to obtain a better understanding in the interactions and decision making of social insects. Ant colonies can form complex social network working towards a common objective despite lacking a decentralize command. This research studies the mechanisms involved in a two strategy dispersal for predator-prey systems. The difference between the strategies on competing species is dispersal driven by local population density as opposed to dispersal based on attraction. Many species are known to display this kind of behavior, even though this research is focus on ant colonies. However, this information can be used to describe other species as well. Our main hypothesis is that many systems encompassed an adaptive dispersal system in which the specie makes use of the two types of strategies. There are two main ideas about how many biological systems make use of these strategies. One idea is that the species relies on switching from one strategy to another depending on their environment conditions, thus activating and deactivating a strategy. Another main idea is that many biological systems partially employ such strategies. Some of the methods to be used for this research involved creating an agent based model to obtain data, and then studying the data and creating a regression analysis. Also, studying different ODE model that describe similar conditions, and possibly creating a new ODE model.

Vallin, Robert *Lamar University*

Penney's Game and Roulette

Themed Contributed Paper Sessions: TCPS 5A - Recreational Mathematics: New Problems and New Solutions

Penney's Game involves choosing a three-outcome sequence of coin flips. Player 1 chooses a sequence (e.g. HHH) and then Player 2 chooses a different sequence (THH). A fair coin is then flipped and whichever player has his/her sequence first appear is the winner. Despite both outcomes being equally likely, Player 2 has a distinct advantage. For this talk, we take the game away from coin flips to look at roulette and what the green can mean.

Vasilevska, Violeta *Utah Valley University*

GeoGebra and Hyperbolic Geometry

Themed Contributed Paper Sessions: TCPS 21 - Show Me Geometry: Geometry Software and Tablet Demonstrations

Understanding non-Euclidian Geometries has been a huge struggle for my geometry students. I have been trying for a while to find ways to overcome this struggle. Recently, I assigned projects that asked students to use GeoGebra software and perform geometric constructions in the Poincare ́disc model of the hyperbolic plane. Use of GeoGebra was motivated by two factors: first it is free and second, most of our math education students are familiar with it. Students were asked to construct the model and then explore some of the properties of the hyperbolic plane. They were expected to demonstrate some hyperbolic results. The idea was to construct the model from "scratch," which meant that they would need to understand the model well. Students who constructed the model (and did not use a template) showed deeper understanding of the model and the discussed results. In this talk I will demonstrate what the

students were asked to do, some of the results that they were asked to demonstrate, what worked/did not work in terms of understanding the model, and their survey feedback about the project.

Vasquez, Jennifer *The University of Scranton*

Visualizing the Actions of Abelian Groups
General Contributed Paper Sessions: Teaching or Learning Advanced Mathematics

In this talk, we describe a visual representation of the action of an Abelian group on a set. This concept is often challenging for students to grasp and we hope this visual technique might be useful for those introducing this topic in an advanced course such as Abstract Algebra.

Venkatesh, Anil *Ferris State University*

Pythagoras to Secor: Generalized Keyboards and the Miracle Temperament
PosterFest 2015: A Poster Session of Scholarship by Early Career Mathematicians and Graduate Students

In music theory, a temperament is a system of tuning. The concept of temperament has been studied since antiquity; it arises as a consequence of the unique prime factorization property of integers, applied to the pitches of musical notes. Most instruments are capable of minutely adjusting the pitches of notes during performance, allowing them to play in any temperament. However, keyboard-based instruments such as the piano cannot adjust pitches in this way. Consequently, temperament is most relevant to keyboard-based instruments. A crowning achievement of the western musical tradition is the well tempered scale, which is the particular tuning convention of modern pianos. In this poster, we present the relationship between prime factorization and the temperament problem. We review historically significant temperaments such as Pythagorean tuning and discuss the innovation of the well tempered scale. We then introduce George Secor's "miracle temperament" and the concept of a generalized keyboard. The properties of Secor's temperament that earn it this distinctive monicker are vastly generalizable. "Miracle" temperaments in the generalized sense have not yet been classified. We therefore conclude by discussing this and other unsolved problems in the theory of temperaments, all of which are accessible to undergraduates.

Venkatesh, Anil *Ferris State University*

Pythagoras to Secor: Generalized Keyboards and the Miracle Temperament
Themed Contributed Paper Sessions: TCPS 6A - Mathematics and Art

In music theory, a temperament is a system of tuning. The concept of temperament has been studied since antiquity; it arises as a consequence of the unique prime factorization property of integers, applied to the pitches of musical notes. Most instruments are capable of minutely adjusting the pitches of notes during performance, allowing them to play in any temperament. However, keyboard-based instruments such as the piano cannot adjust pitches in this way. Consequently, temperament is most relevant to keyboard-based instruments. A crowning achievement of the western musical tradition is the well tempered scale, which is the particular tuning convention of modern pianos. In this talk, we discuss the relationship between prime factorization and the temperament problem. We review historically significant temperaments such as Pythagorean tuning and discuss the innovation of the well tempered scale. We then introduce George Secor's "miracle temperament" and the concept of a generalized keyboard. The properties of Secor's temperament that earn it this distinctive monicker are vastly generalizable. "Miracle" temperaments in the generalized sense have not yet been classified. We therefore conclude the talk by discussing this and other unsolved problems in the theory of temperaments, all of which are accessible to undergraduates.

Visscher, Daniel *University of Michigan*
Nina White, *University of Michigan*

Comparing Oral and Traditional Assessments in Math Content Courses for Pre-Service Elementary Teachers
Themed Contributed Paper Sessions: TCPS 10 - The Scholarship of Teaching and Learning in Collegiate Mathematics

A recent study on oral assessments summarizes several advantages to giving oral assessments, including that they: (1) develop communication skills, (2) are a more authentic assessment, (3) are more inclusive of different learning style and needs, and (4) are better at gauging understanding (Huxham, Campbell, Westwood, 2012). In addition to these, we are interested in (5) their potential as learning opportunities for students. The study we will describe in this session seeks to better understand some of these anticipated advantages. We will share findings from our study on using oral

and written assessments in two sections of a math content course for pre-service elementary school teachers (n=42). Our report focuses on two central questions: Q1. What characteristics of a student leads her to perform better on an oral vs. written assessment relative to her peers? and Q2. What opportunities for student learning can oral assessments provide? Our preliminary answer to Q1 relies on quantitative data exploring connections between students written and oral exam scores and types of math anxiety (as indicated on a survey). Our preliminary framework for answering question Q2 relies on qualitative video data, which we will explore in a case study.

