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Invited Addresses

Earle Raymond Hedrick Lecture Series

Laura DeMarco Northwestern University

Complex Dynamics and Elliptic Curves

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Lecture 3: Saturday, August 3, 10:00–10:50 AM, Grand Ballroom A

In a series of three talks, I will present connections between recent research in dynamical systems and the classical theory of elliptic curves and rational points. On the dynamical side – specifically in the study of iteration of rational functions (Julia sets, bifurcations, the Mandelbrot set) – the first connections were observed about 100 years ago. On the arithmetic side, it was probably the 1960s when dynamical ideas were first used as tools to understand the arithmetic geometry of elliptic curves and higher-dimensional varieties. My goal is to provide an overview of how these relationships developed and where they have brought us today. The three lectures will be independent.

AMS-MAA Joint Invited Address

Thursday, August 1, 10:00–10:50 AM, Grand Ballroom A

Éva Tardos Cornell University

Learning in Games

Selfish behavior can often lead to suboptimal outcome for all participants, a phenomenon illustrated by many classical examples in game theory. Over the last decade we have studied Nash equilibria of games, and developed good understanding how to quantify the impact of strategic user behavior on overall performance in many games (including traffic routing as well as online auctions). In this talk we will focus on games where players use a form of learning that helps them adapt to the environment. We ask if the quantitative guarantees obtained for Nash equilibria extend to such out of equilibrium game play, or even more broadly, when the game or the population of players is dynamically changing and where participants have to adapt to the dynamic environment.

MAA Invited Address

Thursday, August 1, 9:00–9:50 AM, Grand Ballroom A

Ami Radunskaya Pomona College

Uncertainty: The Mathematics of What we Don't Know

Over the past few centuries, the theory of probability has been developed to quantify possibilities and to help us make decisions with incomplete knowledge. More recently, this theory has been refined to include predictions based on randomly perturbed dynamical systems, as well as providing a measure of our belief in future events based on observed data. As mathematicians, we like precision, patterns, predictions. As human beings we want to make wise, informed decisions. In this talk I will explore three questions: how can we quantify the uncertainty in our predictions, how do we make decisions in the face of uncertainty, and when is a bit of uncertainty helpful . . . or fun?

Friday, August 2, 11:20 AM–12:20 PM, Grand Ballroom A

Irena Swanson Reed College

Solving Algebraic Equations

Abel and Ruffini, and later Galois showed that general polynomials of degree five or higher are not solvable with the usual arithmetic operations. Nevertheless, algebra offers powerful methods for solving many equations and for determining the structure of solutions even when the solutions themselves cannot be found. In this talk I will cover some classical and more recent methods, including Hilbert's Nullstellensatz and Gröbner bases. A running theme will be computational complexity, and the talk will end with more recent results in commutative algebra.

Saturday, August 3, 11:00–11:50 AM, Grand Ballroom A

Robert Ghrist University of Pennsylvania

A Vision of Multivariable Calculus

This talk will address certain challenges in teaching multivariable calculus. Classical texts emphasize calculus in dimensions two or three, based on 19th and 20th century applications to physics. At present, many of our students are more motivated by data and systems in higher dimensions. How can a calculus course best adapt to these needs, without overwhelming students (or professors)? This talk will outline a plan for increasing both the dimension and sophistication of multivariable calculus instruction with the use of video. Topics covered will include the use of visualization, matrix algebra, and differential forms.

MAA James R.C. Leitzel Lecture

Saturday, August 3, 9:00–9:50 AM, Grand Ballroom A

Rochelle Gutiérrez University of Illinois

What's at Stake in Rehumanizing Mathematics?

Embracing an "equity" standpoint that has been poorly defined (Gutiérrez, 2002) or constantly shifting (NCTM, 2008) has led to a state of "tinkering" as opposed to real change within mathematics (Gutiérrez, 2017). That is, our progress has often focused on, and ended with, closing the achievement gap or recruiting more diverse students into the mathematical sciences, but not trying to radically reimagine a mathematics that supports students, teachers, and members of society to thrive, something I refer to as Rehumanizing Mathematics. This approach begins with 1) acknowledging some of the dehumanizing experiences in mathematics for students, teachers, and citizens and 2) designing ways for people to be provided with windows and mirrors onto the world and relating to each other with dignity through mathematics. This focus on Rehumanizing Mathematics allows us to think differently about student misconceptions, teachers as identity workers, the histories of mathematics, our bodies in relation to mathematics, and why it is not just that diverse people need mathematics but mathematics needs diverse people. In this talk, I explore "what's at stake" along two dimensions: 1) what it means for teachers, students, and society if we do not rehumanize mathematics and 2) what knowledge bases, sensibilities, and forms of risk taking it will require from us as mathematicians (and mathematics educators) if we commit deeply to rehumanizing mathematics.

AWM-MAA Etta Z. Falconer Lecture

Friday, August 2, 1:30–2:20 PM, Grand Ballroom A

Tara Holm Cornell University

Dance of the Astonished Topologist ... or How I Left Squares and Hexes for Math

Topology is often called "rubber sheet geometry" and is described as "floppy" while geometry is more "rigid". Symplectic geometry, the natural geometry of classical mechanics, is floppier than Riemannian geometry but more rigid than topology. I will give a friendly introduction to some geometric and algebraic techniques in topology, proving along the way that a topologist can turn her trousers inside out without taking them off. I will then give an overview of the floppy/rigid spectrum, motivated by many pictures and examples. I will conclude with a description how covering spaces have been useful in my own work in symplectic geometry, and how they can make square dancing more challenging.

MAA Chan Stanek Lecture for Students

Thursday, August 1, 1:30–2:20 PM, Grand Ballroom A

Mohamed Omar Harvey Mudd College

Secrets of Grad School Success

Around this time of year many rising seniors and even rising juniors are wondering what to do after college, and many contemplate the idea of going to graduate school. Naturally, they seek advice from peers, professors at their college and the internet. In this talk, we'll give some pretty unconventional advice based on the speakers experiences through the same process.

Pi Mu Epsilon J. Sutherland Frame Lecture

Wednesday, July 31, 8:00–8:50 PM, Grand Ballroom A

Alice Silverberg University of California, Irvine

Alice in Numberland — Adventures in Cryptography, Number Theory, and Life

I will give an account of some of my adventures in the wonderlands of mathematics and cryptography, offering some food for thought on how mathematics can be useful in cryptography, and mentioning some useful things I learned along the way that I wish I had learned sooner.

NAM David Harold Blackwell Lecture

Friday, August 2, 4:00–5:45 PM, Grand Ballroom A

Johnny L. Houston Elizabeth City State University

Dudeney's No Three-In-Line Problem: Problem, Solutions, Conditions, Progress, and Conjectures

In 1917, Henry Dudeney, an Englishman who had done some intriguing things with mathematical puzzles and games, posed an interesting question for persons interested in discrete geometry. Let an $n \times n$ grid be given in the Euclidean plane for any natural number n, what is the maximum number of points that can be identified in the grid so that no three of these points are in the same line (no 3 colinear). For various natural numbers n, solutions have been discovered and certain conditions have been encountered. The presenter discusses many of these solutions and conditions. For large natural numbers n, even for some $n < 60$, progress (or lack of progress) is being made slowly. By the Pigeon Hole Principle, the maximum number of such points that can exist is $2n$. The problem of finding for which n this value is reached is known as the No-Three-In-Line Problem. Several conjectures exist. These conjectures and their motivations are discussed as well as some related problems. However, the No-Three-In-Line Problem is still an open problem. The year 2019 is the centennial year of the honoree for which this lecture was named. The presenter will also discuss the life and contributions of David H. Blackwell. Additionally, a light reception will follow the lecture to celebrate the National Association of Mathematicians's 100th anniversary.

Martin Gardner Lecture

Saturday, August 3, 2:00–2:50 PM, Grand Ballroom A

Erik Demaine Massachusetts Institute of Technology

Recreational Mathematics and Computer Science: Martin Gardner's Influence on Research

Martin Gardner's beautiful writing about fascinating mathematics, puzzles, and magic tricks has attracted and inspired many people to become mathematicians. At an even deeper level, Martin's writings highlighted exciting research directions and posed open problems which directly influenced mathematical research. Much of my own research was deeply influenced by Martin Gardner, in both recreational mathematics and a branch I call "recreational computer science". While most of this research may have started out recreational, many of the results also have practical applications. I will give a tour of many examples of Gardner's writings and how it inspired new research, from paper folding to mazes to penny puzzles to polyomino packing to magic. I encourage you all to read more Martin Gardner and look for more unsolved research questions and directions.

Alder Awards

Alder Award Session

Friday, August 2, 2:30–3:50 PM, Grand Ballroom A

The MAA established the Henry L. Alder Award for Distinguished Teaching by a Beginning College or University Mathematics Faculty Member to honor beginning college or university faculty members whose teaching has been extraordinarily successful and whose effectiveness in teaching undergraduate mathematics is shown to have influence beyond their own classrooms. Each year, at most three college or university teachers are honored with this national award. The awardees are invited to make a presentation in this session. The session is moderated by MAA President Michael Dorff.

This year's honorees are:

PJ Couch *Lamar University*
Pamela Harris *Williams College*
Alicia Prieto *Youngstown State University*

PJ Couch Lamar University

How I Learned to Stop Worrying and Love the School

2:30–2:50 PM

Much of what a student takes away from school is knowledge of the system, teaching styles, and the status quo of education, in addition to (or at the expense of) the intended curriculum. I would like to offer some of my experiences in the classroom and explain how (and why) they influenced my approach to teaching. Topics include: pyrrhic victories, taking the path of least resistance, and how to break the news to someone that you're a mathematician.

Pamela Harris Williams College

The Undergraduate Mathematics Classroom as a Publishing House: A New Type of Learning Community

3:00–3:20 PM

I recently led an undergraduate senior seminar course with the following lofty goal: coauthor an accessible book on research in a wide range of topics in the field of algebraic combinatorics. Imagine the students' surprise to learn of this during the first day of the course. Not to mention the level of work such an undertaking entails, both on the students and on the professor! Fourteen students took on the challenge and in this talk I discuss the process of building a learning community and how through this community we reached our goal of writing a book.

Alicia Prieto Youngstown State University

Teaching with H

3:30–3:50 PM

In this talk we will discuss the idea of "meaning and purpose" and how it connects to teaching mathematics. These ideas have slowly infiltrated my own learning and the way that I teach helping me connect with my students and greatly enhancing the pleasure of teaching and learning mathematics. I will discuss some particular example of ways in which I have tried to improve my teaching with various degrees of success and consider what other might try if they want to include this ideas in their own teaching.

Invited Paper Sessions

The Serious Side of Recreational Mathematics

Friday, August 2, 1:30–3:50 PM, Room 200

Organizer: Robert W. Vallin Lamar University

More than a pastime, recreational mathematics runs the gamut from the combinatorial questions to the mathematical structures in the game SET to using juggling to create a proof in number theory. In this invited paper session, experts in recreational math show how starting with a fun puzzle, game, or story can take one on a trip to deep mathematics.

Art Benjamin Harvey Mudd College

Bingo Paradoxes
1:30–1:50 PM

Suppose you walk by a large Bingo Parlor and hear someone excitedly shout Bingo! Is it more likely that the Bingo is Horizontal or Vertical? Or maybe it's Diagonal? The answer to this, and related questions, will surprise you.

James Sellers Penn State University

Garden of Eden Partitions for Bulgarian and Austrian Solitaire
2:00–2:20 PM

In the early 1980s, Martin Gardner popularized the game called Bulgarian Solitaire through his writings in Scientific American. After a brief introduction to the game, we will discuss a few results proven about Bulgarian Solitaire around the time of the appearance of Gardner's article and then quickly turn to the question of finding an exact formula for the number of Garden of Eden partitions that arise in this game. I will then introduce a related game known as Austrian Solitaire and consider a similar question about the Garden of Eden states that appear. The talk will be completely self-contained and should be accessible to a wide-ranging audience, including undergraduate students and faculty members. This is joint work with Brian Hopkins and Robson da Silva.

Liz McMahon Lafayette College

Geometry, Combinatorics and the Game of SET
2:30–2:50 PM

The deck of cards for the game of SET is an excellent model for the finite affine geometry AG(4,3) and provides an entry to surprisingly beautiful combinatorial structure theorems for that geometry. In this talk, we'll explore that geometry and find a beautiful structure hiding within the collections of cards that have no sets (called maximal caps). There's a connection to the outer automorphisms of S6 as well, but you don't need to know what those are to follow what we'll do.

Steve Butler Iowa State University

Throwing Together a Proof of Worpitzky's Identity
3:00–3:20 PM

Juggling is about patterns and we can use mathematics to explore and count the different patterns that emerge. By combining together different ways to describe juggling patterns we will give a bijective proof of Worpitzky's identity. We will also discuss the odd juggler problem (and it is not that all jugglers are odd).

Bob Bosch Oberlin College

Domino Variations
3:30–3:50 PM

Ken Knowlton was the first to devise an algorithm for arranging complete sets of dominos into mosaics that resemble user-supplied target images. Knowlton's method is a two-step approach that begins by partitioning the "canvas" into domino-sized "slots" and concludes by assigning actual numbered dominos to these slots. Donald Knuth pointed out that each step of Knowlton's method is an instance of the linear assignment problem (which is solvable in polynomial time). Bosch's integer programming model is more computationally intensive. It tackles both steps at the same time. In this talk, we compare the Knowlton/Knuth and Bosch methods, we discuss the use of non-rectangular canvases, and we present a method for constructing a domino mosaic that contains a hidden second image.

Cryptography and the Mathematics Behind It

Thursday, August 1, 1:30–3:50 PM, Room 205

Organizer: Alice Silverberg University of California, Irvine

Modern day society and the security of our voting, banking, and military systems rely on cryptography to ensure privacy and allow secure communication. Important problems in cybersecurity are being solved using number theory, algebraic geometry, and the mathematics of lattices. This session on the mathematics behind cryptography is aimed at a general mathematical audience. This session will have expository talks aimed at a general mathematical audience and will be suitable for both students and faculty.

Adriana Salerno Bates College

Language, Probability, and Cryptography

1:30–1:50 PM

What rules define a language? Can we use this information to decrypt secret messages? In this talk, we look at the application of Markov Chain Monte Carlo methods to decrypt different types of substitution ciphers. By studying the state changes in consecutive letters of a particular language, one can program a computer to make exceptionally 'smart' guesses as to what an encrypted message actually says. We will discuss some famous examples, and how this can be made into a particularly interesting undergraduate research project.

Steven J Miller Williams College

Inrtoduwtion to Erorr Dwtetcion and Czorrectmon

2:00–2:20 PM

In today's world it is essential for numerous applications, from cryptography to e-commerce to streaming videos, to be able to efficiently send information and have the recipient receive what we intend. We'll discuss some of the challenges in doing so, explore some systems that can not only detect but also correct transmission errors in real-time, and highlight some applications in cryptography. For example, due to how RSA encodes messages, a one bit error can lead to a completely different text being transmitted than intended. For another, by deliberately changing some bits we can hide a message in an image.

Jintai Ding University of Cincinnati

Post-quantum Key Exchange Based on "Learning with Errors" Problems

2:30–2:50 PM

Public key cryptosystems are critical part of the foundation of modern communication systems, in particular, the Internet. However Shor's algorithm shows that the existing systems, such as Diffie-Hellmann key exchange, RSA, and Elliptic Curve Cryptography, can be broken by a quantum computer. To prepare for the coming age of quantum computing, we need to build new public key cryptosystems that could resist quantum computer attacks. In this lecture, we present first the basic mathematical idea and history of key exchange, and explain why it is hard to build new key exchanges. Then we will present a practical and provably secure (authenticated) key exchange protocol based on "learning with errors" problems and explain the fundamental mathematical idea behind such a construction.

David Jao University of Waterloo

Public-key Cryptography from Supersingular Elliptic Curve Isogenies

3:00–3:20 PM

Isogeny-based cryptography represents one of the few number-theoretic approaches to cryptography that remains relevant in the context of post-quantum cryptosystems, schemes that are intended to be secure against adversaries with efficient universal quantum computers. Compared to other post-quantum cryptosystems, isogeny-based cryptography has smaller keys, and simple, straightforward parameter selection involving only one tunable security-sensitive parameter. In this talk, we survey one existing proposal for isogeny-based cryptography, the Supersingular Isogeny Diffie-Hellman (SIDH) proposal of Jao and De Feo, whose underlying hard problem is a variant of the Charles-Goren-Lauter cycle finding problem on Pizer's family of expander graphs. We demonstrate some explicit examples of SIDH computations, and discuss the current status of the security of the cryptosystem against classical and quantum adversaries.

Kumar Murty University of Toronto

xn+x+a

3:30–3:50 PM

These polynomials are not only important computationally and in cryptographic applications, but they also have many beautiful mathematical properties. There are also many open problems.

The Mathematics of Uncertainty

Friday, August 2, 10:10 AM–12:00 PM, Room 200

Organizer: Ami Radunskaya Pomona College

We encounter uncertainty everywhere, at all levels of our consciousness, in almost every one of our endeavors. Even things of which we are certain: the sun will rise tomorrow, our current existence has a finite time span, are subject to imprecision. How has mathematics helped us understand uncertainty and unpredictability? How can we use use quantitative tools to make decisions under incomplete information or cognitive limitations? In this session we will present mathematical tools and results from probability, dynamical systems and ergodic theory that give insight into these questions.

Tom LoFaro Gustavus Adolphus College

Crossing the Threshold: The Role of Demographic Stochasticity in the Evolution of Cooperation

10:10–10:30 AM

We will discuss a pair of models for the evolution of cooperation that incorporates game theoretic ideas into a discrete generation population genetics framework. The first model will be completely deterministic and we will show that when a small population of "cooperators" is included into a larger population of "defectors" then the cooperators will always die off. However, when stochasticity is incorporated into the model then there is the potential for the population of cooperators to become established. We will explore conditions that increase the likelihood that this will occur. In particular, we will prove that if the relative advantage of defecting is small relative to the benefits of cooperating then it is more probable that cooperation will evolve.

Kim Ayers Pomona College

Stochastic Perturbations of the Logistic Map

10:40–11:00 AM

The logistic map is a famed map on [0,1] that exhibits a period-doubling bifurcation that eventually leads to a chaotic regime. In this talk, we examine a stochastically perturbed logistic map, and the dynamics that arise. We'll examine the differences in dynamics when looking at uniformly distributed noise, as compared with noise that is distributed according to a β -distribution. In this situation, fixed points and period orbits are no longer deterministic objects, but rather are random variables. How does this affect the chaotic regime?

Joshua Sack California State University, Long Beach

Logic for Reasoning about Uncertainty Dynamics and Informational Cascades

11:10–11:30 AM

Uncertainty of a group of people or agents can be represented using a multi-graph, where the vertices are the possibilities and agent-labeled edges reflect uncertainty agents have between the possibilities. Informational events change these graphs to reflect new states of uncertainty. This talk discusses how such dynamics is modeled and described by probabilistic dynamic epistemic logics, and discusses how such logics can help us reason about informational cascade, a phenomenon where agents prioritize judgements by other observers over their direct observations.

Aloysius Bathi Kasturiarachi Kent State University

Probability As a Tool for Studying Problems in Behavioral Economics

11:40 AM–*12:00* PM

In this presentation we introduce probabilistic ideas to study problems in behavioral economics. The research will have three components that form the foundational props of the platform on which probability will uncover the rich interplay between mathematics and behavioral economics. The first component explores through several probability experiments, how Deterministic Behavior can be extended to understand Uncertainty and Misbehavior. We evaluate the number of games one will need to play (against the dealer) in order to win a prize, if a priori, the player knows that the probability of winning is less than 0.5. Even though at the outset the player is destined to lose, a calculation can be done to come up with the ideal number of plays for the game, to maximize chances of winning if the player's probability is close to but less than 0.5. This idea can be further extended when a financial incentive is added to each extra game the player is willing to risk. The second component is to turn Uncertainty into Relative Determinism using probabilistic ideas. The examples for this study comes from financial markets. The final component involves experiments performed with human subjects that provides insights to refining the value function model in behavioral economics. This is an example on how we learn by learning more in high-stakes complex systems, such as medicine.

Equity and Justice in the Context of Inquiry

Thursday, August 1, 1:50–4:20 PM, Room 200

Organizer: Brian Katz Augustana College

Inquiry pedagogies offer rich learning experiences that can support under-served populations in collegiate mathematics. However, elements of these environments can alienate exactly the students instructors are hoping to support. So equity and inquiry must be theorized and researched together in order to offer justice for all students. This session brings research agendas into direct conversation for mathematicians and educators.

Brian Katz Augustana College

Introduction to the Session

1:50–2:00 PM

Sandra Laursen University of Colorado Boulder

Inquiry and Equity: Necessary But Not Sufficient

2:00–2:20 PM

In a recent commentary, Chris Rasmussen and I identify four pillars of a vision for inquiry-based mathematics education (IBME): student engagement in meaningful mathematics, student collaboration for sensemaking, instructor inquiry into student thinking, and equitable instructional practice to include every student in rigorous mathematical learning and mathematical identity-building. This vision is based in research studies of IBME in undergraduate mathematics, but we call it a vision intentionally to indicate that the four pillars are aspirational: these elements should guide instructors' decision-making but are not automatically nor even easily accomplished. They define what is possible but not what is general. I will make research-based arguments to support each part of my claim, that inquiry is necessary but not sufficient for achieving equitable outcomes and experiences for mathematics students.

Robin Wilson California State Polytechnic University, Pomona
Stacy Brown California State Polytechnic University, Pomona

The IBL Experience When Students of Color Are in the Majority

2:30–2:50 PM

Much of the research on inquiry-based learning (IBL) at the university level has not specifically addressed the impact of these pedagogies in diverse institutional settings. Indeed, there is little to no research on the impact of IBL pedagogies at Hispanic-serving institutions (HSIs), especially with regard to the impact of IBL pedagogies on students' sense of belong, mathematical identity, or competence. In this talk we will share findings from a study of students' experiences in advanced mathematics courses which implement inquiry-based learning pedagogies at an HSI institution where students of color are in the majority and discuss why attention to belonginess, identity and competence are critical to enacting equity-oriented forms of IBL pedagogies.

Jessica Smith Florida State University
Christine Andrews-Larson Florida State University
Daniel L. Reinholz San Diego State University
Amelia Stone-Johnstone San Diego State University
Brooke Mullins Virginia Polytechnic Institute and State University

Examined Inquiry-Oriented Instructional Moves with an Eye Toward Gender Equity

3:00–3:20 PM

Prior research has suggested that inquiry-based instruction could make classes more equitable for men and women. In this study, we analyze data from 42 undergraduate instructors and 681 students in the context of inquiry-oriented instruction in abstract algebra, differential equations, or linear algebra. Instructional units were video recorded and coded to see how teachers distributed opportunities to participate in whole class discussion, how these opportunities were taken up by students, and what teachers did with student ideas. Mathematically substantial opportunities were not distributed equitably between men and women, which was consistent with observed patterns of student contributions. Further, instructors tended to leverage women's ideas at lower rates than men's ideas when building on and formalizing students' mathematical contributions.

Rochelle Gutiérrez University of Illinois

TBA

3:30–3:50 PM

Panel Discussion
4:00–4:20 PM

Mathematical Diversity in Mathematical Biology

Friday, August 2, 1:30–5:20 PM, Room 205

Organizers: Nicholas A. Battista The College of New Jersey
Rebecca Everett Haverford College

Mathematical biology is grab-bag description for using mathematics to understand biological phenomena. The math used is not restricted to a particular sub-discipline within math, but rather is as diverse as the biological systems themselves. In this session, the 2018 Project NExT'rs will showcase the diversity of mathematics used to better understanding biology. It is geared for an undergraduate audience.

Brittany Stephenson Lewis University

Comparing Intervention Strategies for Reducing Clostridium difficile Transmission: An Agent-Based Modeling Study
1:30–1:50 PM

In recent years, healthcare facilities have experienced an increasing substantial burden from the toxin-producing bacteria Clostridium difficile, which can cause severe intestinal disease. This bacteria can survive for extended periods of time on hospital surfaces. In this talk, I will discuss the development of an agent-based model that simulates the transmission of C. difficile in a healthcare setting and considers contributions of the pathogen from environmental surfaces. This model explicitly incorporates healthcare workers (HCWs) as vectors of transmission, tracks individual patient antibiotic histories, incorporates varying risk levels of antibiotics with respect to CDI, and tracks contamination levels of ward rooms by C. difficile. I will also discuss how we used the model to evaluate the efficacy of a variety of control interventions and combinations of interventions on reducing C. difficile nosocomial colonizations and infections. The control tech- niques include two forms of antimicrobial stewardship, increased environmental decontamination through room cleaning, improved HCW compliance, and a preliminary assessment of vaccination.

Forest Mannan Colorado School of Mines

Enhanced Coupling of Cilia Through Cell Rocking
2:00–2:20 PM

Motile cilia are long, hair-like organelles that extend from cellular surfaces and induce fluid flows by undergoing an oscillatory bending motion. Cilia often exhibit coordinated beating and many researchers have shown that this synchronization is mediated through hydrodynamic interactions. It has been suggested that the rocking of a free swimming cell body might play an additional role in synchronization. Using the Method of Regularized Stokeslets and modeling the ciliary structure as a system of springs, it is demonstrated that cell rocking can have a significant impact on the coupling of cilia.

Reginald McGee College of the Holy Cross

Parameter Informatics for Nonlinear Models
2:30–2:50 PM

In 2017, Dawes et al. created a nonlinear model for signal transduction in epithelial cell development in roundworms. Via a parameter space sampling procedure over 6000 parameter sets were found to satisfy a wild-type pattern defined by the expressions of a ligand and phosphotase in the signaling network. Moreover, in silico perturbations to the signaling pathway replicated species- specific responses of protein knockout experiments and separated the parameter sets into groups corresponding to the model organism C. elegans and the less studied roundworm C. briggsae. We motivate the advantages of a perspective where each parameter sets is viewed as an observation in a high-dimensional dataset and present an approach for clustering the data by the associated model dynamics. We discuss how the aforementioned perspective could be used to avoid global bifurcation analysis and contrast parameter sets that have been dynamically clustered together, but replicate behaviors of distinct species.

Diana Schepens Whitworth University

Role of Resource Allocation and Transport in Emergence of Cross-feeding in Microbial Consortia

3:00–3:20 PM

Microbial communities that implement mutual cross-feeding are commonly observed in nature and with synthetic constructs in laboratory experiments. A mathematical model of competition in a chemostat is developed to investigate the role that resource allocation and transport of metabolites play in cooperation. The model contains four cell types that differ by whether they produce two, one, or none of two essential metabolites. Producing cell types may export these resources into the environment, and those that do not produce both metabolites must import the missing resource. The contribution to the emergence of a collaborative consortium of single resource producers from the transport rate of these metabolites and the type of transport used by the cell (active vs. passive) is studied. Multiple instances of bi-stability and tri-stability are observed, and the effect of the initial concentration of a non-cooperative cheater cell type on the final outcome of the competition is examined. When the cost of producing metabolites is introduced into the model, significant changes to the outcome of the competition are observed, including coexistence of multiple cell types.