Vivas-Barber, Ana *Norfolk State University, VA, USA*
Eun Chang, *Norfolk State University,VA,USA*
Sunmi Lee, *Kyung Hee University, Yongin, Korea*

A Mathematical Model with Asymptomatic Individuals for Malaria in the Amazon Region
General Contributed Paper Sessions: Interdisciplinary Topics in Mathematics and Modeling or Applications

Despite of the efforts made by the public health institutions, there is still a considerable number of deaths caused by malaria around the world, affecting mostly specific areas with the poorest economic conditions. In this work, we propose a model to study the dynamics of the transmission of malaria, including social and economic conditions. A system of nonlinear ordinary differential equation that includes asymptomatic individual is presented; the basic reproduction number is derived; results for the stability of the disease-free equilibrium are presented; a sufficient condition for the existence of the endemic equilibrium is obtained; and numerical simulations with parameters from the Amazon region are performed.

Vo, Anh *Creighton University*

Timing of Action Potential in Auditory Neuron System
General Contributed Paper Sessions: Interdisciplinary Topics in Mathematics and Modeling or Applications

Auditory Neuron is interesting both biologically and mathematically. Auditory neuron cells has smaller sizes, thus have fewer membrane channels, which transports ions and compounds in and out the cells. Because of its interesting behaviour, biologists and mathematicians are interested in modeling the timing of action potential and property of auditory neuron system. In this research, we will find the solutions of systems of partial differential equations using numerical method. We then will compare our theoretical data to clinical data to correct our model.

von Mehren, Ann *Arcadia University and University of Houston*

Inspiration for Elementary Mathematics Descriptions from a "Heritage" Reading (in the Sense of Grattan-Guinness) of On the Nonexistent by Gorgias
Themed Contributed Paper Sessions: TCPS 1D - History and Philosophy of Mathematics

Lessons for elementary mathematics concepts may be developed by a heritage reading of an early Greek text, On the Nonexistent, by the fifth-century B.C.E. Greek Sophist philosopher and rhetor Gorgias. The history versus heritage source distinction made by Ivor Grattan-Guinness, when applied to this text by Gorgias, defines the approach. On the Nonexistent by Gorgias is not considered to be a historical math text by historians of mathematics. Grattan-Guinness, for example, makes no reference to it. However, my paper suggests that this work by Gorgias can be probed successfully by elementary mathematics educators. I now understand how to explain, thanks to Grattan-Guinness, that my suggestions about the possibility of the heritage use in a contemporary math classroom of the language used by Gorgias does not mean that I think similar math lessons were taught by Gorgias. Nonetheless, Grattan-Guinness notes that giving attention "to the broad features of history may well enrich the inheritance" of mathematics education (Grattan-Guinness, 2004(a), p.168). Teachers should, however, be warned by Grattan-Guinness's concerns about notions "photocopied onto the past" (Grattan-Guinness, 2004(a), p.165). If mathematics educators delve into Gorgias's intricate thought, for their own contemporary teaching purposes, then they must seek to find their own rewards, rather than search for math history, when grappling to understand the meaning of this great Sophist teacher.

W

Walk, Julia *University of Iowa*

Mathematical Modeling of Kidney Function

Graduate Student Session: Great Talks for a General Audience: Coached Presentations by Graduate Students, Part A

The kidneys are organs that play several important roles in the body, including the removal of metabolic waste, the regulation of the balance of water and electrolytes, and the regulation of blood pressure. When the kidneys stop functioning correctly, the human body begins to shut down. How can doctors evaluate kidney function to catch patients' kidney problems early? We can think of the kidney as a "black box" –we don't know what's happening inside, but we can measure inputs and outputs to make predictions. This talk will introduce basic kidney physiology, as well as explore the way math is used to evaluate kidney function.

Walker, Erica *Columbia University*

"A Multiplicity All At Once": Mathematics for Everyone, Everywhere

Invited Addresses: AWM-MAA Etta Z. Falconer Lecture

What does it mean to learn mathematics? What does it mean to say that some people are "math people"? In this talk, I draw upon 20 years of research and teaching to describe multiple contexts for mathematics learning and socialization across the lifespan. I share findings from studies with elementary students, high school youth, teachers, and mathematicians to describe how they engage in mathematical practice, develop mathematics identities, and craft meaningful spaces for rich mathematics learning. I discuss implications of this work for reframing teaching and learning, both within and outside of schools, to better foster people's success, interest, and creativity in mathematics.

Walker, Erica *Teachers College, Columbia University*

"In a Beautiful Way": Lessons for Mathematics Education from Dr. Abdulalim Shabazz

Invited Paper Sessions: Special Session: "Notes of a Native Son": The Legacy of Dr. Abdulalim A. Shabazz (1927–2014)

In this talk I describe and discuss lessons from Dr. Shabazz's life and work for mathematics teaching and learning. I share implications of his work for (re)current reform efforts in mathematics education, as well as ways to incorporate Dr. Shabazz's philosophies in spaces for mathematics learning for young people in and out of school.

Walker, Robert *University of Michigan*

Continued Fractions Can Resolve Singularities?!

Invited Paper Sessions: MAA Invited Paper Session: Concrete Computations in Algebra and Algebraic Geometry

For the lion's share of number theorists, continued fractions are not a tool for solving not-so-trivial problems. They're not hip enough perhaps. In birational geometry, however, they can be used to obtain minimal resolutions of several classes of singular algebraic varieties—a not-so-trivial problem to be sure. For coprime integers $a > b > 1$, the affine plane curve $x^b = y^a \in k^2$ (k any field) has a cusp at the origin. Say we want to resolve this isolated cuspidal singularity. The goal of the talk is to show how the continued fraction expansion of a/b can serve as a "cheat code" for completing this task.

Walkins, Mary *The Community College of Baltimore County*

Experiencing a 'GREAT' Project in a Liberal Arts Mathematics Course

General Contributed Paper Sessions: Teaching or Learning Introductory Mathematics, Part B

Every three years, the Community College of Baltimore County (CCBC) investigates different courses to see how well each course satisfies its general education goals. To do so, a common graded assignment or project is created for each course and a rubric sets forth the standard by which the project is graded. In the fall 2014, during my second year at CCBC, I was privileged to experience my first GREAT project in a Liberal Arts Mathematics course. We assessed students' competence in the following areas: Written and Oral Communication Skills; Critical Analysis and Reasoning; Technological Competence; Information Literacy; and Scientific and Quantitative or Logical Reasoning. I will present and discuss the 'GREAT' project and its results.

Walkowiak, Temple *North Carolina State University*
Valerie N. Faulkner, *North Carolina State University*
Paola Sztajn, *North Carolina State University*

Examining the Features and Outcomes of a STEM-Focused Elementary Teacher Preparation Program
Themed Contributed Paper Sessions: TCPS 13 - Successful STEM Programs for Elementary Education Majors

The goals of this paper session are to: (1) describe the features of our STEM-focused elementary teacher preparation program, highlighting its mathematical components; and (2) share findings from an NSF-funded study that examines the program's outcomes. During the freshman and sophomore years, preservice teachers (PSTs) complete nine courses of STEM content that include one engineering design, three science, and three mathematics courses. For two of the mathematics courses, PSTs take a two-semester course designed specifically for elementary teachers. During their junior and senior years, PSTs complete three full-time semesters of elementary education coursework accompanied with field experiences and one semester of student teaching. The PSTs take one engineering methods, two science methods, and two mathematics methods courses (K–2 and 3–5). They complete field-based assignments in their simultaneous K–2 and 3–5 semester-long field experiences. The foci of the mathematics methods courses include: mathematical content (with a strong emphasis on number and operations); children's mathematical thinking; the use of high-quality tasks, representations, and discourse in instruction; and issues of equity in elementary mathematics classrooms. We have been evaluating the outcomes of the program through a longitudinal mixed methods study. Specifically, we have examined the development of our PSTs' knowledge, beliefs, and instructional practices from junior year and into their first two years of teaching. Findings focused on knowledge and beliefs will be shared.

Wang, Frank *LaGuardia Community College, CUNY*

Development of Students' Bayesian Reasoning Skill
Themed Contributed Paper Sessions: TCPS 10 - The Scholarship of Teaching and Learning in Collegiate Mathematics

Problems in which the probability of a cause has to be inferred from an observed effect have been termed the "Bayesian inference problems." In this presentation, we will report our effort to teach Bayesian reasoning based on psychological principles. Gerd Gigerenzer's technique of natural frequency representations for solving the medical diagnosis problem, mammography problem, and other Bayesian reasoning problems is summarized. Such a method has been introduced to community college students in an elementary statistics course. We will report our assessment of student learning in four semesters. With repeated practice, many students can acquire the skill and avoid reported judgment errors that are commonly committed by medical professionals. However, weaknesses in basic skills such as percentage calculations prevent some students from obtaining the correct probability. This project is part of an NSF-funded program "Numeracy Infusion Course for Higher Education" (NICHE); see www.teachqr.org for additional additional information.

Wares, Arsalan *Valdosta State University*

Exploring Mathematical Ideas through Origami
General Contributed Paper Sessions: Geometry

During the session we will construct an origami box from a sheet of paper and discuss the mathematical ideas that are involved with the activity. We will explore the relationship between the dimensions of the sheet and the dimensions of the constructed box. We will also derive a formula for the volume of the box in terms of the dimensions of the sheet of paper used to construct the box

Warnberg, Nathan *University of Wisconsin-La Crosse*

Propagation Time on Directed Graphs
General Contributed Paper Sessions: Graph Theory

Imagine that you would like to start a rumor so that eventually everyone in your school is aware of the rumor. As a mathematician, you do not want to leave this to chance so you decide to develop and scrutinize a model of the situation so that your rumor spreading campaign is as efficient as possible. The model you decide to create must exhibit the relationships that exist between individuals in the population and how the rumor is spread from person to person. We will use a directed graph as our model. More precisely, a vertex in the graph will represent a person, and, if person A is willing to tell the rumor to person B then we will draw an arrow (arc) from A to B. Further, if a person knows a rumor

their corresponding vertex will be colored blue and if they do not know the rumor their vertex will be colored white. Given this situation there are many rules to determine how the rumor will spread. We will study one of these 'rules' and answer questions about how fast we can make the rumor spread and what is the minimum number of people that need to know the rumor initially and still make the rumor spread to everyone. This talk will focus on basic graphs such as paths and trees.

Warner, Harry *University of Southern California*

A Visualization of Quillen Stratification with Applications in Restricted Lie Algebras

PosterFest 2015: A Poster Session of Scholarship by Early Career Mathematicians and Graduate Students

Let p be a prime number. A result due to Daniel Quillen states that the cohomology of a finite group Γ with coefficients in the finite field of p elements can be built up from pieces coming from abelian subgroups of Γ with exponent p. In this poster, we briefly review this "stratification" and present a few concrete computations which elucidate Quillen's result. The computations are accompanied by visualizations constructed with the aid of Magma. In the case that Γ is the group of rational points of an algebraic group G with Lie algebra $\mathfrak{g}$, the poster presents an application of our computations with finite groups to understanding the structure of certain "elementary" subalgebras of $\mathfrak{g}$.

Washington, Talitha M. *Howard University*

Sharing the Impacts of Dr. Abdulalim Shabazz

Invited Paper Sessions: Special Session: "Notes of a Native Son": The Legacy of Dr. Abdulalim A. Shabazz (1927–2014)

In the mathematical community, Dr. Abdulalim Shabazz touched the lives of many. As a mentor, colleague, advocate, and friend, he actively strove to uplift others throughout the entire world. This interactive talk will provide an opportunity for audience members to share the many stories, memories, and contributions of Dr. Shabazz.

Washington, Tyrone *Millersville University*

Integrating Worked Examples into a Flipped College Algebra Classroom

General Contributed Paper Sessions: Teaching or Learning Introductory Mathematics, Part A

In this talk, I will share how I use worked examples in a flipped College Algebra course. Students need a conceptual understanding of fundamental topics in algebra as well as procedural skills. A worked example problem presents a completed problem and includes questions that focus on specific steps. Using worked examples allows my students to apply reasoning and sense-making skills as they explain why certain steps were carried out or what misconception is exhibited. Worked examples can be used to facilitate small group discussions as well as whole-class discussions. Additionally, I used worked examples as individual formative assessments tools. I was able to gauge how well my students understood facets of the videos they watched prior to class.