Garner Cochran Berry College

k-Foldability of RNA

3:30–3:50 PM

I will speak about a model which generalizes the folding of the RNA molecule in biology, first introduced by Black, Drellich, and Tymoczko (2017+). RNA is represented by a word from the alphabet of nucleotides A, U, C, and G in which Watson-Crick bonds form between nucleotides A and U and between C and G. Sometimes RNA sequences will fold such that some base pairs are left unmatched. We wish to consider only the case where all the base pairs completely match up. I will answer the question of when a sequence will fold completely and will answer some questions about the different ways that a sequence can fold onto itself. I will conclude with some open problems in the area.

Amy Buchmann University of San Diego

Mixing and Pumping by Pairs of Helices in a Viscous Fluid

4:00–4:20 PM

It is difficult to mix and pump fluid in microfluidics devices because the traditional methods of mixing and pumping at large length scales dont work at small length scales. Experimental work has suggested that rotating helical flagella may be used to effectively mix and pump fluid in microfluidics devices. To further explore this idea and to characterize the flow features around rotating helices, we study the hydrodynamic interactions between two rigid helices rotating at a constant velocity. Helices are coupled to a viscous fluid using a numerical method based upon a centerline distribution of regularized Stokeslets, and we analyze the effects of spacing and phase shift on mixing and pumping.

Amy Veprauskas University of Louisiana at Lafayette

Modeling the Impacts of Disturbances: What Can We Learn about Population Responses and Possible Management Strategies?

4:30–4:50 PM

As species are increasingly being exposed to disturbances, it is important to be able to better understand and predict how disturbances may impact populations. Here we explore how a population may be affected by a single disturbance or by reoccurring disturbances. Alongside general analysis, we provide an application to a sperm whale model to better understand how disturbances, such as oil spills, may impact this species. We first apply sensitivity analysis to study the recovery process for a population following a single disturbance. We then use a two-state Markov chain to describe disturbances occurring stochastically. We derive an approximation for the stochastic growth rate that allows us to consider how properties of the disturbance, such as duration and magnitude, may impact a populations survival. We find commonalities in both situations that suggest how to focus management strategies.

Nicholas A. Battista The College of New Jersey

Don't Be Jelly: Modeling Effective Jet Propulsion

5:00–5:20 PM

Jellyfish (Medusozoa) have been deemed the most energy-efficient animals in the world. They are soft body marine organisms composed of gelatinous bell, tentacles containing nematocists for prey capture, and either 4 or 8 oral arms. Their nervous system typically consists of a distributed net of cells. There are between four and sixteen distributed nets of cells around the rim of the bell, which coordinate muscular contraction to propel the jellyfish forward. Their simple morphology and nervous systems make them attractive to robotocists, but we do not understand the limits of jellyfish jet propulsion and maneuverability. Numerous scientists have developed sophisticated computational models of jellyfish that produce forward propulsion, even having compared swimming performance over a large mechanospace of bell flexibility, muscular contraction strength, and contraction frequencies. However previous studies have not addressed swimming performance in the presence of ambient oscillatory flows, like those in natural oceanic environments, nor have they considered the effects of complex morphologies, e.g., tentacles, or using non-buoyant materials for building a biomimetic robotic jellyfish. And so our work dives headfirst into that.

Commutative Algebra

Saturday, August 3, 9:00–11:20 AM, Room 200

Organizers: Irena Swanson Reed College
Lance Miller University of Arkansas, Fayetteville

Commutative algebra is a central discipline at the intersection of algebraic geometry, number theory, combinatorics, and so on. Many of the foundations were laid by Emmy Noether. Modern commutative algebra combines techniques from computational symbolic algebra, combinatorics, graph theory, and homological and homotopical algebra. The session will cover many flavors with a broad appeal towards the subject's natural influence.

Matthew Toeniskoetter Florida Atlantic University

Convergence of Rees Valuations

9:00–9:20 AM

Associated to every ideal in a Noetherian ring, there is a finite set of divisorial valuations called Rees valuations which arise naturally through the integral closure of powers of that ideal and through the blow-up of that ideal. For a Noetherian local domain, we repeatedly blow up the maximal ideal to obtain an infinite sequence of Noetherian local domains, and if the maximal ideal of each of these rings has a single Rees valuation, we show that the corresponding sequence of Rees valuations converges. We demonstrate examples with polynomial rings and give explicit descriptions to the valuations we get in this case.

Patricia Klein University of Kentucky

An Algebraic Condition that Allows Us to Do Intersection Theory

9:30–9:50 AM

A classical theorem in intersection states that if X and Y are two curves in three variables defined by homogeneous polynomials whose greatest common divisor is a constant, then the number of points of intersection of X and Y is equal to the product of the degrees of the polynomials that define them. This result is known as Bézout's theorem and was first published by Bézout in 1779. If one wants to generalize Bézout's theorem to higher dimensions, it is not obvious what the right analogue of the greatest common divisor being a constant should be. We will discuss some examples to explore possibly appropriate conditions and end by describing the condition known as Cohen-Macaulay, which is of wide interest not only to those working in intersection theory but to those working in virtually all areas of commutative algebra.

Ranthony Edmonds Ohio State University

On Flavors of Factorization in Commutative Rings with Zero Divisors

10:00–10:20 AM

Factorization theory is concerned with the decomposition of mathematical objects. One of the earliest and most significant results involving factorization is the Fundamental Theorem of Arithmetic, which states that every integer can be written uniquely as the product of primes. Thus we can think of prime numbers as the atoms of the integers. We can generalize this idea of unique factorization into atoms to a commutative ring called a unique factorization domain. Many early questions related to factorization in commutative rings were concerned with how close a ring is to having unique factorization. In 1990 Anderson et all presented a general theory of factorization properties in commutative rings weaker than unique factorization, which was then extended some years later to commutative rings with zero divisors. In this talk we discuss some issues that arise when working with zero divisors, and the different flavors of factorization in commutative rings with zero divisors that emerged to remedy these issues. Some techniques for constructing counterexamples in rings with zero divisors will also be described.

Nicholas Baeth Franklin and Marshall College

Direct-sum Decompositions of Modules: The Good, the Bad, and the Ugly (aka Interesting)

10:30–10:50 AM

In most scientific endeavors, one wants to classify the basic building blocks of objects and then describe how all objects can be constructed in terms of these atoms. In linear algebra we learn that every n-dimensional vector space over a field F is really just Fn — a direct sum of n copies of the field F. It is then possible to study any finite-dimensional vector space using this nice identification. Modules are the generalization of vector spaces when the field F is replaced by a ring R. While many nice vector space-like properties carry over to module theory, many do not. In particular, most R-modules do not decompose as a sum of copies of the ring R, and even over very nice rings it can be difficult to identify the "indecomposable" modules. While over some rings, all modules decompose in a unique way as a direct sum of indecomposable modules, this is not always the case. In this talk we will give a brief history of the study of direct-sum decompositions over certain kinds of nice rings and illustrate, by way of examples, how good, bad, and ugly (or interesting, depending on your point of view) direct-sum decompositions of modules can be.

Courtney Gibbons Hamilton College

Syzygy - When Submodules Align

11:00–11:20 AM

In astronomy, a syzygy is an alignment of celestial bodies. In mathematics, a syzygy is an alignment of a kernel of one homomorphism with the image of another! In this talk I'll introduce free resolutions, syzygies, and a few applications thereof.

Contributed Paper Sessions

A Centennial Celebration of David Harold Blackwell

Part A: Thursday, August 1, 1:30–3:30 PM, Room 232

Organizers: Edray Herber Goins Pomona College
Janis D. Oldham North Carolina A&T
Scott W. Williams SUNY Buffalo

David Harold Blackwell (April 24, 1919 - July 8, 2010) is arguably the most decorated and well-known of African Americans in the Mathematical Sciences. Blackwell would have turned 100 years old in 2019. To commemorate this, the National Association of Mathematicians (NAM) will host a Themed Contributed Paper Session for individuals to examine the influence Blackwell has had on the profession.

Asamoah Nkwanta Morgan State University

Game Theory: A Survey of an Intriguing Contribution of David Blackwell

David Blackwell, the seventh African-American to earn a PhD in mathematics and a prominent scholar, made significant contributions to mathematical statistics, probability theory, set theory, information theory, and game theory. Game theory is an important branch of applied mathematics. In this talk we survey an intriguing contribution Blackwell made to game theory. Topics covered will include games, strategies, decisions, and payoffs.

Mark Lewis Cornell University

Blackwell's Contribution to Dynamic Programming

David Blackwell was perhaps the pre-eminent African-American mathematician of the 20th century. He is well-known for his contributions in the area of statistics. What is less well-known is his pioneering efforts in dynamic programming; which forms the basis of decision theory, artificial intelligence and machine learning. In this talk I will explain the basic dynamic programming set-up, show where the optimality criterion now called Blackwell optimality fits in the landscape of decision-making and discuss various application areas of the results.

Kimberly S. Weems North Carolina Central University

David Blackwell: Bayesian Statistics and Contributions to the Statistics Community

David Blackwell made contributions to many areas of mathematics and statistics. This talk will highlight his work in the area of Bayesian statistics as well as his leadership roles in professional associations, such as the Institute of Mathematical Statistics and the American Statistical Association. The speaker will also discuss how Blackwell has influenced her own teaching, research and career.

Carlos Castillo-Chavez Arizona State University

Blackwell-Tapia 2000-2018

The David Blackwell and Richard Tapia event was established as a result of my participation as a member of the diversity committee at the MSRI in Berkeley directed by David Eisenbud, in 1999. From my membership in this committee, I had learned for the first time about the history of the foremost African American mathematician. As Latino mathematician, full professor at Cornell, and engaged in efforts to promote the representation of minorities in mathematics, it was embarrassing to say the least, that I had no idea who this giant was. On my return to Cornell, I decided to do something about it so that future generations of mathematicians would learn about the accomplishments of minority mathematicians. I established the Blackwell-Tapia Lecture Series at Cornell University in 2000 in a memorable event that I will describe. David Eisenbud proposed that this effort should be carried jointly with UC Berkeley, adding the Blackwell-Tapia award that included a monetary award of $5,000.00. It was been awarded now to 9 mathematicians. I will briefly talk about them and how the award has been funded. Finally, I will talk about my participation as a member of President's Barack Obama national medal of science committe (2010-2015), a period of time when Richard Tapia, David Blackwell (posthumously), James Sylvester Gates, and Shirley Ann Jackson were awarded this national recognition. First time, as far as I can tell, that two mathematicians and two physicists (4 minorities out of 8 in 4 years) were recognized with the national medal of science (the norm being one physicist and one mathematician receiving this award each year). I was present at the ceremony were David Blackwell was recognized, posthumously. I will talk about the day that his family received this award.

Richard A. Tapia N/A

Behind the Scenes: The David Blackwell that I Knew

I met David Blackwell in the year 2000 at the inaugural meeting of the Blackwell-Tapia Conference at Cornell University founded by Carlos Castillo Chavez. Of course I had heard about the distinguished mathematician David Blackwell, but in the years following the Blackwell-Tapiaconference I had the opportunity to learn much about the quiet and private , but profoundly deep, David Blackwell. We shared understanding on representation and built a rather close relationship .In this talk I will share stories about the David Blackwell that I knew.

Ronald Elbert Mickens Clark Atlanta University

The Alternative Universes of David Blackwell and William Claytor

As we celebrate the centenary of David Harold Blackwell's birth, it is useful and insightful to compare his family background, college and graduate education, career immediately after obtaining the doctorate degree, and subsequent academic and research paths, to that of William Schlieffelin Claytor. From the perspective of the general mathematics community, one, Blackwell, achieved international fame for his research, mathematical related leadership, and academic positions. However, while Claytor's early life and career were essentially the same as Blackwell's, his subsequent academic and research paths diverged greatly from that of Blackwell. Our main purpose is to provide a possible explanation for why this occurred.

Building Teaching Teams: Professional Development in Departments

Part A: Saturday, August 3, 9:00–10:40 AM, Rooms 230 & 231

Organizers: Sarah Mayes-Tang University of Toronto
Jessica Deshler West Virginia University

Research has shown that professional development programs play an important role in developing instructors who are more student-focused, but financial constraints, time limitations, and lack of buy-in often serve as barriers to offering these types of programs. This session will showcase a wide range of professional development programs situated within mathematics departments.

Jeffrey Kurtz Denison University
May Mei Denison University

On Fire: FFLAME and the ECCP

With the support of institutional funding, I hosted a conference entitled Female Faculty in the Liberal Arts: MathEmatics (FFLAME) at Denison University. I was the second recipient of the Early Career Conference Program (ECCP) grant, which provides "the funding and resources needed to organize a conference at Denison that brings together nearby early career faculty in a specific area of teaching and research." This grant supports early career faculty in developing a peer-mentoring network that is geographically local, discipline specific, nonevaluative, and rooted in the liberal arts. Applicants are encouraged to invite participants within driving distance from similar institutions to attend a conference themed along a particular subject area. I will present preliminary outcomes from the grant for 2017-18 and 2018-19, as well as reflect on my own experience hosting this conference.

Sharona Krinsky California State University Los Angeles

Job Embedded Professional Development in an Introductory Statistics Course

Beginning in Fall 2018, the Mathematics department at California State University Los Angeles, in response to an executive order by the Chancellor's office removing mathematics remediation, implemented a newly redesigned Introductory Statistics course with embedded support where 37 instructors participated in a tightly coordinated course structure. We discuss the types of Professional Development that were provided and implemented both during the preparation phase and during the first two semesters of implementation. Instructors involved ranged from Graduate Students to Part-Time and Full-Time Lecturers. We touch on the various levels of professional development including ACUE's Certificate in Effective Teaching, weekly meetings with in-depth content-based conversations, as well as periodic workshops on active learning, effective teaching, equity and inclusion. We also provide results from student surveys, instructor surveys, and student success (course completion rates).

Emily Hendryx University of Central Oklahoma
Kristi Karber University of Central Oklahoma

Providing Mentorship and Professional Development at a Metropolitan University

The University of Central Oklahoma (UCO) is a metropolitan university that places a strong emphasis on creating transformative learning experiences for its students of varying backgrounds. Achieving this goal requires department and university environments that support the development of early-career teachers. In this talk, we will discuss mentorship provided for new faculty members at UCO, as well as professional development opportunities offered at both the departmental and university levels. We will share how effective mentorship, including support for teaching various mathematics courses, is accomplished with little to no departmental funding. Both mentor and mentee experiences/perspectives will be presented.

Sarah Mayes-Tang University of Toronto, Toronto, ON Canada
Mihai Nica University of Toronto

Starting a Calculus Community of Practice

In 2018, we formed a participant-led Calculus Instructor Community of Practice (CoP) within our department for early-career calculus instructors. In this presentation, we will discuss the factors that led to the proposal and formation of the CoP, strategies used to make meetings work, the outcomes of the CoP, and our plans for the upcoming academic year.

Elizabeth Miller The Ohio State University
Jenny Sheldon The Ohio State University

Creating Overlapping Communities of Practice

In partnership with the Student Engagement in Mathematics through an Institutional Network for Active Learning (*SEMINAL*) grant, the math department at The Ohio State University is making a concentrated effort to develop and promote a culture of excellent teaching practices, student centered instruction, and active learning in our first year courses. Many of our first year courses are taught by a diverse and often temporary set of adjuncts, lecturers, and post-docs. Thus, professional development for instructors is a foundational component of our project. One thing that sets OSU apart is the sheer volume of instructors involved in first year courses; a one-size-fits-all approach would not work well for us. Instead, we have developed a series of overlapping communities of practice. Some components include a teaching orientation for new instructors, a math education reading group, an Active Learning Lunch (ALL), lecturer/coordinator meetings for large courses, a math for teachers group, and a weekly meeting of instructors teaching the active-learning based, hybrid calculus classes. We will speak about each of these and how they promote and support one another to lead to overall cultural change in our first year classes.

Diversity, Equity, and Inclusion in Mathematics

Part A: Friday, August 2, 10:10 AM–12:10 PM, Rooms 260, 261 & 262

Organizers: Joel Kilty Centre College
Ranthony A. C. Edmonds The Ohio State University
Alison Marr Southwestern University
Alex M. McAllister Centre College

National data trends indicate a need to shift representation in the mathematical sciences with respect to diversity, equity, and inclusion. In response, many departments and instructors have sought to understand the barriers that inhibit persistence and success in mathematics, particularly among underrepresented minority, first-generation, low-income, and female students. This session invites presenters to share how they engage diverse student populations.

Alison Marr Southwestern University
Ranthony A. C. Edmonds The Ohio State University
Joel Kilty Centre College
Alex M. McAllister Centre College

Beyond Leaky Pipes: Fostering Pathways and Persistence in the Mathematical Sciences

A leaky pipe has become a prevalent metaphor in STEM education to describe the loss of talent that occurs as students progress through various stages of our educational system. After acknowledging these problematic outcomes, the question then becomes, what role do we in the mathematics community have in addressing the systemic issues that lead to these 'leaks' in our pipeline, and how can we understand the ways in which these issues are exacerbated for underrepresented students? In this talk we highlight data trends that indicate a critical need to increase representation in the mathematical sciences. We also give a broad overview of different approaches to promoting pathways and persistence in mathematics at the undergraduate level. In particular, we discuss evidence based strategies and our own efforts at Calculus reform.

Feryal Alayont Grand Valley State University

Informing and Encouraging All Math Majors

Grand Valley State University is a regional primarily undergraduate institution with a high percentage of first-generation students. These students are usually less aware of academic opportunities available to them. Even when students in general are aware of the opportunities, they might not pursue the opportunities thinking they are not qualified enough. In order to help our 300 math majors take advantage of opportunities available to them, we started actively and clearly informing all math majors (not just those well-connected students) of the available opportunities and strongly encouraging them to participate in these opportunities to level the playing field for all. We use many methods, including hosting career events open to all math majors, implementing mentoring programs, sending weekly email newsletters, offering a career and grad school preparation course, and teaching independent studies in which students complete mini-research experiences. In this talk, I will briefly describe how we came to implement these changes, what components we have tried and what results we have achieved, including some lessons learned.

Rachel Frankel UC Blue Ash College
Karen F. Smith UC Blue Ash College

Leveling the Playing Field: Effective Classroom Practices for First Generation College Students

Teaching first year mathematics courses in a diverse open access college with many first generation students is challenging because students don't know what they don't know. For a variety of reasons, these students frequently won't ask questions or take advantage of available resources and, as a result, may fall behind their peers. In this presentation, we will address various strategies that we have developed over the past eight years to help level the playing field and further the success of first generation college students. Specific examples will include pointers for syllabus creation and review, suggested classroom policies, ice-breakers, strategies to encourage effective note taking, self-reflection exercises, and non-threatening ways to encourage use of college resources.

Linda McGuire Muhlenberg College

Finding Your Mathematical Roots

This presentation will detail a semester-long course project that can be adapted for use in mathematics courses ranging from introductory level, general-education classes to advanced courses in the mathematics major. Through the creation of aspirational mathematical family trees and writing their own mathematical biographies, this assignment is designed to battle "belonging uncertainty" and to challenge students to "self-situate" in relation to the history of mathematical and scientific knowledge. It requires thoughtful consideration of history, society and culture, both in American society and globally. This talk will highlight the construction and scaffolding of the project, student work, foundational readings, and assessment. Most importantly, we will detail how students moved toward seeing themselves as members of a deeply-rooted mathematical community.

Kathryn Cerrone The University of Akron
Irina Chernikova The University of Akron
Sukanya Kemp The University of Akron

Change is a thing you can count on: Adjusting to meet diverse student needs

Declining numbers of traditional-age high school graduates, changing student demographics, and struggles with student retention are creating what can be termed a "perfect storm" in higher education. It is crucial to understand what non-traditional and first-generation students want and need in order to increase retention and encourage degree completion. It is important for students to see logical connectivity among courses while following program curricula and for curriculum designers to think far beyond traditional methods of teaching and learning. Over several years of data collection from and about learners, it was found that students are looking for time flexibility in course scheduling and structure as well as clarity in course content and delivery. These observations by faculty guided two major changes: 1.) curriculum redesign for the engineering technology mathematics sequence and 2.) creating a flexible schedule utilizing a variety of course delivery methods including online, hybrid, and accelerated sequels. The presenters will document how this redesign, along with converting traditional face-to-face technical mathematics and economics courses to an online or hybrid delivery mode, were implemented to ensure accessibility and the achievement of learning objectives.

Sayonita Ghosh Hajra California State University Sacramento

Diversifying and Humanizing Mathematics through Community Collaboration

This talk describes a mathematics enrichment program, a partnership among university faculty, university graduate and undergraduate students and K-12 students, supporting underrepresented students in developing math literacy through after-school and community engagement in the west coast. This program aimed to develop mathematical interests in underrepresented students through hands-on application-based mathematics and provided an opportunity for students to learn mathematics through a different lens. This program aimed to increase equitable access for underrepresented students by providing a brave-space to develop student ownership in the problem-solving process, as a teacher or a learner or both and bolster each student's mathematical identity and confidence by cultivating curiosity, sense-making, and self-efficacy. In

this talk, we will discuss the program, its outcomes, and future pathways. We will also discuss its implication in the curriculum and hurdles that we encountered along the way.

Part B: Friday, August 2, 1:30–4:30 PM, Rooms 260, 261 & 262

Jennifer R. Bowen The College of Wooster

Women Who Count: Experiential Education in Mathematics

This talk will describe 'Women Who Count' - a CityTrek experiential education opportunity offered at The College of Wooster. CityTrek: Women Who Count provided undergraduate students with opportunities to network with alumnae in Philadelphia, Pennsylvania. Student participants explored Philadelphia while meeting with females who work in data analytics, public health, and other STEM capacities. The program focused on the unique experience of women in data and STEM careers and aimed to develop students' professional skills: mentoring/networking, career research, and navigating a new city. Immediately after the experience, students participated in a re-entry reflection session, following best practices of experiential education.

Ying Luo The Pennsylvania State University

Mathematical Classroom Discussion of K-12 Emergent Bilinguals in North America Context: A Review of Literature

This paper reviewed the mathematical classroom discussions of K-12 emergent bilinguals in North America context in light of the systematic literature review. To heed the calls of math educators promoting mathematical classroom discussions and voicing for paying more attention to emergent bilinguals' math learning, in this paper three questions were addressed:1) How is "mathematical classroom discussion" defined in the research and what are the constructs or elements within these conceptualizations; 2) What theories are used to frame research surrounding mathematical classroom discussion; 3) What are the major findings about how emergent bilinguals engage in mathematical discussions to promote reasoning and conceptual understanding. This article found that 1) The definition of "mathematical classroom discussion" was not unified; 2) Overall, "systematic functional linguistic theory" , "sociocultural theory" and "the theory of discourse" were mainly used in framing "mathematical classroom discussion" research. 3) (a) "Mathematical classroom discussion was beneficial for emergent bilinguals" , (b) Bilingual students bring in different resources and in participating in the mathematical classroom discussions" and (c) Pedagogical instructions are different in "mathematical classroom discussions" . This review article also proposed more research specifically in investigating the quality of "mathematical classroom discussion" , in the research more explicit clarifications of the background information should be provided including emergent bilinguals' English proficiency and math proficiency and for comparison purposes, more coherent follow-up research should be conducted.

Pat Devlin Yale University

Community, Belonging, and the Putnam Exam

MAA's annual Putnam competition is always beautifully crafted, and it connects our students to eight decades of a lovely mathematical tradition. On the other hand, its notoriously strict grading can be demoralizing (the median score is typically only 0 or 1 out of 120 possible points). So the question becomes: how can we use the Putnam to foster a sense of belonging and community (for all students) despite its competitive aspects? This talk explores this question as it relates to the implementation of the speaker's Putnam seminar (fall 2017, fall 2018). We discuss inclusive pedagogical practices contributing to the seminar's growth, with the experiences of students from traditionally underrepresented groups being a particular focus. All materials developed for this seminar are readily available from the speaker on request.

Jeanette Shakalli National Secretariat of Science, Technology and Innovation

Program on Math Outreach in Panama

The main goal of the Program on Math Outreach of the National Secretariat of Science, Technology and Innovation (SENACYT) of the Republic of Panama, which was born in 2016, is to convince Panamanians that math is fun, and that it has many interesting applications, and also to inspire more students to study math. Through various methods, like magic, mime and music, talented mathematicians have inspired Panamanian kids and adults of all ages to rejoice in the beauty of science and math. This Program is an example of an extracurricular activity that reaches out to the general public, which includes a diverse group of people, and it is an initiative that you can adapt to do at your own college/university or at your own community. In this talk, we will discuss some of the logistics, the marketing strategy and the publicity that are necessary to get people to attend, and in general, what has worked and what has not. Ideas of how we could expand the Program to reach more students and maybe improve it to make it sustainable for years to come will also be discussed.

Alessandra Pantano UC Irvine
Mark Yu UC Irvine
Li-Sheng Tseng UC Irvine

Inclusive teaching and learning of mathematics in an afterschool math enrichment program for underrepresented minority, first-generation, low-income students.

UC Irvine Math CEO is an innovative afterschool outreach program designed by UCI faculty to improve math outcomes and dispositions, and increase interest in a STEM college education for underserved youth in Orange County, CA. Math CEO features math enrichment sessions and STEM-focused field trips for middle school students, as well as bilingual college-orientation workshops for their parents. Almost all participating children are Latinx and come from low-income families with low educational attainment. Every week 160 middle schoolers come to UCI to work on engaging math curriculum with caring undergraduate mentors (100 per year). Like the program participants, many mentors are underrepresented or first-generation, low-income college students. The intergenerational nature of Math CEO, whereby youths are paired with undergraduates in a university-based STEM afterschool program, provides an opportunity to support math motivational beliefs for all students involved, and their sense of belonging in STEM and in college more broadly. To enhance program quality, Math CEO mentors receive weekly training on math content and on inclusive and culturally responsive math pedagogy. In this talk, we focus on the teaching practices in Math CEO and their impact on both the children's and the mentors' experiences in the program. Specifically, we share some preliminary data on 1) how participation in Math CEO increases children's math motivational beliefs and their college-going identity; 2) how Math CEO mentors improve their relational and teaching self-efficacy and their perceptions of STEM and Teaching Careers. Furthermore, we discuss advantages and disadvantages of our intergenerational approach, related to mentors' training.