Weir, Rachel *Allegheny College*

Math and Civil Rights: An Interdisciplinary Reading Course

General Contributed Paper Sessions: Teaching or Learning Introductory Mathematics, Part B

In Spring 2015, as part of Allegheny College's Civil Rights and Democratic Participation annual theme, I co-facilitated a one-credit reading group based on the book *Quality Education as a Constitutional Right*, edited by, among others, Dr. Robert Moses. The students in this course were able to meet with Dr. Moses when he visited campus and they also put together a panel discussion entitled "What Does Algebra Have to do with Civil Rights?" as part of Allegheny's Undergraduate Conference on Voting Rights and Democratic Participation. In this talk, I will discuss the format of this course and its impact on both myself and the students involved.

Wess, Jane *Edinburgh University/Royal Geographical Society-IBG*

The Mathematics in 'Mathematical Instruments': The Case of the Royal Geographical Society, London, in the Mid to Late Nineteenth Century

Themed Contributed Paper Sessions: TCPS 1K - Special Session on Mathematical Communities

The RGS, London, was founded in 1830 with a remit to acquire instruments suitable for exploration. Twenty years later it had accumulated a range of artefacts for measuring length, direction, position, for making surveys in the field,

and for drawing and calculating back in the Map Room in London. These were all 'mathematical' instruments as opposed to 'philosophical' instruments. These mathematical instruments were lent out to explorers repeatedly, in a manner which accords closely with actor network theory. The instruments embodied considerable resource, an aspect of which was the mathematical relationships assumed and utilised. While some of the mathematics was basic, such as trigonometric formulae, the explorers were also relying on the very considerable efforts of mathematicians such as Newton, Halley, Cotes, D'Alembert, Clairaut, Euler, and Maskelyne for longitude astronomically. They were relying on Francis Wollaston for work on the relationship between boiling point and height, using various map projections, assimilating the four colour theorem on which Cayley wrote in the Society's Journal, and the calculations with respect to the magnetic pole by Young, Sabine and others.Another resource expended in order to utilise the latent knowledge within the instruments was that of training the explorers. The RGS spent a considerable sum on this mathematical training. The paper will expose the mathematics inherent in the instruments and investigate the mathematical training given to potential explorers. It will argue that even in difficult circumstances the instruments had embedded value which the explorers recognised and exploited to the best of their ability.

Whieldon, Gwyneth *Hood College*
Alison G. Schuetz, *Hood College*

Dissecting and Coloring Polygons Using Power Series

Themed Contributed Paper Sessions: TCPS 5B - Recreational Mathematics: New Problems and New Solutions

A regular $(n+2)$-gon can be dissected into triangles by adding n diagonals in exactly $C_n = \frac{1}{n+1}\binom{2n}{n}$ ways, e.g. the Catalan numbers $1, 2, 5, 14, 42, ...$ count the number of ways to break a triangle, square, pentagon, hexagon, heptagon, etc. into triangular pieces. How many ways are there to break an $(n+2)$-gon into pieces made up of different polygons, with each piece a d-gon for $d \in \{d_1, d_2, ..., d_k\}$? What if we allow our pieces to be of different colors?All of these puzzles can be translated into the language of power series, where the number of "dissections" of an $(n+2)$-gon into a fixed type is counted by coefficients of the series inversion of an easy-to-describe polynomial. In this talk, we examine how power series connect to polygonal dissection, and present a few open follow-up problems that are accessible to undergraduates.

White, Diana *University of Colorado Denver*
Brandy Wiegers, *University of Central Washington*

A Partial History of Math Circles

Themed Contributed Paper Sessions: TCPS 1K - Special Session on Mathematical Communities

Originating in Eastern Europe, Math Circles migrated to the United States in the 1980s. Starting approximately at the same time on both the east and west coast, they have grown to several hundred today. While the inaugural Math Circles in the United States started with a focus on preparing mathematically talented high school age youth for advanced mathematical competitions, their focus has now broadened in scope. There are now Math Circles for all ages of children (preschool through high school) as well as for teachers. In addition, while some focus on preparing for local or national competitions, others focus on providing non-competitive mathematical enrichment experiences for all interested students. In this talk, we provide an overview of this history, focusing on inter-relationships between various Math Circles and how they have both contributed to the development of mathematical communities as well as benefited from it.

White, Jacci *Saint Leo University*
Monika Kiss, *Saint Leo University*
Brian Camp, *Saint Leo University*

Writing with Critical Thinking and Values for Effective Problem Solving

Themed Contributed Paper Sessions: TCPS 12 - Improving Undergraduate Math Writing

At Saint Leo University we have several major initiatives related to critical thinking and writing. We integrated Writing Across the Curriculum (WAC) into our University curriculum approximately five years ago. As part of our SACS accreditation two years ago, we implemented a Quality Enhancement Plan to use Critical Thinking and Values for Effective Problem Solving. Writing is an essential part of both of these initiatives. In this session, we will share examples from three books we have written that contain writing across the curriculum and critical thinking problems for all of our mathematics course content for College Mathematics, Finite Mathematics, and Introductory Statistics.

These books are used by faculty at all locations, online and on ground, to assist with implementing these initiatives. In addition, students in our mathematics major complete a senior mathematics project, which requires them to write a research paper. To prepare our students for this endeavor we incorporate smaller research projects in most of our mathematics courses. One example in Discrete Mathematics is to allow students as a group to choose a topic of their choice such as cryptography, the four color theorem, and the shortest path problem. We also talk about how writing can be included in math classes through the use of a wiki.

Whittlesey, Marshall *California State University San Marcos*

Inequalities in Spherical Geometry: Ancient and Modern

General Contributed Paper Sessions: Geometry

We discuss a number of inequalities in spherical geometry, some of which are the same as in plane geometry (e.g., the triangle inequality) and others which are not (e.g., the exterior angle theorem.) We give some simple proofs of them and show some connections via duality relationships in spherical geometry. We also discuss their appearance in ancient work of Menelaus and make connections to problems in astronomy.

Wiegers, Brandy *Central Washington University/ National Association of Math Circles*
Diana White, *University of Colorado, Denver / National Association of Math Circles*

Growing Math Circles for the Next 100 Years

Themed Contributed Paper Sessions: TCPS 3 - Math Circle Problems Involving the Number 100 in Honor of the MAA's 100th Anniversary

The National Association of Math Circles was founded in 2007 with the primary goals to (1) Seed the creation of additional Math Circles in the United States; (2) Build a community of Math Circles leaders through which novice and existing leaders are connected, encouraged and inspired; (3) Provide high-quality resources that help Math Circles build and sustain effective programs; (4) Document and disseminate the impact of Math Circle programs across the nation. Join us to learn about our current work and future plans to promote these goals including the Math Circle Mentorship And Partnership Program (MC-MAP) starting in Fall 2015. The end of the session will include time to share questions and ideas that you have for the growth of the national Math Circle movement (mathcircles.org).

Wijaya, Michael *Dartmouth College*

A Function-field Analogue of Conway's Topograph

PosterFest 2015: A Poster Session of Scholarship by Early Career Mathematicians and Graduate Students

In *The Sensual (Quadratic) Form*, Conway introduces a new visual method to display values of an integral binary quadratic form $Q(x, y) = ax^2 + bxy + cy^2 \in \mathbb{Z}[x, y]$. This topograph method, as he calls it, leads to a simple and elegant method of classifying all integral binary quadratic forms and answering some basic questions about them. In particular, Conway shows that the topograph of any definite binary quadratic form has a unique "well", while the topograph of any indefinite binary quadratic form has a unique "river". In our work, we develop an analogue of Conway's topograph method for binary quadratic forms with coefficients in $\mathbb{F}_q[T]$, where q is an odd prime power.

Williams, Talithia *Harvey Mudd College*

Reality Shifting: Building Mathematical Confidence

Alder Awards: Alder Awards

The decision to pursue a career in mathematics, whether academic, industry or government, often rests on one's perception of their own mathematical talent. As such, it's easy for us to lose talented students who don't *see* themselves as mathematically gifted. During this talk, I'll highlight teachers and professors who shifted my reality by building my mathematical confidence and discuss ways that I continue that legacy with my own students.

Williams, Travis *University of Rhode Island*

Imagination and Reading the Third Dimension in Early Modern Geometry

Themed Contributed Paper Sessions: TCPS 1C - History and Philosophy of Mathematics

Philosophical, rhetorical, and historical evidence increasingly shows that the imagination is an essential component in the technical and rhetorical development of mathematical concepts, and of a reader's ability to comprehend a

mathematical text. Early modern mathematical writers struggled with the problems of three-dimensional textuality, since the two-dimensional page could, at best, provide only a partial representation of a solid object. Among the solutions they implemented was the inclusion of paper models of solid objects, to be constructed by readers. The traditional interpretation of these paper models is that readers constructed them as tools that would permit easier comprehension of the principles of solid geometry. In this interpretation, the model comes first, and the understanding (with and through imagination) comes second. Using evidence of well and poorly constructed paper models extant in sixteenth-century geometry books, this paper will argue, conversely, that readers had to understand the principles of solid geometry with great proficiency in order correctly to construct the models. The constructed model therefore serves as a mark of successful comprehension of solid geometry and not an instrumental means to achieve it. In this interpretation, spatial components of mathematical imagination possess fundamental importance in mathematical pedagogy and auto-didacticism, since the reader must thoroughly imagine the solid object taking shape before it can be physically constructed.

Wilson, Robin *Oxford University, UK*

The BSHM, 1971–2015

Themed Contributed Paper Sessions: TCPS 1F - Special Session in Memory of Jackie Stedall

Over the past 45 years the British Society for the History of Mathematics has grown from a relatively small group of enthusiasts to a lively association holding up to ten meetings per year. In this illustrated talk I present its development from its founding in 1971 to the present day, describing its range of activities and mentioning some of the distinguished people who have been involved with it, including the late Jackie Stedall and Ivor Grattan-Guinness.

Wojnar, G. Gerard *Frostburg State University*
Deborah W. Devlin, *Frostburg State University*

Developing Mathematical Authenticity, Maturity, and Aesthetic Experience in Pre-Calculus and Earlier Learners

General Contributed Paper Sessions: Teaching or Learning Introductory Mathematics, Part B

The notion of aesthetic experience while doing mathematics permeates popular writing in mathematics from recreational math to expositions of particularly elegant theorems. Most such writing requires knowledge beyond calculus to truly appreciate the nuances of the beauty involved. But much of the particularly appealing nature can be made accessible to students in courses prior to calculus by focusing on the structural echoes and interconnections. Since courses such as Mathematics for Liberal Arts, College Algebra, and Pre-calculus are often terminal courses for undergraduates, many students have never experienced the delightful aspects of doing mathematics: the joys of assembling puzzle pieces into a coherent ideascape, sensing connections among seemingly unrelated contents, creating one's own mathematical construct, conjecturing relationships among one's own constructs, pursuing rationales to support one's own conjectures, and experiencing the emergence of a beautiful solution. Would embedding syllabus-correlated problems crafted specifically to showcase the elegance, beauty and interconnectedness of mathematics deepen early mathematics students' mathematical maturity, confidence, and appreciation for conceptual foundations? This study seeks to establish a framework for embedding such problems into an undergraduate pre-calculus course. It includes a literature review, a qualitative analysis of a collection of pre-calculus course syllabi from across the United States, and a methodology design for conducting a mixed-methods study of a group of students enrolled in such a pre-calculus course. The presentation will include the research-supported framework for the study based on findings in the literature.

Wolbert, Roger *University at Buffalo*

Using Learning Logs to Cultivate Critical thinking Skills

Themed Contributed Paper Sessions: TCPS 11B - Cultivating Critical Thinking through Active Learning in Mathematics

Writing in learning logs can guide students into thinking more critically about their own learning. Unlike journaling, which is often a reflection of feelings and attitudes, the focus of learning logs is on particular mathematical or study skills. They are designed to help students become cognizant of the way they learn and understand mathematics, and they provide a way for students to monitor their own progress. In my own experience, I have used learning logs with students after giving them formative or summative assessments. Students first receive my feedback, and then they are given class time to review my comments, followed by reflecting in their learning logs on ways they can improve in

preparing for assessments. Many web-based platforms are available for students to easily share their learning logs with their instructor. This allows them to identify how critical thinking skills and preparation for assessments can be further developed. In my presentation, I will discuss good guiding questions for learning logs entries and the practicalities of setting up a learning log.