Jacob Castaneda Bridge to Enter Advanced Mathematics

Early Access to Advanced Mathematics for Underrepresented Students

Across almost every field in the mathematical sciences, people from low-income and minority backgrounds are dramatically underrepresented, a gap that traces back to K-12 education. A wealth of programs exist to help students study mathematics deeply during these formative years - from summer programs to math circles to after-school programs - but most programs have limited outreach and support for reaching underserved students. In an attempt to shed light on strategies that foster inclusion in mathematics at the pre-collegiate level, we will share the experiences of Bridge to Enter Advanced Mathematics (BEAM), a program that has been operating in New York City since 2011 and Los Angeles since 2018. BEAM reaches hundreds of students each year through summer programs, weekend programs, and mentoring from 6th grade through 12th grade. Curriculum includes math ranging from logical reasoning through number theory, combinatorics, and group theory, in addition to college access work and educational advising. We will share further information about our program's strategies and outcomes. It is our hope that others can find replicable program elements, and that our experiences can strengthen the broader ecosystem of support for marginalized students.

David Easdown University of Sydney

Reaching Out: Introduction to Calculus

The University of Sydney recently introduced mathematics prerequisites, which need to be satisfied by new prospective undergraduates, in order to qualify for places at the University in the disciplines of science, business and economics. Over the last six months, the speaker developed online resources, and created an integrated, self-contained course, *Introduction to Calculus*, delivered as a Massive Open Online Course (MOOC). The University of Sydney now uses this MOOC successfully, each semester, as an alternative pathway for satisfying mathematics prerequisite requirements. The MOOC is primarily aimed at students ¡ul¿¡li¿from disadvantaged backgrounds,¡/li¿¡li¿from rural or remote areas,¡/li¿¡li¿from schools lacking adequate resources or qualified mathematics teachers.¡/li¿¡/ul¿ The resources of the MOOC are freely available anywhere in the world with a reasonable internet connection. The MOOC is based on a mastery learning model and employs discussion forums, with many different threads and multiple themes and topics, bringing students together, with diverse backgrounds, interests, linguistic and mathematical abilities, interacting with each other and with instructors. The MOOC is thematic, with strong narratives and historical underpinnings, and has already proven to be a useful resource, not only for students, but also for teachers, who need to refresh their knowledge of calculus, deepen their understanding or have access to novel and stimulating resources to use in the classroom.

Jenna P. Carpenter Campbell University

Effective Teams: Helping Students Understand the Importance of Diversity and Inclusion Through Teaming

Undergraduates rarely arrive at college with an understanding of and appreciation for the importance of diversity and inclusion. To implement effective training on these topics, it is important for them to see how it applies immediately, instead of only emphasizing its importance later on in the workplace. Research suggests that student teams are one scenario where implicit bias and stereotyping are prevalent. We have adapted and utilized a lesson on diversity and inclusion focused around effective teams (which are embedded in our curriculum from day one). By painting diversity and inclusion broadly, we have been able to successfully connect with a wide range of students, help them begin to spot occurrences of implicit bias and stereotyping, and equip them with some strategies based on best practices from research to manage around these issues.

Part C: Saturday, August 3, 9:00–11:00 AM, Rooms 237 & 238

M. Sean Lawless University of Illinois at Urbana-Champaign
Mario Rubio University of Illinois at Urbana-Champaign
Simone Sisneros-Thiry University of Illinois at Urbana-Champaign
Joshua Jeishing Wen University of Illinois at Urbana-Champaign
Bryan Dean University of Illinois at Urbana-Champaign

The Limit Does Not Exist: The Value of Math Education in Prison

Prepared by students and instructors of the Education Justice Project (EJP). EJP is a model college-in-prison program hosted by the University of Illinois at a medium security mens prison in eastern Illinois. The value of and need for math education in prisons has been keenly felt by EJP students. Our interest in mathematics and related fields has encouraged the development of an increasingly robust math and engineering curriculum, including a for-credit calculus series and workshops on linear algebra and recursive sequences. Our presentation will introduce the history and current status of EJP math programming. It will focus on student motivation, interest, and background in mathematics, and will include reflections by students and instructors on approaches and outcomes.

Jennifer Elyse Clinkenbeard California State University Monterey Bay
Alison Lynch California State University Monterey Bay
Peri Shereen California State University Monterey Bay

Exploring Equity in Co-Requisite First Year Mathematics and Statistics

In 2017, the California State Chancellor's office called for an end to remedial mathematics across the 23-campus state system within one year. Historical data showed that students who "successfully" remediated still had higher failure rates in subsequent math classes, and that minority, first-generation, and low-income students were the majority for whom remediation was required. Now, one year after remedial mathematics has been eliminated from the CSU system, we explore academic achievement and engagement of first-year students at the Monterey Bay campus. This campus is a Hispanic-Serving Institution (42% Hispanic/Latinx), with 51% of first-generation students and 33% low-income students. We highlight several examples of tasks, discussions, and assignments that were successful in engaging diverse student populations through inclusive instructional practices. We also present findings from this first-year implementation, considering academic outcomes and student engagement indicators, by ethnicity, gender, first-generation, and low-income status.

Roberto Soto California State University, Fullerton

Recruitment, Resilience, and Reaching Higher via Early Research Experiences

Research shows that traditionally underrepresented students in the mathematical sciences struggle to finish their degrees, but a sense of belonging and community can help students reach their goals. In many southern California public universities there is the additional stress of 1-2 hour commutes that can prohibit many students from forming the communities that can provide the type of support that is needed to be successful. We share how early research experiences in conjunction with a network of support has helped many underrepresented students not only accomplish their goal of graduating but also led them to redefine their dreams.

Dennis Davenport Howard University

The NREUP and Howard's Program

Each summer, through grants provided by NSF or NSA, MAA funds small REU programs that are designed to give summer enrichment for undergraduate students who attend the host institution and are majoring in mathematics. In this presentation, we describe MAA's program and provide some funding rate data. We will also describe a summer program that was developed at Howard University which started as an NREUP. Included will be a project on combinatorics and some student results.

Nathan N. Alexander Morehouse College

Supporting the Transition to Undergraduate Mathematics: Collaborative Learning and Mentoring in Teams

There is a gap in research on students' transition from secondary mathematics to undergraduate mathematics. Given the wide range of first-year students' mathematical competencies, colleges and universities tend to sort students using various performance indicators, such as placement tests or mathematical assessments. Given the correlation between high-school mathematics performance and first-year student success, the transition to undergraduate mathematics can be described in three ways: as smooth, rigid, or split. On one end, there are students who have 'smooth' transitions and on the other end are students who have 'rigid' transitions; there are also 'split' transitions, which describes students who have a mixture of experience that, over time, polarize them towards one end of this spectrum. This paper describes models to support student transitions to college mathematics using data from two intervention studies focused on the use of a computer-based lab and peer-work in teams.

Linda Braddy Tarrant County College

Conversations Across the Divide

This presentation will detail how the Vice President for Academic Affairs partnered with the college Equity and Inclusion Council to offer a "Conversations Across the Divide" series open to all employees. The discussions focused on ideas presented in the book, "White Fragility: Why it's so Hard for White People to Talk about Racism" by Robin DiAngelo. Each session began with breakfast and ran 2 1/2 hours. Attendance ranged from 25 to 50 faculty, staff, and administrators at each session. Activities included individual speakers, panels, videos, additional readings, small group discussions with discussion prompts, and whole group discussions. Three sessions were held in the spring semester 2019 and will the series will be continued this coming academic year.

Encouraging Effective Teaching Innovation

Part A: Thursday, August 1, 3:50–5:50 PM, Rooms 230 & 231

Organizers: Susan Crook Loras College
David Failing Lewis University
Russell Goodman Central College
Mami Wentworth Wentworth Institute of Technology
Mel Henriksen Wentworth Institute of Technology

This session will consist of presentations of demonstrably effective and innovative classroom techniques that address the reasoning behind, design, and implementation of resources or activities. This may include whole course techniques (not necessarily original to the presenter) or drop-in activities to bolster student learning and reflection in any course. Materials will be shared after the session at: http://mathfest2019.davidfailing.com/

Suzanne Caulfield Cardinal Stritch University

Reducing Student Testing Anxiety by Implementing a Three-Stage Group Testing Method

Two-stage group testing methods in mathematics have been shown to reduce student stress during exams. In Ives, the argument was posed in favor of two-stage collaborative group exams for just this reason. Sainsbury concurs and discusses the opportunity students have to learn during the testing process, rather than being penalized for a lack of knowledge. Sainsbury also noted that regression can occur, due to group dynamics. Finally, the CWSEI [3] gives strategies on how to implement a two-stage test. However, no evidence or research has been found on the benefits of three-stage testing. This presentation will highlight the rationale of three-stage testing and give examples of its success in reducing student stress during exams, and improving student learning outcomes. One of the ways for an instructor to reliably assess student learning is to quiz the student. However, this quizzing of the student creates such levels of stress that the student cannot adequately represent themselves in the quiz. How can I find out what a student knows, if I ask them in such a stressful situation that they cannot tell me? A group testing method reduces the level of stress on the student. It also acts as an active learning opportunity for the student to recognize the gaps in their knowledge and learn from their peers. A three-stage testing method is implemented into a number of mathematics courses, to see if the level of anxiety around testing can be reduced and to improve student learning outcomes. Results are presented and discussed.

Reza O. Abbasian Texas Lutheran University
Mike Czuchry Texas Lutheran University

Investigation of Inverted and Active Pedagogies in STEM Disciplines, Final Report

In this talk we will discuss the results of our three-year NSF funded grant titled "Inverted and Active Learning Pedagogies , IALP, for Student Success" (Reza Abbasian principal investigator with faculty from biology, chemistry, physics, data analytics and statistics). We will present our results comparing student achievement and retention between inverted or flipped classrooms and traditional lecture formats in natural science and statistics classes at Texas Lutheran University. Our talk will include a brief description of the goals, the study design, data gathering, faculty and students' surveys, and the methodology used for the study. In addition, we will share results from instruments that were developed to measure different levels of cognitive understanding across multiple sections of the same course as well as in sequential courses. We will also discuss various factors affecting the results including use of technology, classroom activities, class size, students' attitudes, type and lengths of the instructional videos, and the instructor and discipline effects. Key Words: Inverted, flipped, active learning

Jeffrey M. Ford Gustavus Adolphus College

Changes to Student Self-efficacy and Motivation with Team-Based Learning

For many students in a liberal-arts perspective mathematics classroom, high levels of anxiety and low motivation are an issue. We present here a Team-Based Learning approach for teaching such a course. During the course of the semester, we had students complete an instrument to determine their motivation and mathematical self-efficacy. We will present the results of this instrument, it's correlation with student performance, and a qualitative analysis of student feedback on the teaching method.

Alex M. McAllister Centre College

Learning about Learning

During the last few years I have incorporated an increasing number and diversity of "Learning about Learning" activities into my courses. My students watch TED talks, read articles, observe their own behaviors, and write self-reflections to various prompts, all chosen for their relevance to how humans learn most effectively and for their connections to the mathematics we are studying together. These topics include setting expectations and exploring values, growth mindset and grit, effective and ineffective approaches to studying, wellness and time management, and more. This talk chronicles the integration of these activities into my courses and shares my students' responses to the experience of becoming more intentional, reflective learners.

Karen F. Smith UC Blue Ash College

Getting the Most out of Collaborative Learning

Title: Getting the Most out of Collaborative Learning Abstract: Collaborative learning involves groups of students working together to solve problems. Frequently, the stronger students dominate the group while the weaker students simply copy the work without really understanding or learning the material. This talk will highlight strategies to involve all students in the group learning process, thereby advancing their learning. Specific classroom-ready examples used in applied calculus classes will be presented.

Justin Dunmyre Frostburg State University

Using Learning Assistants to Encourage Active Learning

In this talk I will discuss utilizing undergraduate learning assistants (ULAs) to support mathematics classrooms and beginning steps in extending support to non-mathematics classrooms. Our ULA program is based on the University of Colorado model. A ULA is a student who is paid to attend all meetings of a particular section of an undergraduate course. The ULA's main focus is to facilitate active learning in the classroom. They also attend a one hour per week "prep" session with the instructor, and hold two evening office hours in the Math Assistance Center. We frequently tap our ULAs for feedback from ULAs on classroom innovations and this feedback has been immeasurable value for our faculty. College algebra classes showed significant improvement in passing rates when we incorporated ULAs into the classroom. ULAs also support us in using inquiry-oriented pedagogies at larger scales than the instructor would otherwise be comfortable with. Faculty in my department have agreed to pilot active pedagogies, e.g. trying out Active Calculus, under the condition that a ULA will be assigned to their class. In this talk I will share how we have funded our ULA program, how we support our ULAs, reflections on the ULA experience, and how the ULA program fits in with a university initiative to incorporate open education resources (OER). The talk will conclude with ongoing work regarding extending the ULA program within the mathematics department, and to other departments on our campus.

Part B: Friday, August 2, 10:10 AM–12:10 PM, Rooms 237 & 238

David Taylor Roanoke College

No Student is an Island: A Plethora of Pedagogical Practices for Collaborative Mathematics Classrooms

For many years, lecture was the norm in mathematics classrooms. As students, and therefore teaching practices, have changed, techniques such as inquiry-based learning, flipped classrooms, and think-pair-share have become more commonplace in our classes. This past year, the presenter, along with twenty-five colleagues at Roanoke College, participated in a teaching-focused online class offered by the Association of College and University Educators. In this talk, we will discuss classroom and course design techniques to promote various modes of collaboration in mathematics classrooms such as peer-review, student-created rubrics, cognitive-level-aligned assessments, and other techniques, supported by education research along with empirical and observational evidence of success.

Tom Mahoney Emporia State University

Read the Book! Improving Reading Comprehension in Mathematics

Reading mathematics is a difficult skill to learn, but it is essential to the ability to become a self-led learner of mathematics. Over the last three years, I have experimented with several methods to help students practice this skill in several undergraduate and graduate courses. We focus on three specific techniques. First is using peer review to expose students to different writing styles, next is having students give detailed annotations of proofs from the textbook, and finally using Perusall to increase student engagement with the textbook itself. Lastly, I'll provide advice on how to successfully implement them in your courses.

Melissa Soto California State University, Fullerton

Continuing the Conversation: Creating *Learning Spaces* via Dynamic Discussion Forums

Occasionally a learning activity in a classroom tends to produce rich discussion. But what happens when class time runs out? Unfortunately, our universities run on a strict time schedule that must be kept. How can we continue these rich conversations without using more class time? Traditional text-based discussion forums offer one avenue, however in this talk we share data from a dynamic discussion forum which allowed students and faculty to continue the conversation beyond the four walls of the classroom. Finally, we present a surprising result - this tool created community in both traditional and non-traditional classroom settings!

Sean Droms Lebanon Valley College

Structuring a Course Around Reading Mathematics

The math department at Lebanon Valley College strongly emphasizes reading and understanding mathematical and other technical content. I will share some of the techniques our department uses to teach students how to read technical content, especially in service courses for non-majors. This often takes the form of a paradigm that shapes the structure of the entire course, so, time permitting, I will discuss course assignment structures, in-class activities, and assessment of student reading ability.

Charlotte Knotts-Zides Wofford College

Teach Students to Prepare for Class AND to Think About Their Learning

Students in my classes are required to prepare for the upcoming class via online assignments that pair reading the text and working problems with answering metacognitive prompts. The hour before class begins, I review the students' online responses to determine how best to organize my teaching for that class. In all classes, metacognitive prompts are utilized to help students reflect on their learning. In lower-level courses, students read the textbook or watch videos, and then work graded problems before class begins; in upper-level courses, students answer reading questions, are guided through proofs of theorems, and work concrete examples of definitions before class begins. I find my students are more engaged and ask more meaningful questions in class. These techniques are adapted from two books by Linda B. Nilson, "Teaching at its Best: A Research-Based Resource for College Instructors, 4^{th} ed." (see Chapter 21 on "Ensuring Students Prepare for Class") and "Creating Self-regulated Learners" .

Adelaide Akers Emporia State University

The Value of Reflective Writing in Mastery-based Grading Systems

In traditional grading systems, a grade is assigned to student work based upon the knowledge that the student had at the time of the assessment. Presumably, the student then learns from their mistakes, but the grade still reflects only the knowledge that the student had in the moment of assessment. In a mastery-based grading system, students can elect to reassess often until they can demonstrate *mastery* of the material at hand. But the onus of learning from their mistakes still falls on the student, who is often ill-equipped with the skills to do so. This talk will explore how reflective writing within mastery-based grading systems has the potential to strengthen the students' ability to effectively learn from mistakes and propel students to achieve mastery faster. We will provide examples of writing prompts that encourage the student to reflect in a truly meaningful way, with the added bonus of significantly improving students' overall communication skills.

Part C: Friday, August 2, 1:30–4:30 PM, Rooms 237 & 238

Erin R. Moss Millersville University of Pennsylvania

Restructuring Lessons as an Antidote to Student Passivity in Introductory Courses

Traditional modes of teaching involve an instructor presenting a problem or definition, demonstrating a procedure, and finally having students work examples similar to what was demonstrated. There is high potential for students to disengage mentally, learning to imitate procedures while lacking understanding of what they are doing or why. A change that can make a profound difference is to restructure lessons so that students are the ones developing the procedures or definitions. This framework requires the instructor to consider their goal and then devise tasks that encourage students to engage in pattern-exploration and meaning-making to get there. For instance, in an introductory statistics course, students might be given names and descriptions of sampling procedures then examples of each. In restructured lessons, students might instead be given several examples of statistical sampling scenarios that they then categorize according to structural similarity and then be provided with the official names of the sampling procedures for each distinct category they discovered. In this way, students are engaged from the very beginning in the process of discerning fundamental similarities and differences in the sampling procedures. In this presentation, I provide additional examples of what this restructuring might look like for specific topics in introductory statistics, college algebra, mathematics for future elementary teachers, and precalculus.

Lauren Sager University of New Hampshire

Core Quantitative Rasoning: The Specifications Grading Version

Concepts of Mathematics is a quantitative reasoning core course with a dual audience: non-mathematics majors looking for core credit, and elementary education majors. Specifications grading seemed a good fit for two audiences who tend to avoid college math classes like the plague. In this talk, I will discuss how I implemented specifications grading in the course, and discuss a bit about student and grading outcomes.

Linda Burks Santa Clara University

Precalculus Active Learning Labs: Focus on Functions

This presentation focuses on the development of ten precalculus active learning labs. To provide active learning opportunities to precalculus students, a concurrent one credit (pass/no pass) active learning lab is offered to students taking a traditional four credit precalculus course. In this 65-minute weekly lab, students work in small groups on different problem solving activities. Focused on deepening students' understanding of functions, the problem solving activities build connections between modelling real life situations with graphs, equations, and tables. Students learn to communicate their ideas and defend their reasoning. In 2018-19, the lab was required of all precalculus students whose ALEKS placement score indicated that they should take a college algebra class. Given their low ALEKS placement scores, it would be expected that, without intervention, the lab students would not perform as well in precalculus as students whose ALEKS score did place them into precalculus; however, the Fall 2019 average precalculus grade and grade distribution of the lab students is comparable to that of the non-lab students. This seems to indicate the labs could be a useful precalculus corequisite for the algebra level students. In this talk, I outline the content of each lab session, highlight some of the activities used, discuss the results of this year's pilot program, and describe changes being made to the active learning labs next year.

Laura R. Tinney University of North Carolina Asheville
Cathy Whitlock University of North Carolina Asheville

Graded Homework in 100-level Mathematics Courses: Should the Students decide?

In response to a debate about the merits of online homework systems vs. free open source textbooks, two instructors at UNCA allowed individual students in their Quantitative Literacy course to choose whether or not they wanted their daily homework to be graded and included in the computation of the final grade. The students who opted to do homework also chose whether they wanted to turn in written homework or purchase access to an online homework system with "help features" . The experiment was an effort to try to reduce the anxiety and resentment commonly expressed by students in this course without altering learning objectives or lowering standards. The results were so surprising that we expanded the trial to include Precalculus, Calculus I and Intro. Statistics. We were not shocked when we found that the students in Calculus classes were more likely to choose the homework option, but we were still surprised by how many students chose homework and how pleased they were to be given options in the first place.

Ralph Stikeleather University of Cincinnati- Blue Ash College

How Flipping the Classroom Led to Better Outcomes for College Algebra and Foundations of Quantitative Reasoning Students

This talk will include a comparison of traditional and flipped teaching techniques and the outcomes of students taking College Algebra and Foundations of Quantitative Reasoning. It will explore the challenges of teaching traditionally and the motivation to convert classrooms to a flipped format. It will highlight the benefits of before class video lectures and assignments to check understanding, spreading out the assignment of homework on the same content to multiple periods, regular in-class exit quizzes, in-class group assignments, and assessing the quality of students' shown work using regular brief checks and periodic overall portfolio checks.

Patricia Baggett New Mexico State University
Andrzej Ehrenfeucht University of Colorado

Introducing the Notion of Variable to Young Children in Courses for Elementary Teachers

For several years we have been designing curricular units used in mathematics courses for elementary teachers in which students carry out arithmetic calculations on a variety of counting boards. Recently we introduced the concept of a variable counter, a counter which does not have an assigned value such as 1, -1, or 10, but only a name, such as a, b, or x. A specific value can be assigned to such a counter before the calculation starts, depending on the problem that is being solved. Or its value can be discovered during calculation from some conditions that are stated in the problem. Such problems can be very simple, such as, "I'm thinking of a number. When you double it and add 3 you get eleven. What is my number?" and "Children and dogs were playing in the park. There were 7 heads and 20 legs. How many children and how many dogs?" For teaching units using counting boards, see https://web.nmsu.edu/ pbaggett/NumberBoards/index.html. In the talk we will describe the counting boards that have been used, explain some techniques for solving problems with them, and show some comments of teachers who have become familiar with such units.

Jason J. Molitierno Sacred Heart University

Teaching Elementary Statistics from A to Z

After teaching a course many times, often there is the urge to overhaul it so that it is fresh. In this talk, I describe how I recently overhauled my Elementary Statistics course into a rhythm that has been successful. I will describe the syllabus I use and the topics that I cover in a course that meets 26 class periods (75 minutes each) per semester - hence the title "A to Z". I will discuss lecture topics, group assignments, and assessment tools that I use. I will discuss how the course has evolved and how the course continues to evolve.

Vinodh Kumar Chellamuthu Dixie State University, Saint George, UT

Improving Student Ownership in Introductory Statistics Class through a Project-Based Approach.

The presentation will highlight a semester-long project-based approach in Introductory Statistics class that deepens on critical thinking and conceptual understanding, rather than mere knowledge of procedures. In this presentation, a project-based approach that improves students' ability to use the techniques and skills learned in Introductory Statistics class in real-world applications will be discussed. The primary goal of this project-based approach is to foster students thinking by creating an experience where students choose a mini research project based on their passion/major study. During this process, students created their own hypothesis for their chosen project, designed a study, conducted the study, described the data, and made conclusions using the data. The presentation will also highlight feedback from the student's and their experiences with this project-based approach pedagogy.

Anil Venkatesh Ferris State University

Help! My Lesson Bombed: Recovering from a Classroom Failure.

We've all been there: a lesson plan seemed great on paper but didn't go as planned in the classroom. If unresolved, this type of miscue can lead to simmering resentment that negatively impacts the atmosphere of the classroom in the long run. As a result, student learning may be substantially curtailed. Instructors who use innovative teaching techniques are at particular risk of this outcome as students may respond defensively to classroom activities that they are less familiar with. In this talk, we present a classroom intervention technique that was employed at the midpoint of a two-semester course sequence. The intervention included the novel use of a math education scholarly article as a proxy through which the class could safely explore their grievances with the instructor. We present quantitative and qualitative evidence that the intervention supported student learning by improving the classroom atmosphere in the second half of the course sequence.

Part D: Saturday, August 3, 10:30 AM–12:10 PM, Room 205

Carol Bell Northern Michigan University

Introduction to Proof Techniques in a Geometry Course

Students should gain experience learning about reasoning and proof in a number of different courses, including geometry. In this talk, I will share how students explore a variety of proof techniques in a geometry course designed for future K-12 educators. As students explore different methods of proof, they are learning what constitutes proof and justification, and what might be an appropriate form of proof for the level they will someday teach: elementary, middle, or high school. A final course portfolio of proofs allows students to revisit the different proof techniques discussed throughout the course and replaces a final exam. I will share sample assignments and discuss ongoing efforts to improve the course.

Kevin Gerstle Hillsdale College

Project-Based Learning in Analysis

In this talk, I will discuss the implementation of a project in which students taking a course in complex analysis at a small liberal arts college were tasked with working in small groups to explore an application of course concepts to some outside topic. I will discuss the assigned paper, classroom presentations, and blind peer reviews of both aspects of this project. In doing so, I will discuss which parts of the project worked well, which aspects can be improved, and how this project can be generalized to a wider variety of courses.

Abigail Bishop Iona College

An Alternate Method for Project Presentation in a Math Course.

Projects that have a presentation component can be an important element to a course, but often it is hard to balance the in-class time needed for those presentations and the time needed to cover the required material for the course. I will discuss an alternative presentation method where student post narrated slides in the discussion board section of a course management site such as Blackboard. I will share examples of student projects and discuss both successes and challenges that came with implementing this project in both Linear Algebra and Differential Equations.

Catie Patterson Austin College

Quantitative Consulting: An Interdisciplinary PIC Math Course

Students of mathematics are often told that there are many ways they can use their skills outside of academia. However, these same students frequently struggle to understand exactly how these skills are used in the "real world." Additionally, success beyond the classroom is often dependent on "soft skills" that are not emphasized in a traditional mathematics course, such as collaboration and communication. To give my students a taste of how mathematics can be used in practice, in Spring 2019 I taught a course through the MAA's Preparation for Industrial Careers in Mathematics (PIC Math) program. This course was cross-listed as a computer science course, giving my students an opportunity to collaborate with peers from another discipline. In this talk, I will explain the structure of my course, which was centered around semester-long, group projects for a specific client, Meals on Wheels of Tarrant County. Finally, I will describe the kinds of projects my students worked on for their client and the skills they gained through these projects.

Lipika Deka CSU Monterey Bay
Jeffrey Wand CSU Monterey Bay
Peri Shereen CSU Monterey Bay

Building Course Embedded Undergraduate Research Experience (CURE) in a Mathematics Major Pathway

The Department of Mathematics and Statistics at CSU, Monterey Bay started an initiative to create a pathway of courses in the major providing students with undergraduate research experiences that promote positive learning experiences in mathematics. Currently, there is a lot of literature on CUREs across many of the scientific disciplines, but there is not much in the literature on CUREs in mathematics. Our vision is to explore the impact of CUREs on student's learning and engagement in mathematics courses. The first step towards this vision is to incorporate CURE projects in the first three math major courses in the pathways: Discrete Mathematics, Math Linear Algebra and Differential Equations and Foundation of Mathematics. We piloted CUREs in all three courses in Fall 2018 and Spring 2019. These are the first courses mathematics majors must take before they start their upper division mathematics pathways and they also build the mathematical foundation needed for our students. Each course piloted a CURE project that all students worked on in groups of three or four either throughout the semester or for a part of the semester. The project in each course is aligned with the course content but provides them with the experience of the research process in mathematics by exploring concepts beyond the curriculum. In this session, we will discuss the specifics of the projects in each course and the kind of support provided to the students. We will share students' experiences as well as provide early anecdotal results on what worked well and what changes we anticipate making moving forward.