Wolf, Elizabeth *Saint Mary's College*

Fostering Critical Thinking in a Liberal Arts Mathematics Course through Graph Theory

Themed Contributed Paper Sessions: TCPS 11A - Cultivating Critical Thinking through Active Learning in Mathematics

A Liberal Arts Mathematics course can take many forms. Two common approaches are the "breadth" approach, in which several interesting and/or especially relevant topics are explored, and the "depth" approach, which explores one topic in more detail. In this talk we will highlight some advantages of a "depth"-type course in which students develop their critical thinking ability by means of graph theory. We will describe several strategies that we attempted in order to encourage students in their learning process. Successful strategies included having students: reflect on mindset, learn to read their textbook effectively, and delve into the history and culture of mathematics and computer science.

Wood, Japheth *Bard College*
Philip B. Yasskin, *Texas A&M University*

The Cell Phone Dropping Problem

Themed Contributed Paper Sessions: TCPS 3 - Math Circle Problems Involving the Number 100 in Honor of the MAA's 100th Anniversary

You work for a cell phone company which has just invented a new cell phone protector and wants to advertise that it can be dropped from the N-th floor without breaking. If you are given 1 or 2 phones and a 100 story building, how do you guarantee you know the highest floor it won't break with the smallest number of trial drops? If you are only given 1 phone you would need to drop it from each floor starting from the bottom, and this might take you 100 drops. If you are given 2 phones, you could drop from every other floor and guarantee you will know the highest floor it does not break with at most 51 drops. Can you do better than 51 drops? How? In what directions does this problem lead? Dr. Yasskin was given this problem by a middle school student at SEE-Math who had learned it at MathPath. Yasskin has used it successfully at the TAMU Math Circle with high school students and at a session of 30 Davidson Young Scholars. Dr. Wood developed an information theory proof that you can't do it with fewer than ? drops (answer withheld until the talk), and is planning to use this problem at the Bard Math Circle this summer.

Wright, Justin *Plymouth State University*

Putting the "Real" Back in Real Analysis

Themed Contributed Paper Sessions: TCPS 11B - Cultivating Critical Thinking through Active Learning in Mathematics

Many students struggle in their first real analysis course despite the familiarity that they have with the real numbers, functions, and limits from their calculus courses. Much of this difficulty can be attributed to the relatively technical definitions and theorems in a course on real analysis. In this talk, we explore several fun and inexpensive hands-on activities that can be used in an active learning environment to help students develop an understanding of analysis concepts while improving their creative and critical thinking skills. Course evaluations and student feedback will be provided as evidence of the success of the course structure and activities.

Wu, Lina *Borough of Manhattan Community College*

Incorporating Maple Software Projects of Graphic Design in College-Level Mathematics Learning

PosterFest 2015: A Poster Session of Scholarship by Early Career Mathematicians and Graduate Students

Maple Software has become one of the most important and popular educational tools in teaching college-level math. Incorporating Maple Lab Graphic Projects as part of my Calculus teaching helped students to better understand Calculus. Using Maple Software enables students to see Calculus formulas come to life. It brings interest and excitement to students learning Calculus. Calculus formulas are transformed to computer generated images. Students in my Calculus class attend math lab as part of the course. In the math lab, students are taught on how to apply Calculus formulas

to create graphic images by using Maple Software. Math problem skills are developed and enhanced by using Maple Software. Examples of two projects entitled "Polar Art Calendar" and "Funny Faces" attached with students' artwork of geometric design will be presented in my poster presentation. Feedback from the 2014 pilot Calculus course at the Borough of Manhattan Community College will be included.

X

Xiao, Pengcheng *University of Texas at Arlington*
Jianzhong Su, *University of Texas at Arlington*

A computational Model for depression and cognitive function

Graduate Student Session: Great Talks for a General Audience: Coached Presentations by Graduate Students, Part A

In this paper we study computationally a mathematical model of people with depression. It is known that people with depression will lead to abnormal levels of hormonal secretion, especially glucocorticoids. As a consequence, the neuronal electric activities also change due to variations in synaptic receptors regualted by hormone levels. We measure the We measure the hippocampal plasticity variability computationally through the synaptic spike timing-dependent plasticity characterized in spine's calcium current in the neuronal system, and the results provide the evidence of long term potentiation changes in a Hippocampus model due to depression.

Xu, Xiaoqian *University of Wisconsin-Madison*
Alexander Kiselev, *Rice University*

A simple way to ruin bacteria's social life – mixing and chemotaxis

Graduate Student Session: Great Talks for a General Audience: Coached Presentations by Graduate Students, Part B

In this talk, we will explain why mixing can suppress the bacteria and make them unhappy. This result is the mathematical explanation of the fact that mixing can break up the groups of bacteria and force them to change their surviving strategy. Here we will use a differential equation to model the bacteria's aggregation behavior driven by the chemical stimulus, which is also called chemotaxis, and the mixing by human beings. How to define mixing is also an interesting and hard math problem, especially in the field of mathematical analysis. We will introduce an intuitive way to define mixing quantitatively by an example of playing checkerboard.

Xue, Fei *University of Hartford*
Larissa Schroeder, *University of Hartford*
Jean McGivney-Burelle, *University of Hartford*

Students' Perceptions of and Expectations for Videos in a Flipped Calculus Course

Themed Contributed Paper Sessions: TCPS 19B - Innovative Approaches in the Calculus Sequence

In 2012, the mathematics department at the University of Hartford initiated a departmental project to flip all sections of Calculus I, in which the primary delivery of content is moved outside of class via videos and the homework such as problem sets is shifted into the classroom. During the past three years we have produced several versions of videos that are stylistically varied and created using a variety of tools. In this presentation, we will share findings from surveys and focus groups regarding students' perceptions of and expectations for the videos. We will also briefly provide suggestions for making videos.

Y

Yancey, Kelly *University of Maryland*

An Introduction to Interval Exchange Transformations

Themed Contributed Paper Sessions: TCPS 2B - The Contributions of Women to Mathematics: 100 Years and Counting

Interval exchange transformations are piecewise isometries of the unit interval. Although this family of maps is easy to explain, they possess a variety of fascinating, and diverse dynamical properties. In this talk we will introduce IETs,

give some examples, explain how they are related to translation surfaces, and discuss some of their basic dynamical properties. This talk will be accessible to everyone and include many pictures.