Part E: Saturday, August 3, 3:00–5:20 PM, Room 205

Sarah Ann Fleming Belmont University

A Calculus Study: Class Preparation Worksheets

This talk is based on a calculus study conducted at Belmont University during three semesters concluding with fall semester 2018. Students were asked to complete and submit online a Class Preparation Worksheet before every class meeting excluding test days. The worksheet required students to read the textbook before class and answer preliminary questions about the material to be covered in class that day. In addition, the worksheet provided a place for students to ask questions of the instructor. The instructor could then use these worksheets to tailor his/her lecture to best meet the students' needs. This talk will provide further insight into the Class Preparation Worksheets including implementation methods as well as feedback from students and faculty about the pedagogical tool. In addition, findings in comparing classrooms that used the method with those that did not will be presented.

Stepan Paul Harvard University
Janet Chen Harvard University

Manipulative Calculus: Active Learning with 3D Models

Manipulative Calculus is a project underway at Harvard University to construct 3D models and manipulatives to be used in active learning lessons in our calculus course sequence, primarily in multivariable calculus. In these lessons, we put models into students' hands, and they are asked to make geometric sense of the concepts learned in the course through problems requiring them to handle, discuss, and sketch on the models.The presenters will discuss the design of the lessons and models, the process of producing the models and training our instructional team in their use, and feedback we have received from instructors and students about the lessons.

John Prather Ohio University

The Transformation of a Luddite: Using Technology Outside of the Classroom Setting

As a firm believer that calculators have destroyed mathematics education, I resist the use of technology within the mathematics classroom, especially in introductory courses. However, recent developments in technology outside the classroom make it possible to improve student engagement with faculty. Currently, I teach classes to students on multiple campuses of Ohio University using interactive television capabilities. Engaging with these students outside of class poses a challenge. Here I will share some of the ways that I have used to improve the frequency and quality of contacts outside the classroom for students on remote campuses. In addition, I will discuss the use of smartboards and lecture-capture technology in a traditional setting to improve engagement with students on a commuter campus. Together these technological options have made my classes more accessible to students, and have allowed me to engage with them more fully outside of the classroom.

Benjamin Wilson Stevenson University

Full Speed Ahead: A Day 1 Calculus Activity

In this presentation, we will examine an activity intended to introduce first-semester Calculus students to some of the big-picture concepts they will encounter in the course, while also building a classroom community where they are comfortable asking questions, working with their peers, thinking outside the box, and trusting their intuition. The focus of the activity is a slow-motion video of a toy car rolling in front of a meter stick with a timer showing in the background. Students watch many loops of the video and discuss questions they have and answers to those questions. With little input and guidance from me, this activity has always led to excellent discussions on a variety of topics including the difference between average velocity and instantaneous velocity; the relationship between position, velocity, and time; and limits. It also provides a good reference as we more formally study these topics throughout the semester. In addition to introducing students to these concepts, the activity showcases a classroom environment similar to what occurs the rest of the semester, one in which students are mainly working with their peers, asking questions, and presenting solutions.

Paul N. Runnion Missouri S&T

The Challenges - and Successes - of Remediation in Calculus

Calculus students at Missouri University of Science and Technology arrive in Calculus I having officially met the prerequisite either by transcripted credit or by placement exam, yet they often lack the necessary foundational knowledge - and life skills - to succeed in Calculus I. These students frequently find themselves in a situation where, by midterm, they are almost guaranteed not to pass Calculus I. The Success for Calculus program was designed to provide these students with an opportunity to strengthen their foundational knowledge (and the calculus they've already seen). Students successfully completing this program are showing promising results in future mathematics and other STEM coursework. Information about Success for Calculus and data about its impact on student performance will be presented.

Michelle L. Isenhour Naval Postgraduate School

Collaborative Calculation (CoCalc) in the Classroom

Are you interested in introducing code to the mathematics classroom? In this talk, we discuss the use of the online collaborative calculation tool, CoCalc (https://cocalc.com), in a Python-based statistics classroom. CoCalc, formerly known as SageMathCloud, is a web-based cloud computing platform created by William Stein, a professor of mathematics at the University of Washington. CoCalc, offering both free and paid accounts, is a great option for those who seek to implement coding for only a small segment of a course, perhaps a laboratory exercise or a quick conceptual demonstration. It is also a must-have for those looking to create a computationally-based mathematics course. This session will discuss: 1) How the use of CoCalc eliminated the need to install computing software on individual student computers; 2) Lessons learned in the design and implementation of a CoCalc-based course, everything from designing student handouts and in-class practical exercises to computational-based assessments; 3) Examples of student handouts, in-class exercises, and assessments; and 4) Student performance and feedback on using CoCalc for collaborative coding projects.The use of CoCalc enhances the student's mathematical abilities, confidence in reading and writing code, and exposes the student to cloud-based computing resources that are always available.

Tevian Dray Oregon State University
David Roundy Oregon State University
Aaron Wangberg Winona State University

Interacting with Partial Derivatives

The toolbox of algebraic manipulations that students traditionally learn to use in multivariable calculus is not a good match for the geometric combinations of partial derivatives in electromagnetism (e.g. gradient) or the measurable combinations in thermodynamics (e.g. heat capacity). These applications require students to have rich concept images of partial derivatives that go well beyond what is typically taught in a calculus. In this talk, we describe our efforts to help students master the use of partial derivatives in such physical and geometric contexts, in both mathematics and physics courses. In particular, we describe the development and implementation of innovative hands-on tools, such as the partial derivative machine and dry-erasable plastic surfaces. We also briefly describe our research to understand how students interact with these materials.

Enhance your Teaching through Best Practices that Align with the IP Guide

Part A: Thursday, August 1, 9:00–10:40 AM, Rooms 260, 261 & 262

Organizers: Carolyn A. Yackel Mercer University
Mindy Capaldi Valparaiso University

Speakers in this session share teaching innovations through a scholarly lens by pegging their work to specific evidence-based practices in the MAA Instructional Practices (IP) Guide. Each talk will clearly lay out both the pedagogical technique as well as how it pertains to at least one of the subsections of the IP Guide.

William Fenton Bellarmine University

Guided Explorations in College Geometry

Over many years, a colleague and I have developed a series of computer-based activities that guide students to explore topics in upper-level college geometry. Using either The Geometer's Sketchpad or GeoGebra, small groups of students investigate topics from synthetic, analytic, and transformational approaches. The students' observations and reflections on the activities serve as a foundation for class discussions. These activities have been successful at promoting active engagement with the course topics and have led to fruitful discussions during class. This talk will present the goals of the activities and some details of implementation. Example activities will be shared, plus impressions of the classroom environment that resulted.

Eric C. Johnson U.S. Coast Guard Academy

A Comparison of Homework vs. Exam Averages, or What Kind of Homework Assignments Work Best?

As both the overall number of cadets enrolled at the U.S. Coast Guard Academy and the number of Operations Research majors has increased over the past few years, the Department of Mathematics faculty's workload has grown. Without the ability to hire additional faculty we've had to reconsider how we teach many courses, including the possibility of going to a large lecture format for some service courses, and the use of online homework (issues addressed in subsections AP.6 and AP.6.1, respectively, of the MAA Instructional Practices Guide). For years I've told my students that the best way to prepare for exams is by doing the assigned homework. In this study I finally put my money where my mouth is, comparing over a decade's worth of my Differential Equations students' homework averages to their exam averages. I also looked at whether the type of assignments –daily written graded homework, daily online graded homework, or weekly graded quizzes based on daily suggested homework –made a difference.

Alan Von Herrmann University of Tennessee

Calculus III TEAM Activities: Success of Modified Peer Instruction

Peer instruction (Mazur, 1996) is a form of collaborative learning where students engage with core course concepts and then explain those concepts to one another in small group settings. Unlike the standard lecturing format, peer instruction involves every student in the class. During the Spring 2019 semester I used a modified peer instruction in three Calculus III classes. I started each class by discussing important Calculus III concepts from 3 standpoints (the formula, the geometry behind the formula, and the physics behind the formula). During the last 20 minutes of each 50-minute class session, I polled the students using peer instruction questions in the "Goldilocks Zone" - not too hard and not too easy, but just right for Calculus III students. As a result of this change to my instruction, attendance has improved, student achievement has improved, and students are better at problem solving. In this talk, I will share my library of questions and discuss the evidence of these improvements. Also, because this implementation of modified Peer Instruction has completely changed the way I plan for my classes, I will describe my design practices.

Yuanting Lu Department of Mathematics, Mercer University
Jeff Denny Department of Mathematics, Mercer University

Teaching Calculus with SageMath Widgets

Graphical visualizations of abstract calculus ideas both facilitate students' learning in the subject matter and pique students' interests in the course material. Using SageMath, an open-source mathematics package, we have designed a variety of class demonstrative widgets that include a graphical user interface (GUI) and educational materials which address topics from single variable calculus and multivariable calculus. These widgets and materials link to the Cross-cutting Themes (XT) of the MAA Instructional Practices Guide by supporting exploration and motivation of topics and fostering active engagement. We believe the dynamic features of the GUI widgets are more effective and engaging than static graphics in a text. Hands-on projects with SageMath guide students to a deeper understanding of the material.

Nora Strasser Friends University

Implementing Mastery Grading in Calculus 2

Students who take Calculus 2 tend to find it the most difficult of the Calculus sequence. Many students end up passing the course, but mastering very little of the content due to partial credit. It is not unusual for students to get a "C" without actually being able to solve any one problem correctly. This affects their ability to succeed in future courses and major in a STEM field. By implementing mastery grading in Calculus 2, I am hoping to counter many of these problems. First, students seem to demonstrate less anxiety because they know that they will be able to retake quizzes and tests should they not be able to demonstrate mastery. Second, students cannot survive on partial credit, but actually must master a topic in order to achieve a passing grade. Finally, students should learn the foundational skills more deeply allowing them to succeed more easily in future STEM courses. Initial results from Spring 2019 suggest that mastery grading has had a positive impact on student success and attitude. In this session, I will describe how mastery grading was implemented and the results from the first class.

Part B: Saturday, August 3, 9:00–11:50 AM, Room 232

Daniel Schultheis Smith College

Writing to Promote Understanding in a First College Math Course

Mathematical writing is often seen as a skill for advanced students as they transition to major-level courses. Instead, we propose that the development of mathematical writing in introductory courses such as precalculus and calculus promotes student communication, improves retention of concepts after the semester ends, and provides a crucial alternate way for students to demonstrate understanding beyond pure calculation. We will focus on how Smith College has redesigned introductory math courses to incorporate early mathematical writing.

Matt Boelkins Grand Valley State University

From Formative to Summative: Using a Proof Portfolio to Teach Proof-Writing

The IP Guide affirms that communication skills are essential for mathematics students and states that writing assignments can be used both to develop student writing skills and to assess student learning outcomes. In this talk I'll share how my colleagues and I use a portfolio of 10 proofs in our bridge course, *Communicating in Mathematics*, as a way to both formatively develop students' writing skills and to summatively assess their understanding of key mathematical ideas and conventions of mathematical communication. Students work independently from one another, but with substantial support from the instructor, to prove or disprove 10 different conjectures over the semester. Writing their results in LaTeX, students engage in a process that involves multiple drafts through which they get low-stakes feedback on their early work and build on these developmental efforts to ultimately create a final portfolio that aligns with standard conventions for mathematical proof. Beyond samples of student work and logistics of the project, I'll discuss building supportive relationships with students, explain how using an electronic submission and review process facilitates better and more timely feedback, and reflect on how to leverage the formative and summative aspects of the assessment to help students achieve success.

Abigail Higgins Sacramento State University

An Interactive, Digital, Annotation Platform as a Mechanism for Out-of-Class Engagement, Community-Building, and Peer Instruction

Student engagement is a major theme of the *MAA Instructional Practices Guide.* While many approaches for encouraging student engagement *during* class time are included in the guide, there are fewer recommendations for facilitating *out-of-class* engagement. This session will share how reading assignments, delivered via the interactive, digital, annotation platform *Perusall*, strengthened classroom community, facilitated peer instruction, and provided structure for out-of-class engagement in Calculus II. In interactive comment threads, students shared their understandings and questions related to topics in the course. This facilitated peer instruction outside the classroom. I, as the instructor, also participated in the comment threads by responding to student comments and questions. Students completed these assignments the night before the topic was discussed in class. This allowed me to see how students were understanding the content *before* class. While there were a variety of active-learning strategies employed during class time, not all students are comfortable actively engaging in the physical classroom space. These assignments provided an out-of-class modality through which students could engage in the material with their classmates. This shared out-of-class experience deepened classroom community, offered another space for peer instruction, and provided structure for student engagement outside of class.

Andrew George Penn State Erie

Building Social, Teaching, and Cognitive Presence in the Face-to-face Classroom: Practices Borrowed from Online Instruction that Align with the MAA IP Guide

During my six-year adventure in designing and teaching a sequence of online courses, I became keenly aware of the three pillars of the Community of Inquiry framework of online learning: social presence, teaching presence, and cognitive presence (Garrison, Anderson, Archer, 2000). In this talk I will share practices I have borrowed from online instruction to strengthen teaching, learning, and presence in my face-to-face classes. These strategies include: 1) the use of online self-intro components to build social and teaching presence in the classroom; 2) the use of online "lab" activities to strengthen cognitive, teaching, and social presence in the classroom; 3) the use of narrated videos outside of

class to support cognitive and teaching presence; and 4) the use of writing to assess and sharpen students' understanding. I will also identify how each of these practices aligns with the MAA Instructional Practices (IP) Guide—including CP.1.1: Building a classroom community; CP.2.6: Communication; CP.2.9 and AP.5: Conceptual understanding; XT.4: Technology incorporated into instructional practice; and AP.4: Assessments that promote student communication.

Bobby W. Ramsey The Ohio State University

Active Learning in Large Lecture Courses

In partnership with the Student Engagement in Mathematics through and Institutional Network for Active Learning (SEMINAL) grant, The Ohio State University's math department is committed to active learning in our courses. However, our resources do not allow the smaller class sizes typically advocated in the literature. The Instructional Practices Guide gives some student engagement and assessment techniques that are applicable to our large class sizes. In this talk we discuss some of these techniques and how we have adapted them to fit our constraints.

Lew Ludwig Denison University

Fostering Student Engagement

As the IP Guide confirms, student engagement is a critical part of a successful learning experience for students. In this presentation we will consider several techniques that foster student engagement including first day activities as well as semester-long practices that help build a strong classroom community. We will include findings from a study conducted that support these claims.

Zoë Misiewicz SUNY Oneonta and SUNY Oswego

Developing Persistence and Growth Mindset through Formative Assessment

The MAA Instructional Practices Guide begins with a manifesto, calling on mathematics educators to "advocate for increased student access to the discipline of mathematics" . This presentation links the ideas of the Instructional Practices Guide to one crucial lower-level course: Precalculus, which can serve either as a barrier or as an invitation to further mathematical study. I discuss how my Precalculus course as a whole is built around the idea of formative assessment (section AP.2 in the Instructional Practices Guide) and how this contributes to the development of growth mindset and persistence in problem-solving (CP1.7 in the Instructional Practices Guide). My specific implementation includes an active-learning classroom environment where students regularly present solutions on the board and are celebrated even when those solutions are incorrect. The focus on growth is reflected in the grading scheme, which incorporates test corrections and mastery-based homework. In keeping with my overall student-centered approach, student comments are quoted extensively as evidence for the impact of these practices.

Ryan Therkelsen University of Cincinnati
Noel DeJarnette University of Cincinnati

Maintaining Instructional Best Practices in a Multi-Section Coordinated Course Environment

Instructors teaching in a coordinated environment – in particular, with uniform assessments across all sections – can often feel constrained in their control over Assessment, Design, and Classroom Practices. In this talk we will show how Classroom Practices from the Instructional Guide can still be implemented in such an environment as well as discuss how to advocate for and sell important Assessment and Design Practices to your course coordination team. Our focus will be on creating and defending independence while advocating for broad scale change.

Steven Schlicker Grand Valley State University
Feryal Alayont Grand Valley State University

Teaching Linear Algebra with an Inquiry-Based Textbook and Applications

In this talk we will describe how teaching linear algebra using a textbook with guided-discovery activities and applications aligns with practices from the MAA Instructional Practices Guide. We authored an open-source textbook to specifically satisfy certain main principles: students must actively engage in their learning through pre-class and in-class work; important concepts and principles of the course can be discovered through guided questions; and applications help motivate students and provide another anchor for the abstract concepts of the course. We will provide examples of activities and applications from the book along with how these examples align with instructional practices in the IP Guide.

Ethics in the Mathematics Classroom

Part A: Thursday, August 1, 1:30–4:10 PM, Rooms 260, 261 & 262

Organizers: Victor Piercey Ferris State University
Catherine A. Buell Fitchburg State University

The mathematical sciences have a central role to address the use and misuse of mathematics and data that fueling a global ethics crisis. This session aims to describe the integration of ethics into the mathematics classroom and ethical issues surrounding the teaching of mathematics. Talks cover how ethics are addressed, and reflect upon the successes and challenges to implementation.

Catherine A. Buell Fitchburg State University
Victor Piercey Ferris State University

Ethics in Mathematics: An Existence Theorem

Some think mathematics is "value-free" and as such, see no need for ethics for mathematicians. Recent scandals at organizations that employ mathematicians such as the National Security Agency and Cambridge Analytica suggest otherwise. Describing an ethics for mathematicians intersects with other conversations the community is having concerning social justice and equity. These conversations are happening both within the mathematical community and between mathematicians and professionals in other disciplines. We will discuss the need for ethics in mathematics (in the profession and the classroom), share updates concerning where work on this problem is being done, and raise questions that can frame future conversations.

Dawn Nelson Saint Peter's University

Ethics and Responsibility in STEM

Q: Can a mathematics professor teach an ethics course? A: Of course! In this talk I will describe the challenges and rewards I encountered while designing and teaching the class "Ethics and Responsibility in STEM". Intended for any STEM major, the course focuses on ethical issues that arise from the fact that math and science are practiced in a social context. Units address research methodology, peer review, and publication; collaboration, competition, and intellectual property; institutional responsibility and whistle blowing; conflicts of interest; human subjects; and diversity in STEM. Each ethical issue is discussed in the context of an historical case study such as the discoveries of cold fusion and HIV, the Challenger disaster, the Stanford prison experiment, and the Algebra Project.

Andrew Windle Rockhurst University

Ethical Perspectives Through Game Theory

Game theory provides mathematicians with a lens through which we can study cooperative and competitive interactions. As a result, the analysis of a game leads to a natural ethical question - is playing a game optimally always in line with playing a game ethically? In this talk, we will discuss how having students play games with each other in class can provide different ethical perspectives on a scenario. In particular, we will discuss course activities from a course in game theory that shine light on ethical issues such as fighting pollution and climate change. Finally, we'll discuss how unethical behavior can be adjusted by changing the game.

Adam Giambrone Elmira College

Using Fairness as a Theme in General Education Mathematics Courses

Like all fields, mathematics is taught and created within a sociopolitical context. Like all educators, our goal is to create informed citizens who think ethically and rationally. Therefore, we as mathematics educators have a responsibility to push ourselves and our students to discuss and reflect on how mathematics can and should be used to engage with important sociopolitical issues in our world. In this talk, we will discuss ongoing work to use the theme of fairness and the topics of voting theory, fair division theory, and gerrymandering to incorporate such discussions and reflections into general education mathematics courses.

Stacy L. Hoehn Franklin College

Ethical Considerations in a Data-Driven World

Today's students are entering a world of big data, the likes of which we have not seen before. Understanding the ethical ramifications of using big data to make decisions that impact people's lives is an issue that students will grapple with both privately and professionally throughout their lives. Thus it is crucial for everyone, mathematicians and non-mathematicians alike, to understand big data's uses as well as its limitations. In this talk, I will describe a contemporary issues course called "Ethical Considerations in the Era of Big Data" that I taught at Franklin College to students from a wide array of majors. This course looked at the big data revolution from several different perspectives and included candid conversations with professionals who use data to make decisions in their jobs at Facebook, in political campaigns, and in college admissions. Portions of this class have been adapted for use as mini lessons in other courses, including general statistics and an upper-level big data course.

Patrice Tiffany Manhattan College

Ethics in Mathematics Curricula from the Beginning

I developed 5 mathematics courses that are designed for pre-service elementary school mathematics teachers. Ethics in the mathematics classroom should be evident throughout the elementary and high school curriculum. The courses that I teach are not education courses but mathematics courses. Their content is dictated by the curriculum content of grades 1–8. The way that these topics are taught is dictated by the belief that elementary school teachers must integrate ethics into the mathematics classroom. How can this be done? First from the perspective of ethics in data collection, representation and interpretation and second from the perspective that elementary school teachers are only ethical in their teaching if they show every student that mathematics is accessible, logical, coherent and useful. I am speaking here not of different modes of pedagogy but of different ways of presenting a mathematical topics so as to expose the reasoning behind the algorithms they teach. If a teacher employs a modeling first approach, the students see the usefulness of the mathematics. Prospective teachers should learn mathematics from different perspectives and become more comfortable with numbers. Then when they are in their own classrooms they will be able to teach mathematics as a logical, coherent system. If we have elementary teachers who only teach algorithms and not the logic behind the algorithms then it is too late. Their future students will not have the confidence to question interpretations of data or to question an argument that is fraught with mathematical inconsistencies. This seed of confidence must be planted in their early days not in their college years. Preparing future teachers well is our ethical responsibility.

Erin Griesenauer Eckerd College

Reflective Service Learning as a Means to Teach Ethics

Unequal access to quality education is an issue that has huge consequences for individuals and communities across the United States. However, many of our students are unaware of the differences that exist in access to education. To help address these problems, I added a service learning component to my Calculus II classes. My students volunteered as tutors at some of the local schools with the highest need. In class, we discussed their experiences and observations, and at the end of the semester each student wrote a reflective essay. Our discussions focused on the ethics of what they saw as they volunteered—the conditions the students faced, the differences between their own experiences and the experiences of the students they were helping, the possible consequences, and our responsibility to the students and schools in our community. In my talk, I will reflect on student responses to these ethical questions and make suggestions for implementing service learning in other classes.

History of Mathematics in a Math Circle

Part A: Thursday, August 1, 9:00–10:40 AM, Rooms 237 & 238

Organizers: Amy Shell-Gellasch Eastern Michigan University
Philip B. Yasskin Texas A&M University

During this session, presenters will share mathematical topics and problems of a historical nature for use in a math circle. This can include such ideas as, but not limited to, working a class of problems using historical methods, discovering methods of calculation from a former time or culture, discovering how mathematical concepts were discovered or used historically or culturally.

Seongchun Kwon University of Central Florida

Cryptography

Cryptography has a rich history. It is also widely used in modern society. One of the most well-known ciphers in history is Caesar cipher. The presentation is based on the activity provided to grade 7 and 8 students in the Central Florida Math circle. This topic gave enough challenge and fun to those group of students.

Jie Liu Dixie State University
Clare Banks Dixie State University
Vinodh Kumar Chellamuthu Dixie State University

Red Rock Math Circle (R^2MC)

During 2018-2019 school year, the mathematics department of Dixie State University (DSU) initiated the very first Math Circle in Southern Utah. We are the recipients of 2018 Dolciani mathematics Enrichment Grant. The goal of this program is to encourage students' curiosity and enthusiasm about math through problem solving and interactive exploration; to provide opportunities for students to explore how math is used in real-work settings; and to increase community awareness of the importance of math while building a math community for young students. Our Math Circle is also part of the DSU STEM pipeline program serving the surrounding community. Math Circle students, DSU students, DSU faculty and staff, and community members, hand in hand formed a great circle of learning. In our presentation, we will share our experiences and the results of our Red Rock Math Circle (R^2MC).

Viktor Blasjo Utrecht University

Geometry machines in Greek antiquity

Greek geometry is for doers. It involved numerous mechanical contraptions for tracing curves and constructing geometrical objects. It is not for nothing that Apollonius, whose elaborate treatise on conic sections is a paragon of pure mathematics, is called "the carpenter and geometer" on the title page of one ancient manuscript. I discuss what motivated the Greeks to favor such a hands-on mode of geometrical research, and how we can utilize this for active learning and reflection today. I use historical illustrations such as the duplication of the cube attributed to Archytas, which ostensibly involves the intersection of three surfaces (a cylinder, a torus, and a cone), but which I argue was in fact intended to be executed by a machine.

Amy Shell-Gellasch Eastern Michigan University

Multiplication with Ancient Chinese Rod Numerals

In this talk we will introduce the Chinese rod numerals and how to preform multiplication using them. The Chinese rod numerals date back at least two thousand years. The oldest examples of bone rods are dated to about the second century BCE. The rod numerals are of interest for the clever way that place value is depicted using rod orientation. Multiplication was performed by physically manipulating the placement of rods on a place-value counting board. The beauty of this system is the physical movement of rods to show carrying and place value of each partial sum. Students can learn this system from scratch in a short time and can make rods out of simple items such as popsicle sticks. This activity combines review of place-value, an introduction to a new cultural approach to multiplication, and the kinetic reinforcement of prior knowledge of the western method of multiplication by regrouping.

Felicia Tabing University of Southern California

Drafting Japanese Crest Designs in a Math Circle activity for High School Teachers

Japanese family crests, called mon, are black and white, usually circular emblems associated with a Japanese family as means of identification. These designs can be very old, and have been historically used in battle to ease identification. There are thousands of different designs and variations of mon that commonly feature objects from nature, such as flowers or leaves, and geometric shapes. In their simplicity, mon designs feature a variety of symmetries, and include an example of most n-fold symmetries for n less than 20. There is an apparent connection between mon designs and the Japanese geometry problems that developed during the Edo period. In particular, an interesting problem is how to construct mon using a compass and straightedge, as mon designers are known to utilize those tools in drafting mon. I will describe the activity I facilitated for a math circle for high school math teachers, which connects mathematics with Japanese art, history, and culture. The goal of the activity was to try to draft mon, in increasing difficulty of the design, using only their knowledge of geometry, and a compass and ruler.

Part B: Thursday, August 1, 1:30–3:25 PM, Rooms 237 & 238

Andy Martin Kentucky State University

The Frobenius Stamped Coin McNugget

Given two relatively prime positive integers p and q, what is the largest integer which cannot be written as $mp + nq$, where m and n are integers? This problemis credited to Frobenius, who did not publish it, and not to Sylvester, who did.As a recreational problem it was often couched in terms of stamps or coins, but a modern formulation counts servings of Chicken McNuggets. This talk will discuss the problem, its history, and its solution.

Chris Bolognese Columbus Academy
Raj Shah Math Plus Academy

Problem Posing with Dice Probability in Mathematics Teacher Circles

Abstract Title: Problem Posing with Dice Probability in Mathematics Teacher Circles Abstract: In 1654, de Méré posed a problem that laid the foundation for modern probability theory. Which has greater probability? Rolling at least one six in 4 rolls or rolling at least one double-six in 24 rolls of 2 dice? Not only did this problem stump de Méré, but probability can be a challenging topic for many teachers (Batnero, Godino, & Roa, 2004). In our own Circle, many teachers express a lack of confidence in probability so such a topic is apt for exploration. Probability can be related to other K - 16 topics such as polynomial algebra and combinatorics. Given this connectedness, problems involving dice, both historical and modern, can serve as a springboard to create one's own problems through problem posing. We will share some historical probabilistic problems, including de Méré's, rich for exploration then share a Circle session where participants explore a simple dice game called Tenzi. Each player starts with 10 fair six-sided dice. All the players roll at the same time and continue to re-roll until all 10 dice show the same value. Various strategies are considered during this play time. After playing this game, participants generate their own mathematical questions for further exploration. In particular, our participants analyze the expected number of rolls to get Tenzi using *n* dice and also the probability of the worst starting roll. These questions and their work will be shared as well as their takeaways relative to the teaching and learning K - 16 mathematics. References: Batanero, C., Godino, J. D., & Roa, R. (2004). Training teachers to teach probability. *Journal of statistics Education*, *12*(1).

Skona Brittain SB Family School

Many Worlds History of Map Coloring

Map Coloring is my favorite math circle topic, as well as the one about which I include the most history. My presentation of it involves a story about a king and queen who kept having more children and increasingly difficult problems dividing their land. While the students do not *need* a story to be engaged, it enhances it for them. The characters' names parallel those of historical figures; then when I present the real history, they're already familiar with the names. Exposure to mathematical history gives students a sense of how idea generation, incremental progress, error correction, and cross-disciplinary germination take place. And I have seen it fostering students' images of themselves as future mathematicians. The more recent history of Martin Gardner, whom I want students to know about, also gets introduced, because of his 1975 counterexample joke. Due to the emotional investment from storytelling, particularly for my younger students, the fantasy has a happy ending, one that leads to further topological exploration.

Emilie Hancock Central Washington University
Brandy S. Wiegers Central Washington University

Journal of Math Circles (JMC)

In the last decade, we have seen the rapid growth of Math Circles, and with it increased participation by mathematicians in scholarly thought and action around Math Circles. We believe this work necessitates more explicit professional recognition. To meet that need, we have created Journal of Math Circles (JMC). Through a double-blind peer review process, JMC offers high-quality, practitioner-focused resources for Math Circle leaders through the dissemination of local knowledge to the broader mathematical community. Articles are authored by and for mathematicians and mathematics educators who organize a wide range of community-responsive Math Circle programs for K-12 students and teachers across the country. JMC solicits original submissions capturing best practices for building and sustaining Math Circle communities that promote enthusiasm for mathematics and foster the habits of mind of mathematical thinkers and problem solvers. In this talk, we will motivate and introduce Journal of Math Circles, an open-access journal which publishes three types of articles that provide thorough, evidence-based reflection: lesson plans, outreach programs, and professional development. Our discussion will be supported with excerpts from our inaugural volume which captures the intersection of Math Circles and the work of the Global Math Project. Finally, we will provide an overview of how practitioners can write for JMC, including a discussion of our current and future efforts to support a diverse group of JMC authors in contributing to the journal. Learn more at https://digitalcommons.cwu.edu/mathcirclesjournal/

Robert Sachs George Mason University

Math Circles based on Newton's mathematics

This talk will describe several successful math circles centered on topics related to Newton's work. This includes: Newton's method for solving polynomial equations by iteration (avoiding harder cases which use derivatives); Newton polynomial interpolation; Newton's method for finding expansions of inverse functions. These are accessible without knowing calculus and have some playful "hooks". In some sessions, I have not mentioned Newton's name until the students have made progress, in which case there is a huge satisfaction in rediscovering something done by Newton.

Cymra Haskell University of Southern California

Exploring Infinitesimals in a Math Teachers Circle

Calculus was originally developed in the late 17th century using the concept of infinitesimals; numbers that are greater than 0 but smaller than every positive real number. Although there was no rigorous proof that such numbers existed, for the next 200 years people used their intuition to manipulate these numbers and develop the theory of calculus. In the middle of the 19th century Weierstrass made calculus rigorous with his development of the epsilon-delta definition of a limit. With this approach there was no need for infinitesimals and the use of these numbers, whose existence was questionable, fell by the wayside. However, having been used for 200 years, it can be argued that infinitesimals may be a more intuitive approach to calculus and, if adopted, might make calculus accessible to a wider group of people. One hundred years after Weierstrass, In the middle of the 20th century, the existence of infinitesimals was established rigorously by Robinson, so we can now rest assured that the intuitive calculations people did for 200 years are, indeed, rigorous. However, it is hard to turn around 100 years of established ritual, so the limit approach to calculus is still the default used across the world. In this session, we describe a math teachers circle activity in which we introduce K-12 teachers to infinitesimals and the hyperreal numbers. The teachers were thrilled to learn about these numbers and comfortable manipulating them intuitively. It also gave them an opportunity to explore real numbers and the relationship between mathematics and the physical world.

Inquiry-Based Learning and Teaching

Part A: Thursday, August 1, 9:00–10:40 AM, Rooms 230 & 231

Organizers: Victor Piercey Ferris State University
Susan Crook Loras College
Brian Katz Augustana College
Eric Kahn Bloomsburg University
Amy Ksir United States Naval Academy

Inquiry-based learning (IBL) transforms students from consumers to producers of mathematics. IBL methods aim to develop a deep understanding of mathematical concepts and processes by putting students in direct contact with mathematical phenomena, questions, and communities. This session invites scholarly presentations on the use and effects of IBL methods for teaching and learning.

Min-Lin Lo California State University, San Bernardino

Mission: Possible - A whole class REU project?!

One of the High-Impact Practices (HIPs) promoted by the Association of American Colleges & Universities is "Undergraduate Research" , a HIP that provides an opportunity for a student to work with a faculty member on a research project. However, this valuable opportunity is often available to only a very few students due to funding limits. With the support of my university and department, I designed a format for an introduction to proofs course that provided such valuable research experiences to all students enrolled in my course, experiences that not only enhanced student learning, but also promoted equity, diversity, and inclusion by providing research experiences to a broader range of undergraduate students including those those that have jobs, family obligations or academic records that may impede participation in REU programs. In this talk, I will share with the audience the class format and materials used that allowed students to gain research experience as undergraduates. Students had the opportunity to learn concepts and prove theorems like mathematicians do: read papers/books to understand definitions and learn other people's approaches for solving problems, use examples to look for patterns, form conjectures for general cases, and try to prove or disprove their conjectures. Students were also required to learn the communication skills needed as a researcher through in class presentations, writing research papers, and participating in class poster presentations. I will also share the result of implementing such a class structure and lessons learned. Come join me to re-live my fun journey of engaging in a whole class REU project!

Audrey Malagon Virginia Wesleyan University

Proof Bridges

Many years ago, a professor taught me to think of proofs as a bridge connecting what we know to what we'd like to know. After teaching our introduction to proofs course for many years now, I've built on this idea and developed inquiry-based classroom activities to help students build connections and write proofs using "proof bridges." In this talk, I'll share the activities I've designed for class discussions, small group work, and assessment, and discuss the pedagogical ideas and learning gains associated with them.

Kayla B. Dwelle Ouachita Baptist University

Fundamentals of Teaching Fundamentals of Mathematical Proof

Despite the differences in our institutions, for many of us, teaching an introductory proofs course involves some common purposes. 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. For this reason, Proofs was the first course that I mindfully created to be entirely inquiry-based and I had many failures and challenges to work through before I found 'my stride' and I discovered the proper ways to assess that I was meeting these fundamental objectives. This talk will relay some of the challenges that had to be overcome, how they were overcome, and what components of the course have consistently been successful. Additionally, I will discuss some pre-test and post-test data I have been collecting for a few years and their efficacy in predicting success in future courses requiring Proofs.

Mike Janssen Dordt University
Melissa Lindsey Dordt University

Writing and Implementing a Set of Rings-First IBL Course Notes

We recently resequenced our abstract algebra course to use a rings-first approach. Our primary motivation for this change was to better serve our secondary education majors who are only required to take the first course in abstract algebra. Given the documented benefits of inquiry-based learning, we set out to write a set of rings-first IBL course notes, the goal of which is to explore the idea of factorization from an abstract perspective. We start with factorization in the integers, and then factorization properties of polynomials, with a larger goal of precisely describing deep structural properties common to both the integers and polynomials that guarantee that unique factorization. In this talk we will give an overview of the content of the notes, how the course was run during the Fall 2018 semester, and what improvements we have planned for the next iteration of the course.

John Asplund Dalton State College

Computational IBL in Number Theory

When conducting academic research in mathematics, there is no guarantee that we will be able to get the result we originally intended to prove. However, the exhilaration when we finally see the full picture or prove a major result is difficult to describe. It is even more difficult to recreate that feeling within our students in a repeatable manner. To give my students a glimpse into the world of academic research, my number theory class has been constructed so that students can use technology to address questions, form conjectures, and subsequently prove those conjectures...maybe. Come find out how I was able to use computational tools in an IBL setting for a number theory course!

Part B: Thursday, August 1, 1:30–3:30 PM, Rooms 230 & 231

Jacci White Saint Leo University
Monika Kiss Saint Leo University

It Takes a Village to Learn Mathematics

One concern faculty face is the time to allow students to "discover" new concepts in class. In our Trigonometry class, we have an activity to inspire students to appreciate the importance of vectors in real life. We have implemented this activity in a group setting in class. To save time, we are planning to utilize our IBL activity outside of class using our learning resource center and mathematics tutors. The students are required to complete the activity in a small group, then have it reviewed by the tutor assigned to this activity. Probing questions are provided to the tutor, along with a project grading outline. Data regarding responses is then provided to the instructor to follow up in class on consistent mistakes or misconceptions. The activity, grading outline, probing questions, and assessment results will be detailed in this session.

Megan Wawro Virginia Tech

Using Videos, Reflections, and Portfolios to Promote Inquiry

The goal of the Inquiry-Oriented Linear Algebra (IOLA) curricular materials is to promote a research-based, student-centered approach to the teaching and learning of introductory linear algebra. IOLA's curricular materials build from a set of experientially real tasks that allow for active student engagement in the guided reinvention of key mathematical ideas. In this presentation, I will discuss three different types of activities that can be used to complement the IOLA tasks: student-generated video presentations, end-of-class reflection questions, and pre-exam portfolios. I will share examples of student work and discuss ways in which various IOLA instructors have integrated the activities into their courses in ways that facilitate student inquiry.

Diana Underwood Purdue Northwest

A Guided Reinvention Approach to Beginning Algebra

An inquiry approach to mathematics teaching requires an instructor to develop an expertise in initiating and guiding classroom norms and socio mathematical norms that support mathematical argumentation and justification. However, without carefully designed instructional materials that support mathematical inquiry while supporting students' acculturation into the mathematical practices of the mathematical community, inquiry approaches are vulnerable to justifiable criticism. Instruction designed using Realistic Mathematics Education (RME) instructional design theory provides a useful framework for addressing this need. (Gravemeijer, 2004) The purpose of this session is to describe the heuristics of RME instructional design theory and the planning and teaching practices of the Guided Reinvention teacher. (Author, 2014) To accomplish this, the author will share a RME designed sequence for linear equations used in a course for preservice teachers. The sequence is also used with middle school students. The presentation will also share pedagogical actions for teachers for facilitating productive classroom discourse.

Heidi Andersen University of Dallas

Euclidean and Non-Euclidean Geometries: Using Group-Work and IBL Methods in a Textbook-Free Approach to Teaching Non-Math Majors Logic and The Basics of Proof-Based Mathematics

The University of Dallas in Irving, Texas, requires all of its liberal arts students to embark upon a Core Curriculum, which consists of special courses in history, philosophy, theology, mathematics, fine arts, etc. The math department has created the course "Euclidean and Non-Euclidean Geometries" especially for non-science majors, and all who teach this course aim to familiarize their students with the basic logic and methods of proof that mathematicians use. Central to the course is a "Neutral Geometry" conjecture sequence similar to, but different than, Euclid's classic theorem sequence. Students must puzzle out the truth, or lack thereof, of each conjecture and either rigorously prove this conjecture or provide a counterexample to it. Currently, I and two other instructors teach this course every semester, in which we employ varying amounts of group-work, lecture, use of manipulatives, and other student-centered IBL methods. In this talk, I will discuss pedagogical issues that have arisen in the last four semesters, and describe activities and tools I have used to address these issues.

Grace McClurkin Saginaw Valley State University

Hands-on Activities for a Liberal Arts Math Course

I will describe the design and implementation of several activities that were implemented in a liberal arts math class at Saginaw Valley State University during Fall 2018. These hands-on activities cover topics such as algorithms, platonic solids, dimensionality, and mobius strips. The goal of these activities is to allow students to tangibly engage with the objects we're discussing to explore definitions and find patterns.

Gregory D. Foley Ohio University
Stephen N. Shadik Ohio University
Deependra Budhathoki Ohio University

Quantitative Reasoning via Inquiry

In Fall 2018, Ohio University began offering a freshman-level course in Quantitative Reasoning. The initial instructors at the Athens campus have followed an instructional approach that engages the students in the "twin pillars" of inquiry-based learning: "deep engagement with meaningful mathematics and collaborative processing of mathematical ideas" (Laursen et al., 2014, p. 413). This preliminary report will examine the student activities and student outcomes of the initial sections of Quantitative Reasoning offered at the Athens campus during 2018-2019.

Part C: Friday, August 2, 10:10 AM–12:10 PM, Rooms 230 & 231

Alex Rennet University of Toronto, Mississauga

Something for Everyone

Once or twice a year for the last four years I've run an upper-division course in Combinatorics and Graph Theory. Initially I had wanted to try to run the course with an adapted "modified Moore method" style which would focus on student presentations in class. However, various situational factors presented difficulties that pushed me in a different direction. These factors include the fact that typically a diverse group of around 90 students enroll in the course. They represent a range of different backgrounds and maturity, ability, and interest levels, from math minors to math "specialists", and sophomores to seniors. Over the years I've tried a number of different course designs, but have settled on a "flipped" structure with class time focused on collaborative student work on inquiry-oriented activities. My focus in this talk will be on successes and challenges with this course design, and on specific activities I designed to engage with as wide a group of students as possible.

Topaz Wiscons California State University, Sacramento
Abigail Higgins California State University, Sacramento
Sayonita Ghosh Hajra California State University, Sacramento

Supporting Instructors in the Transition to Inquiry Based Methods: A Preliminary Study on a Multi-Sectional Implementation in College Algebra

The efficacy of Inquiry-Based Learning (IBL) in mathematics education is supported by a large body of evidence (S. Laursen, Hassi, Kogan, Hunter, & Weston, 2011, Bruder & Prescott, 2013, S. L. Laursen, Hassi, Kogan, & Weston, 2014). But implementing research-based practices in one's own classroom is hard! This difficulty is one explanation for practitioners' slow uptake of research-based pedagogies (Hayward et al., 2016). In this session, we will share what we learned from supporting instructors in the transition to inquiry-based approaches. The instructors, who were all new to IBL, ranged from graduate students to tenure-track faculty and spanned 44 sections of two different College Algebra courses. Various support structures for these instructors were developed before the start of the academic year. These included weekly instructor meetings, prepared course materials, and a half-day IBL workshop training. Our Findings: Over the course of this implementation, we learned more about which support structures were productive for instructors, how and why these structures were helpful, and the areas in which our support structures can grow. These claims are supported by survey responses from instructors, survey responses from students in these courses, post-course interviews with instructors, and our own experiences. We are excited to share what we have learned in this session and look forward to hearing reflections from attendees.

Andrew-David Bjork Siena Heights University

Successes and Failures in an IBL Pre-Calculus Course

Over the last four years, I have taught pre-calculus using notes, activities and curriculum pieced together to encourage student-centered explorations of the subject matter of pre-calculus. The course has focused on understanding and using families of functions in preparation of the calculus sequence. In this talk I will share many of my struggles and frustrations, but also joys and successes, as I experimented and adjusted the content of the course over the years. Learning from failures is a staple of IBL pedagogy, so I hope my failures will be beneficial to all. The talk will feature many activities from the course, as well as a description of the current form of the course.

Timothy Boester University of Maine

Characterizing Failure: The Case of Pre-Calculus

The University of Maine has recently restructured its pre-calculus curriculum, using guided inquiry to help students learn about functions and their properties with an emphasis on covariation. While gain scores on the Pre-Calculus Assessment have improved, the large number of students who fail or withdraw from the course remains unchanged. To address this continuing problem, we conducted an analysis of who is not passing the course, in order to characterize why some students are not more successful. This talk will broadly outline the structure of the current pre-calculus course, highlight important findings from the student data from the past several semesters, and summarize our plans to address issues of placement and engagement.

Kelly Bubp Ohio University
Harman Aryal Ohio University
Deependra Budhathoki Ohio University
Otto Shaw Ohio University

Student Responses: Would You Take Another IBL Mathematics Course?

Students in an IBL Calculus I course completed a survey on their experience in the course. The course used the textbook Active Calculus by Matthew Boelkins, and students completed the textbook activities in small groups. The students engaged in group work during the majority of each class meeting. In the survey, students were asked if they would take another mathematics course structured the same way - doing daily group work supported by the instructor and learning assistants. We will discuss the results of this survey question, and the explanations students provided for their decisions. In particular, we will elaborate on the two major themes in students' responses - they appreciate learning in groups, and they learn best through lecture - and discuss the implications of these themes to designing IBL courses.

Mel Henriksen Wentworth Institute of Technology
Mami Wentworth Wentworth Institute of Technology

Specification Grading in an Inquiry-based Introductory Differential Equations Course

Intrigued by the promise of greater rigor and the hope of saving ourselves time, we introduced to our inquiry-based introductory differential equations course, specification grading, based, in part, on material described in Linda Nilson's *Specification Grading: Restoring Rigor, Motivating Students and Saving Faculty Time*. Defining six "fundamental concept" specifications and 25 general specifications, students were afforded four opportunities to pass an assessment on each of these specifications. Course grades were determined by the number of specifications passed and the results of the final exam. The multiple assessment opportunities allowed us to demand fully correct solutions as well as ask more probing questions than we would otherwise have been comfortable with, thus complementing our inquiry-based approach. We will describe in detail our implementation, show the effect on student performance, and recount student feedback to this approach, as well as discuss potential changes necessary to make this methodology sustainable.

Part D: Friday, August 2, 1:30–2:50 PM, Rooms 230 & 231

Mihai Nica University of Toronto

Adapting IBL Questions for Large Classrooms

Many existing IBL resources are written with a small classroom in mind. In larger classrooms, it can be more challenging to engage students individually and to encourage on-task student discussion between students. In this talk, I will present advice for fostering student engagement based on experiences in extremely large first year courses at the University of Toronto (multi-section courses of 200 students per section). In particular, I will talk about lessons learned in creating IBL problems that work well with classroom response systems on this scale but still foster deeper mathematical discussions. This talk is based on the combined experiences of several early career instructors who met regularly as part of a "community-of-practice" to share stories of what works and what doesn't.

V. Rani Satyam Virginia Commonwealth University

Engaged IBL Group Work: Vertical Non-Permanent Surfaces and Horizontal Movable Pieces

How do we promote groups working together on inquiry-oriented activities - specifically working together as a cohesive group? I report on my experiences as an instructor implementing Liljedahl (2015)'s idea of vertical non-permanent surfaces (i.e. whiteboards or chalkboards around the room) for group work. The advantage of a vertical surface is all members of the group can see the work and the non-permanency of a white/chalkboard allows for students to easily try things out, erase, and adjust their work. I report on group activities done via this method that worked - and also ones that did not work, analyzing probable reasons and features why. This points to the importance of thinking about what makes for a group worthy task. Because classrooms lined with enough white/chalkboards for the entire class are not always available (and I in fact had this problem), I also report on an activity where students sorted cut-out pieces of a proof in order (Barnes & Libertini, 2017) as an alternative, i.e. horizontal movable pieces. I end with a discussion about how as math educators we should be careful about how we set-up group work, so as to not inadvertently exclude students and thereby exacerbate bad experiences with mathematics; group work should be inclusive and an entry point to engaging mathematics for all.

Kerry O'Grady Johns Hopkins University

Motivators and Characteristics of Creative Mathematical Inquiry: Aesthetics, Affect, and Epistemology

This presentation contextualizes creative mathematical inquiry within models of the creative process generally and within models of the mathematical creative process more specifically to distill characteristics of inquiry behavior and to understand what motivates the initiation and ongoing pursuit of inquiry-based processes. Particular attention is paid to thinking in a mathematical symbol system, the role of aesthetics throughout the mathematical process, the role of intuition, and dispositions of openness, curiosity, an embrace of non-closure, and perseverance as inquiry evolves and unfolds. Employing a brief review of key literature, I illustrate how inquiry is a durational and iterative behavior in creative mathematical work, noting that it is an essential element of creative ideation, problem-posing, experimentation, and problem-solving. I then query what motivates and guides creative mathematical inquiry as a durational behavior, highlighting discussions of intuition, affect, and aesthetics within the process. I also note where descriptions of mathematical creative inquiry intersect with mathematical epistemology, as inquiry is intended to produce new mathematical knowledge. This presentation raises questions regarding how we create space for aesthetic and affective motivators of authentic mathematical inquiry within mathematics learning contexts and provides another lens through which to advocate for an address of mathematical aesthetics, intuition, and creative problem-posing in mathematics education.

Brian P. Katz Smith College

Building Student-Community Ownership of Proof Validation

In order for students to build their mathematical authority, they need to be able to decide for themselves if an argument is convincing and valid. I believe it is important to develop these proof validation skills as extensions of the argumentation skills that the students bring with them to our courses, especially in inquiry courses. In this session, I will describe an activity I use to help students develop a framework for thinking about proof validation. This activity, based on a paper using Toulmin Analysis by Weber & Alcock, engages key philosophical and sociological elements of proof; it has been a pivotal moment for student ownership of their arguments across both my high school and college teaching.

Math + X: Mathematics Courses, Curriculum, and Projects Serving Professional Disciplines

Part A: Thursday, August 1, 9:00–10:15 AM, Room 232

Organizers: Francisco Savina Charles A. Dana Center, University of Texas at Austin
Stuart Boersma Central Washington University

Mathematics departments have provided content supporting partner and professional disciplines for decades. For disciplines such as business and engineering, numerous resources support a contextualized curriculum. This session highlights curricular elements for professions, disciplines, and math pathways where supporting materials for contextualized student learning are lacking. Of particular interest are successful examples of nontraditional curricula that match students' future work environment.

Lindsay Good Pennsylvania College of Health Sciences
Daniel Ozimek Pennsylvania College of Health Sciences
Gayle Watson Pennsylvania College of Health Sciences
Anna Wendel Pennsylvania College of Health Sciences

Mathematics and Nursing: Narrowing the Classroom-Practice Gap with Authentic Dosage Activities

A recently launched national initiative and taskforce has placed attention on building partnerships between the mathematics and nursing communities in order to improve mathematics education for nurses. This session will describe the collaborative effort of mathematics and nursing faculty to narrow the gap between mathematics in the classroom and its application in nursing practice. Known as the Math in Clinical Practice Labs, faculty collaborated to create authentic, scenario-based activities for a variety of clinical situations, including those involving insulin, IV fluids, and weight-based dosage. In order to successfully complete the activities, students were required to work together to interpret medication orders, calculate dosage and rates of administration, and accurately prepare medications for safe administration. This session will also describe the lessons learned from implementing these authentic dosage activities, including the importance of collaboration for creating scenarios that tightly integrate mathematics and nursing concepts essential for safe practice.

Thomas J. Clark Dordt College

Innovative Pathways in STEM Teacher Preparation

Innovative teacher preparation programs for STEM education are essential for meeting the goal of ensuring that secondary school students receive instruction from a certified teacher. Teacher shortages are well-documented, especially in STEM areas, so the need is great to prepare a growing number of well-trained STEM teachers. However, the percentage of incoming college students who choose teaching is declining, compounding the problem. Here we examine the role that interdisciplinary STEM and mathematics programs can have to increase the number of certified teachers prepared to teach STEM classes from an interdisciplinary approach. We share ways of bringing more students into the teacher preparation program through new interdisciplinary joint majors that not only provide a solid mathematical foundation but also meet the needs of 21^{st} century STEM classrooms.

Katherine Radler Saint Louis University
Kimberly Druschel Saint Louis University
Michael May Saint Louis University
Sadita Salihovic Saint Louis University

In-context, Small Project Based Delivery of a Basic Statistics Course for Nursing, Physical Therapy and Allied Health Students

At St. Louis University, our basic consumer style statistics class STAT 1100 is mostly taken by Nursing, Physical Therapy and other Health Sciences majors. In the Fall of 2018, based on a pilot study and client discipline department input, we re-engineered the STAT 1100 course to better serve these disciplines. These changes took the form of partially flipping the course as well as including discipline specific projects so that the students can apply the statistics learned in the class to their future work. These projects encompass using Medicare data and having students use information from the consumer-oriented website hospital compare as well as article reports which are looking at statistics in articles from their future field of study to put the statistics in perspective. We have been collecting data on the effect of these projects on student performance, knowledge retention and perception of the class although full collection of data has not yet been completed. This presentation will cover the changes we made to the class during this redesign, as well as the effect of these changes on the student grades and retention from the data we have collected so far.

Benjamin C. Gaines Iona College

Data-Driven Design: A Course on Data Analysis for Entrepreneurs

This is a course that was created for Spring 2019 on the basics of data analysis and interpretation, in the context of real business data. The goals were helping students learn to manage and present data, analyze what it actually means, and discuss ways it can be used to improve and innovate as part of the design process. A major focus of the course was on how students could act as data translators, converting collected data into a form that could be presented and understood by others. While the course did not run as a full class, the author will speak about how it was designed, the parts that appealed to students, and the parts that may have intimidated them. We will also discuss possible changes for future iterations to try to increase student interest and enrollment.