Yanik, Elizabeth *Emporia State University*

"Energizing" Students
General Contributed Paper Sessions: Mentoring and Outreach

This presentation will describe a joint outreach effort for middle school students- particularly "at risk" students. Emporia State University and Flint Hills Technical College are partnering to offer two STEM days- one on each campus as well as a summer progam. The goal is to increase the awareness of STEM career opportunities as well as the need for the appropriate future course selections for these careers.

Yaple, Haley *Carthage College*

Temporal Network Dynamics
General Contributed Paper Sessions: Applied Mathematics

Networks that represent connections between people (or places, or things) are typically assumed to be static; that is, the links between people are specified at the outset and do not change. However, this is not realistic for many situations. Imagine keeping track of the people you pass as you walk through a crowded hallway: your connections would change over time. This may be especially important to consider when modeling diseases that spread only via close contact, such as Ebola, MRSA, or STDs. We study how well-understood phenomena such as percolation and simple epidemic spread compare for static and temporally-varying networks. We explore possible applications of our results and weigh the improvements in realism against the cost of adding complexity to a model.

Yasskin, Philip B. *Texas A&M University*
Douglas B. Meade, *University of South Carolina*

Maplets for Calculus, Rating, Grading and Evaluation
General Contributed Paper Sessions: Mathematics and Technology

The Maplets for Calculus is a collection of Maple-based applets that tutor students in precalculus and calculus. The new release, v.1.4, with over 200 applets, includes 13 new precalculus topics (including 5 on complex numbers), 11 on limits, 9 on derivatives, 3 on integrals, 1 on series, 8 on geometry and vectors, 2 on partial derivatives, and 4 on differential equations. We will emphasize some of the recent enhancements, including grading of student work and user ratings, as well as results of student attitudes towards mathematics and technology, including comparisons of the Maplets for Calculus with Maple worksheets and MATLAB.

Yatauro, Michael *Penn State Brandywine*
Douglas Bauer, *Stevens Institute of Technology*
Hajo J. Broersma, *University of Twente*
Nathan Kahl, *Seton Hall University*
Aori Nevo, *Stevens Institute of Technology*
Edward Schmeichel, *San Jose State University*
Douglas R. Woodall, *University of Nottingham*

A Survey of Best Monotone Theorems in Graph Theory
General Contributed Paper Sessions: Analysis and Other

Given a graph property P, a P-Theorem is a sufficient condition on the degree sequence of a graph G that guarantees G has property P. We define the class of P-theorems known as Best Monotone P-Theorems and discuss in what sense such a theorem is best possible. This is followed by a survey of best monotone P-theorems, both classic and recent, for various properties P.

Yoon, Jeong-Mi *UH-Downtown*

An Undergraduate Research Experience in Financial Mathematics
Themed Contributed Paper Sessions: TCPS 7 - Financial Mathematics

This project is designed as a consecutive two-semester research program. At the first semester, the student registers in the undergraduate research course which begins with an introduction to finance, statistics and mathematics by weekly lectures and assignment of reading materials. At the second semester, he/she registers into the senior project course. Under a faculty advisor's supervision, he/she works on the senior project topic titled in "Study of Analytic and Numerical Solutions of Black Sholes Equation". During the semester it is important to discuss with student the perspective of the research and to provide step-by-step guidance to help him/her achieve the final goal by focusing on intermediate deadlines. To complete the project, the student needs to give an oral presentation and submit the paper until the end of semester. I am interested in developing it as an interdisciplinary education program between mathematics and finance.

Yu, Karmen *Montclair State University*
Justin Seventko, *Montclair State University*
Trina Wooten, *Montclair State University*

Inquiry Based Instructional Supplement (IBIS) for Calculus Sequence
Themed Contributed Paper Sessions: TCPS 19A - Innovative Approaches in the Calculus Sequence

We are in the process of implementing an innovative degree program designed to increase the number of elementary teachers with extraordinary preparation for teaching mathematics. A subgoal of the program is to develop an inquiry-oriented workshop model for students enrolled in historically difficult courses, such as Calculus I and II. The philosophy and structure of IBIS are based on ideas from both Peer-Led Team Learning (Gosser & Roth, 1998) and Complex Instruction (Cohen, 1994). During the fall of 2014, we piloted ten weekly workshops where students worked in small groups on open-ended, high cognitive demand, "groupworthy," mathematical tasks (Cohen, 1994). These tasks, which sought to conceptually reinforce and extend the topics they were learning in their Calculus course, were realistic, thought-revealing, and allowed for multiple entry points. They required cooperation, participation, and mathematical conversation and negotiation amongst all group members. Trained peer leaders facilitated this groupwork using a pedagogical approach compatible with inquiry, and ensured every group member was active and influential. These sessions were video recorded, artifacts were collected, and follow-up focus group interviews were conducted in order to assess students' experiences. Students' responses indicated that IBIS provided them with an environment that promoted their persistence in problem solving and the development of their problem solving skills, two forms of support that seemed to be lacking in their traditional classrooms. Furthermore, students appreciated the opportunities to engage in the kinds of thinking and reasoning that are required to promote a better understanding of Calculus.

Yuan, Serena *New York University*

Mixing Times for Sorry! Game
Graduate Student Session: Great Talks for a General Audience: Coached Presentations by Graduate Students, Part B

In "Sorry!", a popular 2-4 player board game, players essentially want to complete the cycle of the board without being bumped back to their starting space. Given the chances that other players land on a space your piece is already on, you may have to start your journey all over again, no matter how far along the board you have reached. We can formalize rules of the game with the following: we may model the spaces in many board games by an n-cycle since a board has n spaces and its last space leads to its first space. Additionally, a Markov chain, a random process with transitions to various states, may represent each player's path. Mixing times are a measure of how long it takes the Markov chains to become close to their stationary distribution, a state that they converge to. Finding the mixing times gives us clues to predict who is likely to win depending on how much time has elapsed in the game, and this motivates us to find approximate mixing times.

Yuan, Shenglan *LaGuardia Community College, CUNY*

Using Conway's Napkin Problem in an Introductory Probability Class
General Contributed Paper Sessions: Probability or Statistics

John Conway's Napkin Problem has generated much interest among mathematicians and puzzle lovers. In short, the problem imagines a round table of mathematicians who use the napkins on either side of them randomly. The question is: how do you determine the expected number of mathematicians who will end up without a napkin. There have been many solutions, from the elementary to the highly sophisticated, as well as many variations, since it was first proposed

by John Conway at a lunch at Bell Labs in 2001. In this presentation, I'll talk about my attempts to use this problem to introduce generating functions in an introductory probability class.