Part B: Saturday, August 3, 9:00–11:20 AM, Rooms 260, 261 & 262

Hong P. Liu Embry-Riddle Aeronautical University
Keshav Acharya Embry-Riddle Aeronautical University

Matrix Algebra and Multivariate Calculus Modules to Prepare Students for Data Science Graduate Programs

Embry-Riddle Aeronautical University offers a Master of Science degree program in Data Science (MSDS) starting in fall 2019. The degree program includes five tracks that target the college graduates in both STEM majors and Non-STEM majors. Linear Algebra and Multivariate Differential Calculus are the prerequisites of the core courses. We may expect the students in STEM majors to have these courses. For the students in Non-STEM majors, nevertheless, we only expect them to have a good stand for College Algebra and Single Variable Calculus. In this presentation, we will share the two online modules, one in Matrix Algebra, and the other in Multivariate Differential Calculus to remedy the math deficiencies of these Non-STEM college graduates. Each module has 12 lessons that are equivalent to one credit hours for college students. The three challenges are: (1) There is minimal time for reinforcing learning of hard concepts and drilling the necessary skills. (2) The learning must be customizable to fit the different student math preparation. (3) The schedule must be flexible for students to choose in either the summer or the first fall semester. The innovation of the curriculum design and course development are: (1) integrating of Learning Objectives, Learning Activities, and Learning Assessments; (2) motivate students to engage learning by using relevant applications and query-based pedagogy, and (3) using multimedia course materials, blog discussion, and online quizzes to promote collaborative peer learning and immediate feedback. The Matrix Algebra module posted is posted at https://modelsim.wordpress.com/modules/matrix-algebra/. The Multivariate Calculus will be completed in summer 2019.

Alade O. Tokuta NC Central University
RN Uma NC Central University
Gaolin Z. Milledge NC Central University
Xinyu Huang NC Central University

Math+CEMA: Computational and Engineering Mathematics Concentration for Mathematics Majors at NC Central University

We developed a new *Computational and Engineering Mathematics (CEMA)* concentration for our Mathematics majors with special emphasis on the following themes: *Computational Science*, *Software Engineering*, *Data Science, Computer Engineering,* and *Electrical Engineering*. The *CEMA Concentration* provides a solid, interdisciplinary foundation for students interested in academic and industrial careers in engineering and the sciences. This concentration offers students an opportunity to study pure and applied mathematics as essential components of modern engineering. The course and laboratory development in the project infuse engineering principles and design in the curriculum with special emphasis on problem solving and developing communication and team working skills. Engineering design in the curriculum targets new focus areas such as software engineering, data science, computational science, computer engineering, and electrical engineering. Computer Engineering and Electrical Engineering are offered as a 3+2 degree program jointly with NC State University. With a requirement of a capstone design project for this concentration, the engineering skills of the students will be enhanced and strengthened. The CEMA concentration provides a wider range of career options for the students; increases the number of STEM graduates continuing graduate study in a STEM or related field; enhances the Undergraduate Research Program, providing hands-on experience in STEM including opportunities in scientific projects that integrate research into programs and activities of national interest. (Acknowledgement: NSF HRD-1533653)

Victor I. Piercey Ferris State University
Rhonda Bishop Ferris State University (Nursing)
Mischelle Stone Ferris State University (Social Work)

A Faculty Learning Community to Support Mathematics for Students in Nursing, Social Work, and Business

At Ferris State University, the Mathematics Department has partnered with the School of Nursing, Department of Social Work, and College of Business to deliver a hybrid quantitative reasoning/algebra math pathway for students in professional programs. A centerpiece of our partnership has been a faculty learning community. In the faculty learning community, interdisciplinary teams wrote scenario-based case studies and course materials. The case studies and materials were designed to be introduced to students in the mathematics classes and extended in classes in the partner discipline programs. In this talk, we will share both the design and results of this work.

Magdalena Luca MCPHS University

Math for the Health Sciences

MCPHS University students are enrolled in a variety of health sciences programs, from pharmacy and public health to dental hygiene, nursing, and health humanities. In the last few years, new courses were designed and significant curriculum changes were successfully implemented in our programs in order to address students' motivation to do mathematics, success in obtaining professional licenses and future work environments. This presentation will describe successful non-traditional, program-specific initiatives undertaken by the mathematics faculty in the School of Arts and Sciences: the development of new courses such as "Math for Nurses" , "Applied Biostatistics" , and "Math for Health Humanities" ; the redesign of the Statistics course; and the creation of new Supplemental Instruction sessions in the Math & Physics Center.

Jessica Stewart Kelly Christopher Newport University

Intentional Course Design for Project-Based Courses

Providing students with an understanding of how their mathematics background can manifest itself in careers outside of academia is important, but is an area overlooked by traditional curricula. Project-based courses with real-world problems from community partners provide students the opportunity to experience mathematics beyond a textbook and lectures. Although students have the opportunity to drive the content and pace of project-based courses, it is imperative to the overall success of the course that the instructor be intentional with the course structure and design. This talk will highlight some of the issues that instructors new to designing project-based courses may face and focus on ways course design can mitigate their negative effects. Intentional course design should promote positive group dynamics, facilitate communication, and encourage reflection. Course design ideas include: initial team discussion prompts, team contracts and workspaces, individual and team reflection materials, and ways to communicate with community partners. The course design aspects which will be discussed were developed for a course supported by the Preparation for Industrial Careers in Mathematics (PICMath) program. During the semester, students worked in groups to make progress on mathematical projects proposed by the local fire and police departments as well as industrial organizations. Although such a classroom experience is unique and untraditional, preparation and intentional course design by the instructor will help support student learning and provide the foundation for a successful experience.

Megan Sawyer Southern New Hampshire University

BIG Problems in Mathematics

Applied problems from Business, Industry, and Government (BIG) sectors often serve as pathways for students to see mathematics in practice, but in many universities, curricula are not explicitly structured for students to readily have access to these problems. The mathematics department at Southern New Hampshire University has recently restructured its major into concentrations including a mathematical modeling track containing statistical, discrete, and continuous-time modeling courses. This talk will focus on the course structure of the modeling track, how to best utilize BIG sector connections for courses within this track, and the benefits for students who pursue this concentration. In particular, this talk will discuss the experience of students in the Spring 2019 *BIG Problems in Mathematics* course and the future directions of associated mathematical modeling courses in the department.

John Noonan Mount Vernon Nazarene University

How the Government Shutdown Derailed my Plans for a Series of Introduction to Statistics Projects and how I got the Projects Back on Track

During December, 2018, I prepared a series of projects for my Spring, 2019 introduction to statistics classes that included using real world data with technology. The goals of these projects were to familiarize my students with technological tools for computing statistics and to help the students think about the results of various statistical techniques in the context of real data. I had planned to have students use data found on the data.gov website and had prepared instructional videos based on that website. The January 2019 Government shutdown resulted in the data.gov website being unavailable. In my search for a substitute repository of data that students could access, I happened upon the University of Michigan's ICPSR website. In this talk, I will describe the projects I assigned to my students and the benefits and challenges with using data found at the ICPSR repository.

Mathematics and Sports

Part A: Saturday, August 3, 9:00–11:55 AM, Room 206

Organizer: Drew Pasteur College of Wooster

The expanding availability of play-by-play statistics and video-based spatial data have led to innovative research using techniques from across the mathematical sciences, with impacts on strategy and player evaluation. Other areas of interest include ranking methods, predictive models, physics-based analysis, etc. Research presentations, expository talks, and contributions related to curriculum or pedagogy are all welcome. With a broad audience in mind, talks should be accessible to undergraduate mathematics majors, and projects involving undergrads are particularly encouraged for submission.

Nathaniel M. Iverson Siena Heights University

Ranking Sports Teams with Perron-Frobenius Eigenvectors

John Madden once said "Usually the team that scores the most points wins the game". In this talk we will discuss how we can use a simple linear point flow model to give both an offensive and defensive rank for sports teams and how the Perron-Frobenius theorem can be used to ensure that these rankings are unique. This is a fertile ground for undergraduate and graduate student research projects. This talk will offer insights on what skills are necessary for both an adviser and student and what sort of struggles are likely to be encountered.

Tom Tegtmeyer Trinity University

Ranking Major League Pitchers and Batters using the Oracle Method, an Update

The Oracle method (Balreira et al., 2014) is a Markov chain-based ranking method that introduces a fictional common opponent (the Oracle) to create irreducibility and manipulate network flow. Original attempts to apply the method to simultaneously rank pitchers and batters in Major League Baseball resulted in an unfortunate league bias. Successful attempts to reduce the bias and introduce other factors will be discussed.

Ollie Nanyes Bradley University

Predicted Performance using Bayesian Inference

In 1990, Larry Bird of the Boston Celtics made 71 consecutive free throws, which was short of Calvin Murphy's record of 78 straight made during the 1980-81 season. If we were to attempt to infer Bird's (or Murphy's) free throw percentage by that streak alone, what would we infer (the assumption is that our random sample just happened to coincide with that streak).

Paul von Dohlen William Paterson University

Building and Using a Baseball Simulator to Analyze Batting Orders

The structure of a baseball batting lineup has been a hotly debated topic especially during this renaissance of baseball analytics. We will discuss the creation and implementation of a baseball simulator (using MATLAB) to study the effects of variations in hitters by lineup position. Two variations considered are hitter-type and hitter-streakiness. We will consider the results of the simulations and make some preliminary conclusions about possible lineup optimization. As some of this work was done with an undergraduate as part of an honors thesis, we will also mention the role of baseball analytics in undergraduate research.

Daniel Shifflet Clarion University of Pennsylvania

Using Sports to Introduce Game Theory

Game theory is the perfect mathematics subject for an undergraduate topics or honors course. The classic introductory examples students study come from many fields, thus sparking interest from a variety of majors. But often these examples are superficial or contrived so that students without extensive background knowledge can relate. Sports can be the exception. From goalies diving for penalty kicks to ranking players for the baseball draft, examples from sports run the gamut of game theory. In this talk we will explore some of these examples, many of which were developed by undergraduate students in such a course.

Jathan Austin Salisbury University

NFL Betting and Expected Value

In this talk, I will discuss how I have used NFL gambling as a context for teaching expected value in a mathematics for liberal arts course. I will discuss questions and exercises involving real data that are suitable for college students of varying mathematical abilities.

Diana Cheng Towson University

Faster and Higher over Ice: Biomechanical Principles Used to Push the Boundaries in Figure Skating

Biomechanical principles of angular momentum and projectile motion apply to figure skating movements. Equations from physics can be written to model certain aspects of spins and jumps. Knowledge of these principles might help skaters to break existing records in spins and jumps - to rotate faster, achieve more revolutions, and jump higher.

Roland Minton Roanoke College

Player Course Interactions on the PGA Tour

ShotLink data and the Strokes Gained statistics allow us to isolate performances of golfers for different types of shots. For example, some golfers are very good driving but only mediocre putting. Utilizing data from the PGA Tour from 2005 to 2018, players and courses are clustered into groups with similar characteristics. The clusters are then analyzed to try to identify which types of courses bring out the best and worst in different types of golfers.

R. Drew Pasteur College of Wooster

Envy-Free March Madness Bracketing

In traditional seeded tournament bracketing, as is used in March Madness, teams are placed in a bracket such that the highest seeds would face the lowest-remaining seeds in a given round, if all goes according to form. However, the frequency of upsets leads to a variety of match-ups, and it is not clear that the traditional bracketing is the fairest model. As an example, teams seeded #11 and #12 advance to the “Sweet Sixteen” (third round) more frequently than the #8 and #9 seeds. Based on historical team strengths, we develop a model for “envy-free” bracketing, in which no team would prefer to trade places with any lower-seeded team.

Mathematics and the Life Sciences: Initiatives, Programs, Curricula

Part A: Thursday, August 1, 9:00–10:40 AM, Rooms 207 & 208

Organizers: Timothy D. Comar Benedictine University
Raina Robeva Sweet Briar College
Carrie Diaz Eaton Bates College

The 2015 CUPM Curriculum Guide to Majors in the Mathematical Sciences identified the life sciences as a key path through the mathematics major to graduate programs and the workforce. Topics include scholarly contributions addressing initiatives, programs, curricula, and course materials at the interface of mathematics and the life sciences that have been implemented and tested at institutions of higher education.

Mariah Birgen Wartburg College

Modeling Calculus: A First Course for Everyone Including Biology Majors

At a small, liberal arts college, the majority of students in Calculus I may be pre-med Biology majors. They are taking this course to get into medical school. Yet, a traditional differential calculus course is only good at improving their mathematical maturity and often makes very few connections with their future plans. In keeping with the theme, "teach the students you have, not the students you wish you have," about ten years ago the faculty at Wartburg College rearranged their first year of Calculus and now teach Modeling Calculus and Foundational Calculus. Modeling Calculus is a course that uses numerical simulation to teach students the fundamentals of differential and integral calculus, and differential equations though mathematical models. Because the students we have are primarily biology majors, the models created are primarily in the Biological Sciences. By the end of the class students can read and interpret a science journal article with a differential equations model and re-create that model within the software. The presentation will discuss the structure of the class, the models and software used, as well as how the class fits into the broader set of mathematics courses at the college. By the end of the presentation you will see that, not only is this a best first math course for our pre-med majors, but that it fits well in the CUPM Guidelines for a mathematics major as well.

Joel Kilty Centre College
Alex M. McAllister Centre College

Mathematical Modeling and Applied Calculus

We present an entry level Mathematical Modeling and Applied Calculus course for students who will (most likely) only take one mathematics course in college and who are intending to major in an allied discipline, often in the life sciences. In our modern world, we grapple with diverse data sets on a daily basis. As mathematicians, we are often more comfortable discussing the behavior of functions presented analytically, in contrast with the data-driven or tabular presentations of functions ubiquitous in our culture and the life sciences. Our course is designed to develop a student's ability to model data with elementary functions and then improve their models using the Method of Least Squares, which is fully developed in this course along with the central ideas of calculus. In this talk, we give an overview of how these ideas are developed in our Mathematical Modeling and Applied Calculus course, highlighting relevant examples from the life sciences, noting connections to the 2015 CUPM Curriculum Guide to Majors in the Mathematical Sciences, and presenting evidence for the effectiveness of this approach.

Bori Mazzag Humboldt State University

Linking Introductory Mathematics Courses to the Life Sciences

Humboldt State University (HSU) is a public, regional four-year institution that became a Hispanic Serving Institution (HSI) in 2016. A large HSI-STEM grant from the Department of Education to two HSU faculty, Sprowles & Johnson, has funded the redesign of the first-year experience for STEM students. Incoming first-year students are block-enrolled in required courses for their majors, and the courses are linked by some curricular content. STEM faculty from Mathematics, Biology and the Wildlife Departments have collaborated to create a lab that tests whether nitrogen is a limiting nutrient for algae in the nearby Klamath River. Several introductory Mathematics courses contain Excel-based labs, in which students learn about linear and exponential data fitting and submit a detailed lab report on their findings. The talk will describe the some of the faculty collaborative process in creating the linked content, parts of the curricular content, some student course outcome results, and further assessment plans.

Douglas Norton Villanova University

Mathematical Modeling for the Life Sciences: A Curricular Update

In consultation with our university's Biology Department and the Program in Cognitive and Behavioral Neuroscience, our Department of Mathematics and Statistics developed a new course on Modeling for the Life Sciences. The course was first offered in 2016, and experiences with that course were reported in the Themed Contributed Paper Session on Trends in Undergraduate Mathematical Biology Education in the 2017 Joint Mathematics Meetings. In this presentation, we report on the developments in subsequent editions of the course. We also report on the results of checking in with students who took the early versions of the course to inquire about the utility of the material from the course as they proceeded through the coursework in their majors.

Sanjukta Hota Fisk University

Strengthening the STEM Curriculum Through the Introduction of an Undergraduate Quantitative Bio-track Program

Targeted Infusion Project of NSF HBCU-UP provided support to initiate an interdisciplinary quantitative undergraduate curriculum in biomathematics and bioinformatics at Fisk University, Nashville, TN. As part of this project, we have developed some computational bio-track courses and offered faculty-mentored undergraduate summer research internship program. This talk will present our findings on the impact and importance of this computational and data-enabled active learning project in mathematics, biology and computer science.

Part B: Thursday, August 1, 1:30–2:30PM , Rooms 207 & 208

Jacy Beck Utah State University
Ricardo Cortez Tulane University
Brynja Kohler Utah State University

Pain Medication and Tree Leaves: Mathematical Modeling Tasks for Future Secondary Teachers

This research includes two mathematical biology tasks which are part of a curriculum to give future high school math teachers a deeper understanding of math modeling. The pain medication task makes use of principles from a medical journal about how long it takes for pain medication to leave the body and asks students to explore different dosing options. The tree leaves task uses information from an ecology research paper that compares the size of tree leaves to the age of that tree. The task asks students to produce a reasonable interpolating function that relates the size of the leaves to any age of the tree. These tasks allow students to analyze data and create a model for each situation. An overview of the curriculum materials, strategies and approaches used in teaching the course, and the development of a framework about what kind of math modeling competencies and dispositions are relevant for high school teachers will be discussed throughout this paper.

Timothy D. Comar Benedictine University

Engaging Undergraduates in Research in Mathematical Biology with Limited Resources

How does one attract undergraduate students to engage in research in mathematical biology at an institution at which there are specific introductory courses in the field? How does one help bring students who have just completed a first course in calculus to the point at which they can productively begin to research in mathematical biology? This presentation will address these questions. In particular, we will talk about student recruitment and selection and the mathematical and biological preparation needed to help students with minimal mathematical background develop the analytical and computational skills needed for research in ecological and epidemiological areas. We illustrate how using agent-based models can serve as entrance way into using the analytical tools of impulsive differential equations and difference equations for modeling. Examples of recent student projects will be highlighted.

Marepalli B. Rao University of Cincinnati
Rigwed R. Tatu University of Cincinnati

Data Analysis with Destructive Samples: Spina Bifida Case

Title: Data Analysis with Destructive Samples: Spina Bifida Case Presenter: M B Rao Affiliation: University of Cincinnati Format: Contributed Papers Session: Mathematics and the Life Science Abstract I teach Data Science to graduate students. The core syllabus is a combination of Mathematics, Statistics, and Computing. One segment of my presentation is devoted to bringing in data from my collaborative research with biomedical researchers. An open-ended discussion will be initiated how to analyze the data answering questions from the researchers. One such project came from biomedical engineers at the University of Cincinnati. The research team consisted of a biomedical engineer specializing in medical devices, two fetoscopy surgeons, a graduate student, and a statistician. The fetus is diagnosed with spina bifida. There is a gap in the spinal column through which spinal fluid is leaking into the amniotic fluid. Skin is missing. The engineers developed a biodegradable patch, which is a combination of two polymers, having optimal properties. Through fetoscopy, the patch is laid on the gap. Hopefully, skin under the patch grows. Two questions arose: How rough the patch is and how roughness varies over time. The rougher the patch is, the better the nutrients latch onto the patch. In order to measure roughness, the patch has to be removed from the gap. Once roughness is measured, the patch will then be useless. This means we cannot have roughness measured over time. We need to estimate roughness of a patch over time using a one-time measurement of roughness of the patch, using novel statistical methods. I will discuss how this challenging problem is solved.

My Favorite Number Theory Proof

Part A: Saturday, August 3, 9:00–11:20 AM, Rooms 207 & 208

Organizer: Sarah L. Mabrouk Framingham State University

Presenters share favorite proofs suitable for introductory proofs or undergraduate number theory courses, giving the complete proof, discussing how the proof fits into the course, providing information regarding prerequisite topics, areas of difficulty, and making the proof accessible for students. Modifications to the proof over time, historical information, and explorations/demonstrations used to make related theorems/topics comprehensible for students are discussed.

Martha H. Byrne Sonoma State University

Divisibility, Modular Arithmetic, and Induction, oh my!

For any natural number n, $n^3 - n$ is divisible by 6. Actually, this is true of any integer as well, and the proof techniques used don't change. It is well situated in an introduction to proofs course, as it can be proved in a variety of ways. Many novice proof writers struggle to find the "right" way to prove a claim to their detriment. In this talk, the presenter will go over several different proofs and talk about how to draw out student discussion about proof techniques that bridge the different approaches and support student understanding of multiple proving paths.

Kristi Karber University of Central Oklahoma

Various Teaching Strategies to Prove that a Certain Conjecture is Equivalent to Goldbach's Conjecture

One of the most famous conjectures in Number Theory authored by Goldbach states, "Every even integer greater than 2 can be expressed as the sum of two primes." It can be shown that the conjecture, "Every integer greater than 5 is the sum of three primes," is equivalent to Goldbach's conjecture. In this talk we provide various strategies that can be used to help students understand or construct a proof which verifies the aforementioned conjectures are indeed equivalent. Possible strategies include an exploration, as well as an emphasis on beginning proof writing skills such as utilizing definitions and proof techniques. A proof will be provided while demonstrating the various approaches.

Adam J. Hammett Cedarville University

Fermat's Bracelets and Wilson's Polygons: seeing two foundational theorems geometrically

Nearly every undergraduate course in number theory will include a presentation of both Fermat's little theorem and Wilson's theorem. Let p be a prime. The former states that for any given integer $n > 0$ we must have $p|n^p - n$, and the latter that $p|(p-1)! + 1$. Most textbooks include proofs that, while elegant and brief, tend to labor in the realm of the purely analytical. However, George Andrews in his *Number Theory* text [pp. 36-40, *Dover Publications, Inc., New York*, 1994; MR0309838] gives remarkably simple, self-contained proofs of these results that rely only on symmetries of certain colored bracelets (in the case of Fermat) and special polygons (Wilson). In this talk, we will endeavor to present both of these gems in their entirety.

Scott Williams University of Central Oklahoma

Euler's Criterion

If a is an integer relatively prime to m, then we say a is a quadratic residue modulo m if a is a perfect square modulo m (i.e., if $x^2 \equiv a \pmod{m}$ has a solution). For p an odd prime, the Legendre symbol $\left(\frac{a}{p}\right)$ takes a value of 1 if a is a quadratic residue modulo p and -1 otherwise. When initially exposed to quadratic residues, brute-force methods are generally what a student attempts to use to compute $\left(\frac{a}{p}\right)$. Euler's Criterion gives them their first real computational approach to finding $\left(\frac{a}{p}\right)$:

Euler's Criterion: Let p be an odd prime and let a be an integer not divisible by p. Then

$$\left(\frac{a}{p}\right) \equiv a^{(p-1)/2} \pmod{p}.$$

One, possibly more standard, approach to proving Euler's Criterion involves the use of Fermat's Little Theorem as well as primitive roots. There is, however, an alternative proof which makes use of various other results discussed in an Elementary Number Theory course rather than primitive roots; e.g., the existence of modular inverses and Wilson's Theorem. In this talk we will discuss how the latter approach provides an excellent opportunity to tie together numerous concepts which are presented throughout such a course.

Larry Lehman University of Mary Washington

Seeding Polynomials for Quadratic Congruences Modulo Prime Powers

The number of solutions of a quadratic congruence $f(x) \equiv 0 \pmod{p^e}$ can appear to be unpredictable when p^2 divides Δ, the discriminant of f. We will prove that these solutions can be counted and constructed in terms of those of a "seeding polynomial" for $f(x)$, having discriminant Δ/p^2. The proof is one that can be visualized, and is appropriate for a first course in number theory. As a consequence of this approach, we also establish a formula for the number of solutions of an arbitrary quadratic congruence modulo any prime power.

Scott Zinzer Aurora University

The Exact Power of *p* Dividing *n*!

The Legendre formula gives the prime factorization of $n!$. For a prime p, each factor of p appearing in $n!$ must arise from a factor of p in one of the integers between 1 and n. The proof of the Legendre formula for p requires a careful counting of the number of integers between 1 and n that are divisible by each power of p. By using a measurement model for division on the number line, we demonstrate how the greatest integer function provides this count. We provide some initial motivation previewing why the sum of values of the greatest integer function successfully counts the exact number of times p appears as a factor among all of the integers between 1 and n. Finally, we use geometric sums to rewrite the Legendre formula for p in terms of the base-p expansion of n.

Andrew J. Simoson King University

A Silver Version of Dirichlet's Bronze Approximation Theorem

Given a positive irrational number ω and a reduced fraction $\frac{p}{q}$ of positive integers, we say that $\frac{p}{q}$ is a bronze, silver, or gold approximation to ω if, respectively, ω and $\frac{p}{q}$ differ by less than $\frac{1}{q^2}$, $\frac{1}{2q^2}$, and $\frac{1}{\sqrt{5}q^2}$. Johann Peter Gustav Lejeune Dirichlet proved that there are an infinite number of bronze winning fractions for ω in about 1840. Fifty years later, Adolf Hurwitz showed that there are an infinite number of gold winning fractions for ω . We shall do the same with respect to silver by using Farey sequences, named after John Farey (1766–1826), and Ford circles in the xy-plane, named after Lester R. Ford (1886–1967). Briefly, as follows from Euclid's greatest common divisor algorithm, any reduced fraction $\frac{p}{q}$ is the mediant of two unique reduced fractions $\frac{a}{b}$ and $\frac{c}{d}$, called Farey neighbors, where $p = a + c$ and $q = b + d$. The Ford circle associated with $\frac{p}{q}$ is a circle with center $\left(\frac{p}{q}, \frac{1}{2q^2}\right)$ and radius $\frac{1}{2q^2}$. A fun—and elementary—geometric argument shows that two Ford circles are tangent if and only if their associated fractions are Farey neighbors, which is enough to give us a recursion generating a sequence of only silver winning fractions for ω.

Plug and Play Data Science Lessons

Part A: Thursday, August 1, 9:00–10:40 AM, Room 233

Organizers: Michael Boardman Pacific University
Timothy Chartier Davidson College
Jason Douma University of Sioux Falls

In this session, papers include data science lessons that attendees can seamlessly incorporate into courses such as Finite Math, Calculus, Linear Algebra, Discrete Mathematics, Mathematical Modeling, and others. Presentations include such elements as an overview of the lesson, student learning objectives, assessments, and a summary of the effectiveness of the lesson if available.

Mutiara Sondjaja New York University

Teaching Elements of Machine Learning in A Quantitative Reasoning Course

In this talk, I will share a data-centered, three-week module that introduces the basic ideas of the "classification problem" from machine learning to students in a quantitative reasoning course. I taught this module as a part of a semester-long quantitative reasoning course that has no mathematical prerequisites; however, the module can be adapted for use in other courses, such as mathematical modeling and discrete mathematics. The computational tools used in the module are R (or python) with Jupyter Notebook, which are widely used by data science practitioners; a quick start guide for instructors new to these tools is included. The module starts with basic data visualization (e.g., creating scatterplots) and culminates in a project in which students are asked to make predictions about movies' genres based word frequency data in the movies' scripts. Throughout the module, students work hands-on and actively with data and the computing tools. While the module introduces students to standard models known as the "k-nearest neighbor classifier" and the "decision tree classifier", we introduce the basic ideas from these models organically, emphasizing general modeling ideas such as "distances" or "measures of similarity" and how to assess the "goodness" of mathematical models.

Andrew S. Leahy Knox College

A Climate Data Set in Applied Calculus

The impact of human activity on the world's climate is a topic that generates much interest in students (and others) today. In this talk we will describe a culminating project in an introductory applied calculus course that uses a widely-cited data set and exponential regression to create a simple continuous model for carbon emissions due to human activity over time–and then applies the tools of calculus to draw conclusions from this data.

Christopher Brown California Lutheran University

Modeling Regional Bird Count Data in Calculus I and Differential Equations

The United States Geological Survey has performed the annual North American Breeding Bird Survey since 1966, providing a rich and publicly available source of bird count data. In this project we study the count data for Haemorhous mexicanus, the house finch, in different regions in the U.S. The house finch is a highly successful invasive species outside the southwest U.S., and population counts in eastern regions reflect a trend typical of an invasive species. We present a project for Calculus I asking students to assess the appropriateness of functional models based on monotonicity and concavity, and a similar project for Differential Equations asking students to approach the same problem with differential equations models. We discuss difficulties encountered in data wrangling, model assessment, and group project management. We also discuss the tangible deliverables we required and results.

Drew C. Youngren Columbia University

Teaching Riemann Sums and Multiple Integration with Messy Data

When introducing multiple integration, many multivariable calculus curricula give cursory attention to the Riemann sum definition before moving on to iterated integrals. When students are asked to estimate integrals from discrete data, it is often received in neat-as-a-pin tabular form, and the exercise reduces to the "plug-and-chug" variety. In this lesson, students are presented with a simple question, "What is the average temperature in this freezer?" and an unwieldy, nonuniform data set of sampled temperatures. Students work through a Jupyter notebook and come to see that a Riemann sum structure yields a better answer than a simple column average. The lesson is scaffolded such that all students can get a decent result. Along the way, they develop basic skills in data wrangling, data visualization, and the mechanics of indexing. Finally, as the data are sampled from a specific continuous distribution, the students can compete to get closest to the "real" answer, debate the actual fairness of said competition, and find hooks to more advanced topics in numeric integration and regression.

Megan Olivia Powell University of North Carolina Asheville

Querying An Open Sports Database for Research and Education

Sports data is abundant but not always accessible in a format that is conducive to answering specific questions. Many mathematical and statistical modeling techniques can be highlighted through analyzing sports. In this talk, I will show the versatile use of the free online database pro-football-reference.com that be queried to find a multitude of specific information on football plays. I will show some specific queries used to support research on the NFL with undergraduate students.

Part B: Thursday, August 1, 1:30–4:10 PM, Room 233

Liz Bouzarth Furman University
Kevin Hutson Furman University

Data at Disney: Using Clustering to Maximize Mickey Bar Sales

We introduce the concept of k-means clustering and use that as the basis of a project in our three-week study away Math and the Mouse course. The project involves using crowd level data to indicate demand for frozen treats in the Magic Kingdom theme park. Students work in teams to determine time-dependent optimal locations for three mobile Mickey bar stands using weighted clustering. Tableau is used for data visualization. Even though this course takes place in Walt Disney World, the project ideas discussed in this talk can be used in a variety of academic settings.

Russell Goodman Central College

An In-Class Geo-spatial Data Science Project...Inspired by a Comedian

This talk will share the details of an intriguing and appealing in-class data project for students in a class such as Mathematical Modeling, Statistics, or Introduction to Data Science. The project originated with a joke from a popular comedian about whether "La Quinta" is Spanish for "Next to Denny's" and developed into an investigation of that quip. In this project, students learn to acquire the appropriate geo-spatial data, learn some new skills in Excel, RStudio or other data analysis software, experience quite a bit of problem-solving, and then work hard to enjoyably communicate their results.

Jacob Price University of Puget Sound
Jeremy Upsal University of Washington

Movie Recommendation as an Introduction to Machine Learning Principles

Recommendation algorithms are ubiquitous in the modern world. Between Netflix, Amazon, Spotify, and more, companies are leveraging consumer data to tailor recommendations to specific tastes. The mathematics behind these algorithms is remarkably intuitive. We will present a case study in which we developed machine learning principles with movie recommendation as the guiding application. Students selected the movies and feature variables themselves. Recommendation and classification algorithms produced intelligible results even for this small dataset. This material was developed for high school students with a wide range of mathematical and computational expertise and comfort. It would be simple to adapt these materials for courses in machine learning, mathematical modeling, statistics, or introductory computer science.

Daniel T. Kaplan Macalester College

Enough Linear Algebra for Machine Learning

Linear algebra is a core topic of the university mathematics curriculum, and highly relevant both to traditional statistics methods (e.g. regression) and newer, machine-learning approaches. Yet few data science programs require the gamut of calculus courses that are the standard pre-requisites for a traditional linear algebra course. In teaching statistical modeling and machine learning, two core topics of the Macalester College data-science program, we've identified a no-prequisite approach to enough linear algebra to give students a sound theoretical basis for topics in statistics and machine learning. The lessons we use are highly engaging even for math-phobic students. Students learn how to think about under-determined solutions, colinearity, and the geometry behind Simpson's Paradox. A concise approach let's us integrate enough linear algebra for machine learning into a first-level calculus course, using short refreshers in statistics and machine learning.

Boyan Kostadinov City Tech, CUNY

A Lesson in Data Science and Computational Thinking Using Real Data

In this talk, we present an example of a data science lesson from our newly developed course on Introduction to Computational Science, designed to be taken by a wide range of majors with lower-level mathematical and computational prerequisites. We use real data and cover some of the most important steps in the data science framework of analyzing, visualizing and learning from data: Import -¿ Tidy -¿ Transform -¿ Visualize -¿ Model -¿ Communicate. In this data science project, we emphasize the last four steps of the learning from data process and illustrate some supervised or unsupervised machine learning techniques in the modeling part, including some key mathematical details. We also illustrate a complete workflow for implementing our data science project using RStudio, as a one-stop solution, which is free and easy to set up, and it now offers the ability to combine the power of R and Python in the same source R Markdown document in order to create publication quality project reports in several different formats, which can deliver visually rich storytelling that offers insights into our data. The development of this course was supported in part by a MSEIP Grant from the Department of Education.

Jacqueline R. Herman Northern Kentucky University

Discriminant Analysis and Logistic Regression Connections

Two of the topics covered in our Applied Multivariate Data Analysis course are discriminant analysis and logistic regression. Either of these methods can be used when there are only two groups to discriminate between. The lessons presented to the students are intended for them to make the connections between these two methods and decipher when each method is more appropriate. The students demonstrate this using one dataset of their choosing for the first project on discriminant analysis. The students present their findings and then write-up a statistical report. For the second project, the datasets from the first project are shuffled around and they use this new dataset (with the statistical report provided from the previous group's analysis on discriminate analysis) to analyze this dataset with logistic regression. This presentation will involve a summary of the lessons presented to the students, the showing of the assessments given to the students, and finally examples of the projects that the students worked on.

Haiyan Su Montclair State University

Two data science projects in PIC Math class

In this talk, I will give two examples of data science projects that undergraduate students worked on in the PIC Math class in this spring. One project is to search for the nearest correlation matrix (among stock data etc) when estimating the value at risk (VaR) in financial fields. The key component is to find a positive definite matrix that is the "closest" to the one produced by real data. The other one is to search for the closest nth root of a given Markov transition matrix. It is related to credit rating transition matrix for periods different from published transition matrices by rating agencies. Both projects have wide applications in financial fields. Students have learned how mathematics knowledge is applied in real world and learned data analysis skills by using software Python and R.

John T. Sieben Texas Lutheran University
Reza O. Abbasian Texas Lutheran University

R Projects Can Complement the Inverted Classroom

A major hope of the inverted classroom movement is to encourage students to take more responsibility for their own learning. The authors have found that projects play a large part in inverting a class and that R language lends itself to projects in which students, with guidance from their faculty, can build their own set of useful R tools that enhance their projects. Key Words: Inverted Classroom, R Language Intended audience: Undergraduate mathematics and statistics instructors Themes: Using R to enhance student projects.

Professional Development in Mathematics: Looking Back, Looking Forward, on the Occasion of the 25th Anniversary of MAA Project NExT

Part A: Friday, August 2, 10:10 AM–12:10 PM, Junior Ballroom D

Organizers: Dave Kung St. Mary's College of Maryland
Julie Barnes Western Carolina University
Alissa Crans Loyola Marymount University
Matt DeLong Marian University

Since MAA Project NExT was founded 25 years ago, a generation of mathematicians have participated in it and other PD programs. How have those programs impacted teaching and learning in mathematics? How have the challenges faced by college math instructors changed? Looking forward, how do we prepare today's math instructors for the changes to come in the next 25 years?

Sandra Laursen University of Colorado Boulder

Activating Mathematics Instructors for Active Learning: The Role of Professional Development on Teaching

Ample research shows that effective use of active learning approaches in undergraduate STEM courses has many benefits for students' learning, attitudes and persistence in STEM majors. Yet most undergraduates do not experience these benefits of active learning, and some students are disproportionately unlikely to do so, including poor and first-generation college students, and those from minority racial and ethnic groups. To provide rich and meaningful mathematics learning for all students, the Conference Board on Mathematical Sciences has called on math departments and faculties to incorporate effective active learning into undergraduate classrooms. Nationally, the bottleneck to achieving this goal is instructors' uptake of active learning techniques in their own courses. Professional development is one of the best ways we know to enhance instructors' skillful use of active learning approaches, yet there is much we still don't know about how best to design, carry out, and measure outcomes of professional development of college instructors. To provide an overview of the national landscape of active learning, I will highlight findings from a forthcoming report on "levers for change" in undergraduate STEM education. I will link this landscape to key research results from our group and others that offer insight into how professional development supports instructors' uptake of active learning approaches in their own classrooms.

Benjamin Braun University of Kentucky

Emotions, Behavior, Mythology, Passions, and Proof: Challenging Mathematical Culture and Transforming our Teaching

Mathematical culture is a powerful force, and it impacts every aspect of our profession, including the ways that mathematicians view and engage in professional development activities. However, mathematical culture is not a fixed monolith; it changes over time, and can be influenced. In this talk, I will share some of my observations regarding the role of our current mathematical culture in effective professional development, both positive and negative, based on my experiences leading professional development sessions regarding teaching for graduate students, college and university faculty, and K-12 teachers. My hope is that these observations will inspire others to consider the role of culture in their work, and the ways we can collaboratively create positive cultural change through professional development.

Darryl Yong Harvey Mudd College

What the K-12 Education Literature can Tell us about Effective Professional Development for Faculty

Compared to us post-secondary faculty developers, our colleagues working in K-12 contexts have a longer history of developing, deploying, and studying professional development. What can we learn from them in our quest for more effective forms of professional development for post-secondary mathematics faculty? I will review the extant literature on the characteristics of effective teacher professional development and share implications for us at the post-secondary level.

Billy Jackson University of Louisville
Shandy Hauk San Francisco State University
David Tsay University of Texas Rio Grande Valley

Teaching Future Teachers and Mathematics Faculty Professional Learning

In the last 40 years, publicly funded colleges and universities have seen state funding decrease while operational costs continue to rise. In response, many institutions are recruiting a broader pool of students. Such efforts at diversity and inclusion are coupled with the fact that states are now looking to move away from ineffective remediation approaches (e.g., repetitions of algebra). As a result, mathematics departments seek ways to lower drop-fail rates while improving student learning and shortening time to completion of degree. Hence, professional learning for math faculty in the next 25 years must include the means for developing awareness and responsiveness to the diverse needs of the student population. Faculty need the opportunity to learn about and enact instruction that effectively responds to socio-cultural aspects of mathematics teaching and learning. To date, the preparation of future faculty has focused on awareness-building. Personalizing and practicing skills that leverage that awareness have been left as an exercise for the instructor. The session is about designing faculty professional learning to support responsive college instruction. A 15-hour mini-course for faculty who are novices in teaching courses for future K-8 teachers will be highlighted. Specific attention is given to how to support faculty in a cycle of (a) trying out instructional ideas on a small scale, (b) accumulating learning (as an instructor) in and from teaching through such small trials, and (c) using that learning to tailor instructional practices to meet the needs of students who will one day be elementary/middle school teachers.

Jack Bookman Duke University
L. Jeneva Clark University of Tennessee

Distributed Leadership: A Framework for Continued Professional Development Workshops

Distributed leadership (Spillane 2004) abandons the heroism of an individual leader, and instead, capitalizes on participants' expertise and encourages collaboration, planned and implemented by an overlapping web of leaders and followers. MAA CoMInDS, (NSF grant DUE-1432381), along with the University of Tennessee, Knoxville, sponsored a workshop in March 2019 for experienced providers of professional development for Graduate Teaching Assistants. The workshop had five two hour sessions: Instructional Design, Diversity Matters, Assessment Recommendations, Measuring Sticks, and Facing Challenges. At the workshop, each participant had a leadership role in the planning and implementation of one of the sessions. In this talk, we will discuss what we learned about this workshop format. The themes that emerged in participant comments include active learning, diversity, autonomy, and networking. Looking forward, we believe this kind of workshop helps develop future leaders and magnifies learning opportunities for faculty.

Karen Keene North Carolina
Justin Dunmyre North Carolina

Online Faculty Collaboration: Supporting Instructional Change in a Big Way

The TIMES (Teaching Inquiry-Oriented Mathematics: Establishing Supports) project was funded by the National Science Foundation five years ago. In this presentation, we will focus on one of the supports that were used in the project: online workgroups. Online workgroups are a type of professional development for mathematics instructors who are seeking to change their instruction by using inquiry-oriented task-based curricular materials. The online workgroups were designed to help faculty that are spread over multiple institutions collaborate with each other and be supported by an experienced facilitator. The online workgroups met faithfully once a week for an hour and usually had about 4-8 participants. We will share some of the lessons learned from this professional development undertaking. Karen Keene is one of the project's leads, and Justin Dunmyre was a participant the first year, and then a facilitator in later years. We have designed and redesigned the one-hour sessions and will discuss some of the parts of the workgroups that have worked, and some that have not. We also will discuss some of the findings from the research about the participation and how online workgroups have been significant in instructors successfully introducing new instructional strategies into their differential equations, linear, algebra, and abstract algebra courses.

Part B: Friday, August 2, 1:30–3:10 PM, Junior Ballroom D

Violeta Vasilevska Utah Valley University

Reflections on Lessons Learned from Project NExT

This presentation will highlight some of the opportunities that the presenter benefited from by being a project NExT Fellow (2015 Sterling). It will highlight some of the important aspects of Project NExT professional development opportunities that shaped her career, teaching style and philosophy. In particular, the influence of various workshops on active learning, and specifically, Inquiry Based Learning will be discussed.

Mary Shepherd Northwest Missouri State University

Reflections of a Peach Dot

I was in my first year of teaching post-PhD when my department chair, Vasily Cateforis, suggested the I and another first year faculty member, Joel Foisy, apply to this new MAA program for new faculty, Project NExT. We did and were both accepted into the fourth cohort, the Peach Dots. We met Jim Lewis (the last cohort to do so) and Chris Stevens, heard Joe Gallian's "Just Say Yes" lecture, and Iearned there were more ways to teach than just lecture. Throughout the next several years in the Seaway Section I attended workshops and conferences that I would not have even considered had I not participated in those initial Project NExT meetings. I particularly enjoyed the large meetings where I actually knew people. I was involved with the Section NExT in the Seaway Section and helped establish the Missouri Section NExT program. As secretary/treasurer in the Missouri Section, I called Sharon Tryon with a question and said something to the effect, "You can tell me. I understand accounting. I was an accountant before returning to school for math." I'm pretty sure that openness let to me eventually being asked to be on the EC in the role of Budget and Audit Committee Member. I remained on the Audit committee for several years. I also worked on the CTUM committee as it did the work on the Instructional Practices Guide. I can just about guarantee that none of this would have happened without acceptance into and participation in Project NExT. This talk will reflect on my experiences and maybe touch on possibilities for the future.

Lisa Driskell Colorado Mesa University
Doug Ensley Shippensburg University
Rachel Levy Mathematical Association of America
Audrey Malagon Virginia Wesleyan University

The MAA Mentoring Network: Supporting Early Career Mathematicians

In 2013, the MAA Committee on Early Career Mathematicians designed and implemented the MAA Mentoring Network. Over the past 6 years, the network has paired early career faculty, industry mathematicians, and graduate students with senior faculty within the MAA to welcome them to the mathematical community and provide guidance as they begin their professional careers. In this talk, past and present directors of the mentoring network will share the impact of this network on professional development in the mathematical community and what they see as potential next steps.

Dave Kung St. Mary's College of Maryland

The State of Professional Development in Higher Ed Mathematics: Today and What's NExT

For 25 years, MAA Project NExT has helped new math faculty get a jump start on their careers-and with their classroom teaching. During that time, the landscape of professional development in higher education mathematics has changed. In this session, we'll take stock of how MAA Project NExT has changed to meet the needs of new(ish) faculty and how the landscape around us has changed. Then we'll turn toward the future, to what changes we see on the horizon and what changes we need to make in order to move the community forward.

T Christine Stevens AMS, Providence, RI

Project NExT at twenty five and counting

Project NExT (New Experiences in Teaching) is the MAA's professional development program for new and recent PhDs in the mathematical sciences. It addresses all aspects of an academic career: improving the teaching and learning of mathematics; engaging in research and scholarship; and participating in professional activities. As it approaches its twenty fifth birthday, Project NExT has helped almost 2000 new faculty to make the transition from graduate student to faculty member. I will describe some of the factors, both intentional and serendipitous, that led to its remarkable success and reflect on the lessons and challenges that it offers to us as individuals and to the mathematical community.

Recreational Mathematics: Puzzles, Card Tricks, Games, Gambling and Sports

Part A: Thursday, August 1, 9:00–10:40 AM, Room 206

Organizer: Paul R. Coe Dominican University
Sara B. Quinn Dominican University
Kristen Schemmerhorn Concordia University Chicago
Andrew Niedermaier Jane Street Capital

Puzzles, card tricks, board games, game shows, gambling, and sports provide an excellent laboratory for testing mathematical strategy, probability, and enumeration. The analysis of such diversions is fertile ground for the application of mathematical and statistical theory. Solutions to new problems as well as novel solutions to old problems are welcome. Submissions by undergraduates or examples of the use of the solutions of these problems in the undergraduate classroom are encouraged.

Samantha Pezzimenti Penn State Brandywine

Exploring and Extending the Impossible Card Location Trick

In this talk, we explore a variation of the "Impossible Card Location Trick." In this classic card trick, a spectator selects three cards at random while the magician deals three piles with the remaining cards. The spectator puts their chosen cards on the piles and then hides them away by making a cut in each deck. The magician stacks the cards all together and successively splits the deck until the chosen cards are miraculously the last to appear. In this talk, we demonstrate a more general version of this trick and provide a proof for why it works. Based on these techniques, we also give an extension of the trick to allow the spectator to choose the number of cards in the initial pile dealt by the magician, as well as an extension to decks with arbitrarily many cards. This is based on work with undergraduate students Giovanni Di Cicco, Aditya Kommoju, and Dhanush Rajesh.

Jon Stadler Capital University

Guess My Birthday - An Original Mathematical Magic Trick

We demonstrate an original mathematical magic trick in which an audience member's birthday is revealed, both the month and the day of the month. A classic, related trick is discussed in which the only the day of the month is determined using binary representations of integers. We will examine an uncommon number system that provides the basis for the new illusion.

Jeremiah Paul Farrell Butler University

Five Card Study: A Magic Divination

Our Five Card Study is a new mind reading effect, based on five cards, that will confuse even the most sophisticated mathemagician. It is an improvement on the old binary cards used for predicting a chosen number that have appeared for years in magic kits. There are two effects and the subject can secretly choose to tell the truth or to lie to our questions.

Tom Edgar Pacific Lutheran University

A Factorial Card Trick

We will describe, perform, and explain a variant of the 27-card trick that utilizes the representation of integers as sums of factorials. If time permits, we will also discuss how a standard exercise for students learning induction proofs allows them to "count" using factorial representations, and we will provide a visual proof of this inductive result.

Daniel Pritikin Miami University
Nathaniel Coffin Miami University

Buffon's needle and coin problems on hyperspheres

On the unit sphere, an arc of specified length is selected randomly. With what probability will the arc intersect the equator? What if instead a random polar cap of specified diameter is selected? What if we replace 'sphere' by 'hypersphere', and 'equator' by 'sub-hypersphere' and 'polar cap' by 'cap in a sub-hypersphere', being flexible with the dimensions of the two sub-hyperspheres? Elementary solutions are presented, stemming from an undergraduate research project.

Part B: Thursday, August 1, 1:30–4:30 PM, Room 206

Kimberly Jordan Burch Indiana University of Pennsylvania

Using Graph Theory to Analyze *Ticket to Ride*© Expansions

The *Ticket to Ride*© series is a highly successful collection of board games in which players complete train routes connecting cities in various countries around the world. This talk will examine *Ticket to Ride*© Nordic Countries and *Ticket to Ride*© Europe. I will use graph theory to analyze the game and identify the most valuable edges and destination tickets. In both expansions, the game board is represented as a graph, with cities as vertices and the connections as edges. The edges of the graph are weighted based on their difficulty to obtain using many factors such as colored versus gray routes, tunnels, and ferries. All shortest paths between destination tickets cities are examined with this weighting to determine the most desirable edges and the overall value of completing destination tickets.

Darren Glass Gettysburg College
Stephen Lucas James Madison University

Chuteless and Ladderless

This talk will explore what happens if one plays Chutes and Ladders on a board without either chutes or ladders. In particular, we will consider the question of whether you would prefer to play this game with a single six-sided die or with multiple dice, and we will also see what happens when one changes the number of sides of the dice.

Jeremiah Bartz University of North Dakota

Playing Farkle with n-sided dice

Farkle is a popular greedy dice game which requires players to make a sequence of risk-reward decisions. In this talk, we explore the effects on gameplay by swapping 6-sided dice used in the standard game for n-sided dice with $1 < n < 9$. Furthermore, we use expectation and Markov chains to investigate game strategies. This is joint work with Karlee Westrem.

Anne Quinn Edinboro University of PA

Mathematical Results for New Versions of the Game of SET®

SET® is a popular and additive game which I have used for decades to study mathematics with people of all ages and abilities. While searching for strategies, players can explore numerous mathematical topics (such as probability, expected value, modular arithmetic, and proof). This talk will give a very brief summary of some of my published results for the original game of SET® (from the Mathematics Teacher and www.setgame.com) before extending a few of these questions to some recent versions of the game (mobile apps, SET® cubed dice, and crossword SET), with different results. Additional analysis will include probability theory, matrices, and simulation.

Jon-Lark Kim Sogang University

The Polya enumeration with the 1258 game

Ben Coleman and Kevin Hartshorn (Game, Set, Math., Math. Magazine, 85(2), 2012, pp.83-96) applied the Polya enumeration to the SET game to figure out how many different structures are there in a SET game. This is a good example of Polya's enumeration to a fun game. Motivated by this work, we applied Polya's enumeration to the 1258 game which is similar to the SET game but is using numbers 1, 2, 5, and 8. The cards and game rules are found in https://www.youtube.com/watch?v=x0ZKoeUD_iA&feature=youtu.be There are 96 cards, each of which has two numbers from 1, 2, 5, 8. Each card can be rotated 180 degree or flipped, which results in other numbers. Question is that in how many different(inequivalent) ways to put 12 cards on the board up to rotation and flipping? There are 96 choose 12 ways, i.e., 624,668,654,531,480 ways to display without such rigid motions. However, using Polya's enumeration, we show that there are 41,870,624,813 different(inequivalent) ways for the 1258 game. Furthermore, we calculated all possible ways to put n cards for any $n > 1$. Hence, the 1258 game is a good example containing a nice mathematical theory.

Doug Chatham Morehead State University

The Q Queens Problem with P Pawns

The *Q* Queens Problem With *P* Pawns March 25, 2019 Abstract The classic *n*-queens problem asks for arrangements of *n* mutually nonattacking queens on an *n* * *n* chessboard. In this talk, for *q* § *n* we look for arrangements of *q* queens and *p* pawns on an *n* * *n* board so that every pair of queens on the same row, column, or diagonal have at least one pawn between them. We apply the Hastings-Metropolis algorithm and compare results to those of other techniques. 1

Keith Brandt Rockhurst University

Breaking and Remaking the New Zealand Puzzle

The New Zealand puzzle consists of 16 square pieces that are to placed on a 4 by 4 grid. Each piece and each square in the grid has a theme—a kiwi bird, a fern, a sheep, a silhouette of the two main islands of New Zealand, or the letters "NZ." The goal of the puzzle is to place the pieces on the grid one at a time until the grid is completely covered by the pieces. The catch is that no piece may be placed on or next to a square with the same theme. (Once a piece is placed on a square, the theme of that square becomes that of its piece.) I will describe a recursive depth-first algorithm my student Serge Nevsky and I used to solve the puzzle (there are over 14,000 solutions), and I will describe our attempts to make the puzzle harder (that is, fewer solutions) by rearranging the themes on the board and the pieces. In the end, we were able to enumerate and solve all possible puzzles that fit the basic constraints of the original puzzle.

John Bonomo Westminster College

Back to the Tower

In a recent paper I showed an easy way to determine whether or not a given configuration of disks in a Tower of Hanoi puzzle was on the optimal solution path. This talk will give a quick review of this result and then show how it can be used to answer several other interesting questions about disk configurations generated by optimal solutions such as how often is one peg empty and how often is the any disk on the bottom of a stack.

Stanley R. Huddy Fairleigh Dickinson University
Nomin Sukhbaatar Fairleigh Dickinson University

You only need a bit of luck to win MTV's Are You The One?

Are You the One? is an MTV reality show in which a cast of single women and single men try to discover their "perfect" opposite-sex matches within the cast and earn money for doing so. MTV claims to use an extensive match-making process to determine which couples are "perfectly" matched, and the cast has 10 episodes to discover all of these (designated "perfect") matches. Each of the first four seasons of *Are You the One?* featured a cast of 10 couples. After viewing these seasons, we were surprised by the 100% success rate of each cast because they did not appear to use any strategy to discover the matches. However, in modeling the show, we find that even the most basic approach results in determining all 10 matches approximately 90% of the time, and that finding them 100% of the time just requires a few lucky guesses along the way. We model the show as an n-couple game with n rounds (shown in n TV episodes), and we develop three algorithms to pair the cast. We find that each algorithm can win a very high percentage of games with up to 10 couples. Along the way, we obtain a number of combinatorial results that provide insight into the complexity of the game.