Z

Zack, Maria *Point Loma Nazarene University*

Lisbon: Mathematics, Engineering and Planning in the Eighteenth Century
Themed Contributed Paper Sessions: TCPS 1G - History and Philosophy of Mathematics

In 1755 the commercial district of Lisbon was destroyed by an earthquake followed by a fire and tsunami. This catastrophe along with an interesting constellation of political circumstances provided an opportunity for Lisbon to be completely rebuilt from first principles. This talk looks at the rebuilding of Lisbon in light of the mathematics of materials that emerged seventeenth and eighteenth centuries. We will consider specific attributes of Lisbon's reconstruction in light of the scientific advances of the day and the lack of sophisticated mathematics being taught in Portugal in the first half of the eighteenth century.

Zawodniak, Matthew *University of Georgia*

Lecturing Left on the Cutting Room Floor: A Video Project for Pre-service Teachers
Themed Contributed Paper Sessions: TCPS 13 - Successful STEM Programs for Elementary Education Majors

Students have been shifting their education from traditional classrooms to electronic ones through many online programs and universities. According to the U.S. Department of Education, over 2.5 million students were enrolled in exclusively distance education courses in 2012, and those numbers continue to climb. Even in lieu of strictly taking classes online, students are turning towards YouTube to gain knowledge, supplement classwork, or deepen their understanding of content. As of April 2015 educational YouTube channels such as SciShow and MinutePhysics have over 2.5 million subscribers apiece, indicating that they are effective means of STEM communication. Knowing that there is such a vast resource of educational material online, students seek out videos to enhance, complement, or replace their classroom learning. For these reasons, it is imperative that new teachers entering the workforce have some experience with creating and using online educational tools. To give pre-service teachers some experience with this medium, a video assignment was developed and implemented in two successive terms of an Arithmetic and Problem Solving for Elementary School Teachers course at the University of Georgia. This talk will focus on the assignment itself, how it developed across the two terms, and how students felt about the assignment in each iteration. Time permitting, some examples of the projects will be shown.

Zejnullahi, Rrita *Eastern Michigan University*

Students' Understanding of Exponential and Logarithmic Functions
PosterFest 2015: A Poster Session of Scholarship by Early Career Mathematicians and Graduate Students

As part of the duties for a Graduate Assistant, I have taught Intermediate Algebra to undergraduate students that are not majoring in Mathematics but are required to take the course to fulfill their math requirement. The course begins with a review of elementary algebra and continues into the study of functions, graphs, quadratic, exponential, and logarithmic equations. This poster reports on students' difficulties with the concept of exponential and logarithmic functions. We try to interpret their difficulties and modify future instruction of the topic based on the results.

Zelich, Ivan *Anglican Church Grammar School*

A New Theorem Concerning Isopivotal Cubics, Could it be the 'Swiss Army Knife' of Geometry?
General Contributed Paper Sessions: Geometry

The Liang-Zelich Theorem, which was recently discovered, concerns isopivotal cubics i.e. cubics in the triangle plane invariant under isoconjugation. It refers to a specific configuration that generalises many well-known theorems, leads to amazing results that are crucial in identifying triangle centres and trivialises many open problems which until present either could not be solved or solved in a manner requiring profound expertise in higher mathematics. I will give a brief overview of Projective Geometry and prove results that may not be known to the audience, but are undeniably useful in understanding the predominant configuration. Further, after proving the Liang-Zelich Theorem in two different

ways, numerous applications will be discussed thus showing the sheer strength of the Theorem and its associated configurations. Overall, this talk will provide the audience with a completely new perspective on isogonal conjugates, conics (including centres of mutual orthology) and projective transformations, which always play hand-in-hand.

Zides, Steve *Wofford College*

Modeling the Mathematical: Man Ray, Equational Mimesis, and Kinesthetic Learning
Themed Contributed Paper Sessions: TCPS 6A - Mathematics and Art

In the late 19th and early 20th century, designing three dimensional models of algebraic equations was all the rage. However, by the early 1930's this mode of instruction fell out of favor, retiring hundreds of platonic renderings from the lively halls of academia to the more sedentary pastures of the museum. Then enters Man Ray — painter, photographer, film maker, who with the help of his surrealist friends rejuvenates aesthetic interest in these mathematical constructions. This year, Man Ray's contributions to the Math-Art community are being celebrated through both a new publication, "Man Ray; Human Equations" and a traveling exhibition, "Man Ray — Human Equations, A Journey from Mathematics to Shakespeare" organized by The Phillips Collection and The Israel Museum, Jerusalem. In this talk, I will introduce Man Ray — the artist, discuss his initial photographic work with the mathematical renderings housed in the Institut Henri Poincaré in Paris and ponder the later surrealistic painting series, "Shakespearean Equations", based on his original photographs. I will also present a potential Man Ray-esk project that could add some kinesthetic learning opportunities to the impressionistic world of the Multivariable/Vector Calculus classroom.

Zimmer, Michael *Teradata, Inc*

New Algorithms for Solving a System of Linear Equations
General Contributed Paper Sessions: Algebra and Linear Algebra

Two new algorithms are presented for computing a direct solution to a system of linear equations. They involve the orthonormalization of the row (column) space of the coefficient matrix, and produce generalized inverses of type 124 (123). Both admit online versions, such that the computation may proceed as the data becomes available.

Zitarelli, David *Temple University*

Karen Parshall and a Course on the History of Mathematics in America
Themed Contributed Paper Sessions: TCPS 1M - Special Session in Honor of Karen Parshall

This talk describes a course on the history of mathematics in the U.S. and Canada from 1492 to 1958. The central period for research took place 1876–1900, so ostensibly the "textbook" for the course is the Emergence of the American Mathematical Research Community, which Karen Parshall coauthored with David Rowe. Topics from the eras that preceded this quarter century and the major lines of development over the first half of the 20th century will be outlined. Along the way, suggestions for student projects based on original works in mathematics as discussed in papers by Parshall, her students, and several other American historians of mathematics will be presented.

Zorn, Paul *St. Olaf College*

1980–1999
Invited Paper Sessions: MAA Invited Paper Session: Generations of Monthly Gems

I will speak about mathematical ideas explored in papers published in the *Monthly* during the years 1980–1999. This is a rich period in the history of the *Monthly* and several classic papers will be mentioned and discussed.

Index of Speakers