Part C: Saturday, August 3, 9:00–11:40 AM, Room 233

Ryan Higginbottom Washington & Jefferson College

Equilibrium Patterns in the Candy-Sharing Circle

A well-known game called the candy-sharing circle is played this way: Position n players in a circle, each with a positive, even number of pieces of candy. Each player passes half their pile to their left and takes a piece from a common pile only if they end the round with an odd number of pieces. It is easily shown that a candy equilibrium is reached. In this talk we present initial results, for small numbers of players, concerning the equilibrium and the number of rounds played until equilibrium is reached.

Edmund A. Lamagna University of Rhode Island

Frogs + Puzzles = Algorithmic Thinking

Recreational mathematics provides a rich source of fun, interesting problems that can be used in the classroom to develop mathematical thinking and problem-solving skills. Several versions of peg solitaire in which frogs perform various feats, such as exchanging positions, are considered. While some of the puzzles are well known, the mathematics underlying their solutions is not. The problems offer a vehicle for learning about algorithms in an "unplugged" way, without computer programming. The puzzles considered involve significant mathematical content and provide a springboard into such topics as the analysis of algorithms, lower bounds and optimality, parity, and the generalization of solutions. The puzzles also promote the use of important problem-solving paradigms such starting with small cases and observing patterns to develop intuition about a problem.

David Nacin William Paterson University

Padovan, Pascal, and Proofs Without Words

The image of the golden spiral is perhaps the most famous picture in all of Mathematics. It is constructed simply by placing squares in such a way that the next one has no overlap. The side lengths in this construction are simply the Fibonacci numbers. If we repeat this same process with equilateral triangles, the side lengths give us a new sequence, one called the Padovan Numbers and identities are now based around the plastic number instead of the golden ratio. We briefly discuss the history of this sequence and how the architect Hans van der Laan first stumbled upon these numbers. We then move on by showing how this same sequence arises again and again in a number of counting problems involving dominoes, perfect matchings, compositions, and more. We present each of these through pictures alone and show how each one provides a method for finding the initial recurrence relation, as well as proving several identities. Our main result is a collection of new proofs without words that involve nothing more than a pyramid of dots in two different colors. It is possible to prove several of the most famous identities without either words or numbers, simply by associating each Padovan number with the correct diagonals of Pascal's triangle. We can strip the numbers off the triangle completely, and simply lets the dots dance and do the rest.

Eric Landquist Kutztown University
Isaac Reiter Kutztown University

Analyzing Playing Card Cryptosystems

Spies and soldiers alike have used so-called *hand ciphers* throughout history to send secret messages using little equipment beyond a pencil and paper. Modern secure communication, by contrast, requires computer software and hardware to execute various cryptosystems. However, a routine calculation shows that the entropy of a well-shuffled standard deck of playing cards has the potential to provide security to rival modern cryptosystems. Playing cards have the convenient feature that two suits have 26 cards, so the full deck can encode each uppercase and lowercase letter. For these reasons, Neal Stephenson, author of the novel *Cryptonomicon*, commissioned security expert Bruce Schneier to create a cryptosystem using playing cards. Since then, several other playing card ciphers have been designed. In this talk, we will describe and analyze the security of new hand ciphers that are designed to utilize playing cards and are inspired by numerous historical ciphers.

Stuart Boersma Central Washington University
Cheryl Beaver Western Oregon University

KRYPTOS: A Cryptanalysis Contest for Undergraduates

Solving cipher related puzzles has been a popular recreational pastime for hundreds of years. Since 2011 the authors have been organizing a cryptology contest for undergraduates. No special mathematics ability is assumed, just an interest in challenging cipher-related puzzles. Originally offered as a regional competition, KRYPTOS now attracts competitors from over a dozen states and a few countries. This paper will describe a variety of unique puzzles that were designed for this competition, provide strategies for applying mathematical and statistical reasoning to solve them, and share how others can become involved in this exciting recreational activity.

Genghmun Eng Self

World's First 19-Sided Perfect Enneadecagon Construction

We present the World's First 19-Sided Perfect Enneadecagon Geometrical Construction, with integrated geometrical trisections. This geometrical trisection, based on the square hyperbola, gave perfect heptagon and 13-sided Triskaidecagon constructions in prior MathFests. For MathFest 2016, algebraic formulas were derived for the 19-Sided Perfect Enneadecagon; the first regular polygon requiring two trisections. Cyclotomic polynomial analysis ultimately gives 2 trisection cubics, set by $\mathcal{L}(s)$ and $\mathcal{F}(y)$:
(1a) $\mathcal{L}(s) = s^3 + 1s^2 - 6s - 7 = (s - \Lambda_A)(s + |\Lambda_B|)(s + |\Lambda_C|) = 0$,
(1b) $\Lambda_A > 0$, $\Lambda_C < 0$, $\Lambda_B < 0$,
(1c) $\mathcal{F}(y) = [1y^5 - 4y^3 + 1y^2 + 2y - (\Lambda_A + 2)] = [1y^3 + |\Lambda_B|y^2 - (\Lambda_A + 1)y - (\Lambda_A + 2)][y^2 - |\Lambda_B|y + 1] = 0$.
The 1st trisection equation: $\cos(3\theta_o) = [4\cos^3(\theta_o) - 3cos^3(\theta_o)]$, and positive $\mathcal{L}(s)$ root Λ_A, give:
(2a) $\cos(3\theta_o) = 7/[2\sqrt{19}]$,
(2b) $s = \Lambda_A = (1/3)[2\sqrt{19}\cos(\theta_o) - 1] = 2.5070186440929763^{-}$.
The 2nd trisection equation: $\cos(3\phi_o) = [4\cos^3(\phi_o) - 3\cos^3(\phi_o)]$, and positive $\mathcal{F}(y)$ root, give:
(3a) $\cos(3\phi_o) = [10\Lambda_A + (((57)/(2\Lambda_A + 7)))]/[2\sqrt{2\Lambda_A + 7}(\Lambda_A + 2)] = ((29.8146365^{+})/(31.2437992^{+}))$,
(3b) $y = 2\cos(((2\pi)/(19))) = (1/3)[2\sqrt{2\Lambda_A + 7}\cos(\psi_o) - (((\Lambda_A + 3))/((\Lambda_A + 2)))] = 1.8916344834^{+}$.
Starting with any unit distance (1), the length y is constructed, deriving the World's First 19-Sided Perfect Enneadecagon Geometrical Construction having integrated trisections.

Michael Nathanson Saint Mary's College of California

Fibonacci and Adaptive Strategies to Beat the Streak!

In Major League Baseball's Beat the Streak game, every day competitors try to predict a player who will get a hit. The goal is to make 57 good choices in a row, something no one has yet accomplished. We use this competition as a jumping off point to discuss mathematical questions related to streaks. We start by addressing the basic question: If a coin comes up heads with probability p, what is the probability that when I flip it n times, I never get a streak of k heads in a row? Call this function $f(p, n, k)$. If $p = \frac{1}{2}$, this question is combinatorial, and the formula relating n and k arises from the generalized Fibonacci Numbers. We then extend this formula to the case of general p. We will also look at the level sets of the function $f(p, n, k)$ for a fixed value of k: If your task is to get $k = 2$ heads in row, would you rather flip a fair coin 6 times or a biased coin 3 times? Finally, we will discuss an adaptive aspect of Beat the Streak: On some days, you will feel more confident in your choice then others. If you have a 5-game streak and you believe that you have a 50% chance of extending it today, should you attempt it? Or is the better part of valor to sit this day out and hope that the probability will be higher tomorrow? This question is (apparently) less studied; and we will give some preliminary results. All questions are addressed using a variety of techniques from the undergraduate curriculum, and students are encouraged to attend.

Jay L. Schiffman Rowan University

Systematic Counting, Binomial Coefficients, Playoff Scenarios and the 150th Anniversary of The Cincinnati Reds

2019 commemorates the 150th Anniversary of America's oldest professional baseball club and MathFest is appropriately convening in the Queen City as part of the celebration! The Cincinnati Red Stockings were formed in 1869 and were undefeated in their inaugural season. In addition, 2019 marks the one hundredth anniversary of the Reds initial World Championship in the modern era, a five games to three decision over the Chicago White Sox who would make history themselves for somewhat dubious reasons one year later. This paper will examine all possible outcomes that can occur in a best of five League Division Series (1995-2018) and League Championship Series (1969-1984) as well as a best of seven League Championship Series (1985-2018) and the Wild Card Round (2012-2018) which is a win or go home format. We will historically examine those scenarios that have actually transpired throughout the years in these formats. Systematic enumeration and the diagonals in Pascal's Triangle play a role in the solution. We likewise unveil a number of playoff highlights as well as lowlights associated with the Reds franchise throughout the years. The rich history of the five time World Champion Cincinnati Reds will be explored as participants see the marriage of sports and recreational mathematics in full view in commemorating a milestone for both baseball and the Queen City.

Showcase of Modeling to Motivate Differential Equations

Part A: Friday, August 2, 10:10 AM–12:10 PM, Room 233

Organizers: Therese Shelton Southwestern University
Rosemary Farley Manhattan College
Patrice Tiffany Manhattan College

Differential equations is a pivotal STEM course. Student and faculty backgrounds, and departmental constraints provide for variations in the course. Modeling can be incorporated into any version to motivate the study of differential equations. Presenters will share modeling materials and data collection experiences that generate inquiry-oriented learning. Presenters may discuss the value of modeling, assessment techniques, pedagogical successes, and challenges.

Therese Shelton Southwestern University
Emma K. Groves North Carolina State University
Sherry Adrian Southwestern University

DE and Social Justice: A Cholera Model with Bacterial Reservoir

We present a system of differential equations that models the level of bacteria in the water for an SIRB model. Parameter values can distinguish severity of infection. We describe how cholera is intimately linked to issues of social justice.

Jonathan Oaks Macomb Community College

The Local Brewery: A Project to Introduce Differential Equations in an Into Calculus Course

In this session, participants will work through a short scenario that the presenter has used to introduce separable differential equations in an intro calculus course. The presenter chose to create a project for this particular topic after hearing from some of his former calculus students who told him that they were taking a differential equations course, and wish that they would have realized at the time that they were taking their calculus course that they were learning about separable differential equations. The presenter then realized that he needed to do something to try to make the topic more memorable and to stick in the students' minds. Hopefully, all participants will be inspired by this presentation to create projects for their courses that will not only be memorable but will also engage students. The inspiration for this project came from the presenter's love for beer, but also his participation in the National Science Foundation and SIMIODE's MINDE – Model INstructors in Differential Equations Workshop during the Summer of 2018. The project is based on a larger project described in the 2016 *PRIMUS* article, "The Local Brewery: A Project for Use in Differential Equations Courses," by Starling, Povich, and Findlay.

Andrew Sward Augustana College

Pursuit Curves for Accelerating Prey

The study of pursuit curves has been popularized recently by books such as *Zombies and Calculus* by Colin Adams, and *Chases and Escapes: The Mathematics of Pursuit and Evasion* by Paul Nahin. In this talk, we consider a 2D model of pursuit where the target is moving with constant acceleration, but the pursuer is moving with constant speed. We construct a differential equation of motion, and use numerical methods as well as geometric techniques to arrive at a conjecture on the relationship between the target acceleration, the pursuer speed, and the initial separation between them, in the critical case of when capture is just barely possible.

Hope McIlwain Mercer University

Humans vs. Zombies: A Phase Plane Analysis Activity

The game Humans versus Zombies has recently been popular on many college campuses. In this game, which reflects a larger interest in human-zombie behavior, two populations (Humans and Zombies) interact. As a part of a SIMIODE workshop, I developed a mathematical modeling activity which models the interaction between humans and zombies using the SIR model. In this talk, I will discuss how I developed the model as well as how I use the activity in my Differential Equations classroom.

Mary Vanderschoot Wheaton College
Danilo R. Diedrichs Wheaton College

Inquiry-oriented Approach to Teaching Differential Equations Through Modeling Projects

Wheaton College uses a modeling-driven approach in teaching Differential Equations by incorporating several modeling projects throughout the course. We present several creative variations on canonical models (solution flowing into a tank, mass on a spring, predator-prey) that cater to students majoring in economics, physics, environmental science, and social science. We show how these projects not only promote understanding, but also increase students' ability to work in groups and to communicate assumptions and results in written form with clarity and professionalism as a scientific report. Finally, we discuss the challenges and logistical issues related to group dynamics and assessment of group projects.

Part B: Friday, August 2, 1:30–4:10 PM, Room 233

Timothy Lucas Pepperdine University

Mobile Apps that Enhance Modeling in Ordinary and Partial Differential Equations

Introducing mathematical models motivates the study of important classes of linear and nonlinear differential equations and systems. A key to understanding those models is visualizing slopefields, phase planes and solutions. I introduce two mobile apps developed by faculty and students at Pepperdine University that allow users to explore numerical methods and graphical solutions to ordinary and partial differential equations. *Slopes* contains activities for investigating slopefields, phase planes, oscillations and explicit numerical methods. *Waves* allows users to plot and animate Fourier series as well as solutions to the heat and wave equations. Both apps are currently available for the iPhone and iPad, which are highly portable and feature larger touch screens that allow students to view and manipulate content easily. Research based on observations of mathematics courses at Pepperdine University has shown that students are more willing to collaborate and share their results when using tablets such as the iPad (Fisher, Lucas et al. 2013). I will discuss how the apps enhance group-based modeling activities as well as semester-long modeling projects. The intuitive interfaces of *Slopes* and *Waves* invite students to fully immerse themselves in the world of differential equations so that they can understand the models from not only algebraic, but also graphical and numerical perspectives.

Jean Marie Linhart Central Washington University
Gary Epp Central Washington University

Modeling with Census Data: the United States and Guatemala

The United States census data is readily available and offers an opportunity to motivate study of differential equations. The census data for Guatemala was recently been added to Guatemala's Wikipedia page, and provides a contrast to the population data for the United States. Students can review the concept of differentiation and estimate the derivative of population with respect to time from either data set, and from this calculate the per capita population growth rate. The exponential model is derived from the assumption that the per capita population growth rate is constant, and the logistic model is derived from the assumption that the per capita population growth rate is linearly decreasing as population increases. Both provide introductory lessons in solving differential equations by separation of variables. While the per capita population growth rate data for the United States population reasonably matches the assumptions for the exponential and logistic models, the Guatemala data provides a contrast, and demands the exploration of a different population model.

Jiyeon Suh Grand Valley State University
Ciana Witherell Grand Valley State University

Flutter Mode vs. Resonance

SIMIODE (www.simiode.org) is a community of practice dedicated to using modeling to teach differential equations. Among many supporting contents, there is an extensive collection of modeling activities accumulated over time through contributions of educators all over the world. We want to share our experience of implementing some of them for the group project component in a differential equations course at Grand Valley State University. In this talk, we will share a story of what happened with the group project on the study of Resonance, and how it led students to open the door to the world of Aerodynamics!

Tyler Skorczewski University of Wisconsin Stout

Modeling Ornate Box Turtle Shell Growth

Ornate box turtles are found throughout the Midwest from Wisconsin to Texas. In this project we model the growth of Ornate box turtle shells via differential equations in a mathematical biology class consisting of mathematics and biology majors. Using data collected from Ornate box turtles in Iowa, students first describe phenomenological models such as von Bertalanffy or logistic differential equations, before discussing mechanistic differential equation models such as those created through dynamic energy budget theory. In this project students not only calculate and interpret equilibrium solutions to differential equations, but also whether it is proper to assume equilibrium solutions exist and thus connect biological concepts to mathematical ones.

Na Yu Lawrence Technological University

Simple Walking in 2-dimensional Space: Model and Experiment

Our research seeks to model the mechanisms of the human gait in both the stable state and unstable conditions. At the current stage, we are focusing on a simple, two-dimensional dynamical system simulating human legs as constrained movable double pendulum. We test the model with human gait data collected at the Biomedical Engineering laboratory. In the future, we intend to expand the model into three-dimensional space via mathematical modeling and experimental data.

Malgorzata A. Marciniak City University of New York

Modeling Thermal Data with Differential Equations for Sports and Engineering

Ordinary differential equations course offered at LaGuardia Community College of the City University of New York is directed mainly to engineering students with various mathematical strengths and backgrounds. The diversity of the student body in not only characterized by math level and type of engineering but also by students' ethnic background, country of origin, and language skills. This motivates individualized modeling projects that students prepare in groups and present as a team. Most project topics follow suggestions from the textbook, but some are invented by students. During my presentation I will describe two creative projects that involve modeling with data obtained by students using thermal camera and thermal sensor. One project reflects on heating of body muscles during exercising and cooling down afterward. The second project involves modeling the temperature of the solar panel based on the irradiance data collected by students with a pyranometer.

Ibukun Amusan Kentucky State University

Incorporating Projects into a Differential Equations Course: Torricelli's Law of Fluid Flow

This talk will discuss how projects have been used to motivate and engage students in a differential equations course. Some of the projects used will be presented, including Torricelli's Law for the flow of liquid under gravity. The successes and challenges encountered will also be discussed.

Hasala Senpathy K. Gallolu Kankanamalage Roger Williams University

Stability of Interconnected Automobile Platoons

Stability analysis of interconnected systems is an important area of control theory. Designing of efficient automobile platoons, smart automobile systems and adaptive cruise controls depend on string stability of interconnected systems. Despite the variety of applications, this serves as a reasonable platform for student undergraduate research projects. Current work is based on model based approach of string stability of interconnected automobile systems. The work is supported by simulation based validation.

Teaching Mathematics Through Games

Part A: Friday, August 2, 10:10 AM–12:10 PM, Room 206

Organizers: Heidi Hulsizer Benedictine College
Nickolas Hein Benedictine College
Mindy Capaldi Valparaiso University
Martha H. Byrne Sonoma State University

Come see methods for engaging students in mathematics through the development or play of board, card, and video games. Developing a game often requires the application of mathematics and it also appears in how one plays the game. Presentations describe class activities, class projects, or undergraduate research applications of mathematics. This session will be of interest to gamers and instructors.

Jorge Nuno Silva University of Lisbon

Recreational Mathematics. What? How? Why?

The relevance of Recreational Mathematics (RM) is based on several viewpoints. First, many "serious" fields of mathematics have recreational origins (Graph Theory/Bridges of Koenigsberg, Hamiltonian graphs/Icosian game, Probability theory/games of chance, Gray codes/Tower of Hanoi). RM's pedagogical utility cannot be overestimated, and the ancient Babylonians and Egyptians certainly did not. It is a natural vehicle for communicating the multicultural aspects of mathematics, an invaluable tool for the ethnomathematician. Its questions are understood by many, even if solved by only a few. This invitation to the abstract hits students as well as the general public. One name comes to mind: Martin Gardner. His work promoted mathematics pleasantly and effectively. For the historian of mathematics, the genealogy of recreational activities, as problems and tricks (with cards, numbers, etc.) is important. These recreations function as historical markers, helping understand the spreading of mathematical ideas. The rhyme "Going to St. Ives" , popular in the UK and present in Fibonacci, has roots in ancient Egypt (Rhind Papyrus 79). The evolution of the recreational character of mathematical questions gives us also information about the appearance of new theories that, with the generality of their methods, transform recreations in end of the chapter exercises. In our presentation we will survey the activities that the author, together with other members of Associação Ludus, implemented in Portugal. Among these we will focus on the *National Championship of Mathematical Games* (100,000+ each year) and the *Mathematical Circus*, a group that puts on a real Circus show in which all the effects are strictly mathematical.

Amanda Harsy Lewis University
Marie Meyer Lewis University
Brittany Stephenson Lewis University
Michael Smith Lewis University

Learning Mathematics through Games in a General Education Mathematics Course

In the fall of 2019, we introduced a new mathematics general education course called "Win, Lose, or Draw." This course was developed by Dr. Karen Holmes of Butler University and uses games like poker, roulette, sudoku, risk, and blackjack to motivate quantitative and analytical reasoning. This talk shares our experience implementing this general education course and includes the preliminary results of a study which explores the overall perceptions and attitudes of students in this course as compared with a more traditionally taught College Mathematics course.

Adam M. Glesser California State University, Fullerton
Matt Rathbun California State University, Fullerton

Problem Solving Through Board Games

At California State University, Fullerton, we have developed a course, "Strategies of Problem Solving", that teaches our incoming students about mathematical problem solving through games, logic puzzles, riddles, paradoxes, and contest problems. In this talk, we will focus on various ways in which we turned our passion for modern board gaming into a significant learning experience for our math majors, one that helps them transition from procedural thinking into conceptual thinking, and which stresses the beauty, creativity, and open-endedness of mathematical practice.

Axel Brandt Northern Kentucky University

Winning in a Quantitative Literacy Course

Quantitative literacy courses often seek to introduce students to a wide range of mathematical concepts in accessible ways. In this talk, we present some combinatorial games with both a low floor and a high ceiling. We will discuss how classroom activities centered around these games can be used to emphasize structured mathematical thought, generate student interest in deeper mathematical questions, and (anecdotally) contribute to students' self-efficacy.

Christopher Ryan Loga Southwestern Adventist University

A Simple Card Demonstration to Engage College Algebra Students

When teaching a College Algebra course it is often a challenge to find applications that are both useful and engaging for students. In this talk/demonstration, I will perform a simple self-working card trick which I have used in my College Algebra class. The basic mechanism for the trick involves generating piles of cards and then exploiting how the stacks were formed to "predict" a card at the top of one pile. While simple in both execution and explanation, the math involved is elementary to the point that it allows for further student experimentation in altering the original trick.

David Clark Grand Valley State University
Feryal Alayont Grand Valley State University

Graph Theory Games Designed by Pre-service Teachers

Our discrete mathematics course is required for all pre-service math teachers. To engage students both with new mathematical content and with their intended careers, we have created a semester-long game-design project. Groups of students learn new graph theory content on their own and create original games based on these topics. Our students then visit a middle school classroom of a teacher we partner with, where they teach and play the games with middle school student groups. We will describe the logistics of this project and the benefits that we have observed for students, and we will give some practical advice for those interested in implementing a similar project in their own classes.

Part B: Friday, August 2, 1:30–3:30 PM, Room 206

Michael Martinez Charleston Southern University

Using Apples to Apples to teach Set Theory

The concepts of set theory are relatively straightforward, but the terminology and details can be a barrier to entry for students in introductory math courses. After a few years of teaching set theory in a service level class, I have have begun using the game "Apples to Apples" to introduce the ideas in a way that the students find engaging and accessible. In this talk I will share the ways that I use the game and some of the modifications to the rules that have been made to adapt it to a classroom setting.

Benjamin Peet St. Martin's Univeristy

Integrating Puzzles and General Problem Solving Techniques into Undergraduate Mathematics Classes

This paper first summarizes the empirical research and anecdotal evidence of the benefits of puzzles in mathematics education at the undergraduate level. We then list a set of general problem solving techniques that offer a framework to solving puzzles, before offering an example set of puzzles with reference to the stated solving techniques. We set out a proposed structure with examples for how these problem solving techniques can be applied to traditional mathematics curriculum problems, specifically using small group projects with students presenting their solutions.

William T. Jamieson Southern New Hampshire University

Undergraduate Research with Lights Out

Lights Out is a game which was introduced by Tiger Electronics in 1995. The game consists of a 5×5 grid of backlit buttons, some of which are illuminated at the onset of the game. When a button is pressed, the light behind the button is toggled, along with the lights of the buttons directly above, below, to the left, and to the right of the pressed button. The objective of the game is to turn off all of the lights. Lights Out has attracted a fair amount of attention from the mathematics and computer science community after Anderson and Feil made the observation that a Lights Out game could be solved by row reducing a particular matrix in modulo two. This presentation will discuss several undergraduate research projects that are focused on modifications of the action of a button press.

Joshua Steier Seton Hall University

World of Mathcraft: How Mathematical Analysis of Video Games leads to Optimal Player Performance.

Theorycrafting, which is the mathematical analysis of videogames is prevalent in Massively Multiplayer Online Role Playing Games (MMORPG) will be demonstrated using World of Warcraft as an example. In World of Warcraft, mathematical models may be constructed to analyze and simulate damage over time(DPS) for warlocks. Warlocks primarily cast spells, and three possible specialization configurations exist: affliction, demonology, and destruction. Prediction of optimally selected specializations, items and rotations are examined. A rotation is simply a sequence of casted spells. Although this is a specific case, it may be generalized to any class in World of Warcraft. Students would learn how to construct mathematical models, simulate them and analyze data to predict optimal choices in MMORPGs. Keywords-MMORPG, Mathematical Modeling, Simulation, Data Analysis, C++, World of Warcraft

Mike Spivey University of Puget Sound

Mathematics in Interactive Fiction: A Beauty Cold and Austere

Interactive fiction is one of the oldest computer game genres, dating back to the 1970s with titles like *Zork* and *Adventure*. Since then there have been many works of interactive fiction that have featured mathematical ideas or required mathematical thinking, such as *Trinity* (with its Klein bottle puzzle), *Beyond Zork* (Zeno's bridge), and *Spellbreaker* (the twelve-coin balance puzzle). The puzzles in these games succeed in presenting mathematical ideas in a format in which people don't generally encounter mathematics: interactive narrative. However, as interesting as they are, the puzzles are merely one-off set pieces in larger games that aren't really about mathematics. In 2017 I wrote a work of interactive fiction, *A Beauty Cold and Austere*, that is about mathematics from start to finish. In the game the player must navigate a dream world in the process of preparing for an upcoming final exam in a survey of mathematics course. To win the game the player must solve a series of puzzles that require engaging ideas from a variety of areas of mathematics, such as algebra, geometry, probability, calculus, linear algebra, graph theory, infinite series, and complex numbers, to name a few. The player essentially recreates the history of mathematical thought over the course of the game, meeting several famous mathematicians in addition to solving a large number of mathematics-based puzzles. The game was well-received, placing 7th (out of 79 works) in the 2017 Interactive Fiction Competition and earning a "Best Puzzles" nomination for 2017 interactive fiction games. This talk will consist of a demonstration of some of the puzzles in *A Beauty Cold and Austere* as well as some commentary on the use of interactive, text-based narrative to engage mathematical ideas.

Sarang Aravamuthan FogLogic

Activity Based Gaming

Games (two- and multiplayer) are induced by activities that can be completed in different ways, provided a value is associated with each completion. The scores of each player are derived from the value at completion and the *minimax* value of the activity. We show how to compute the minimax value using a *game tree* and illustrate these ideas with combinatorial examples on planar graphs and checkerboards. We highlight some of the challenges encountered in transitioning from a two-player to a multiplayer game. We conclude by introducing the concept of *fair* games wherein the players are equally likely to win under random play and show how such games can be realized.

Understanding Mathematics Through its History

Part A: Friday, August 2, 10:10 AM–12:10 PM, Rooms 207 & 208

Organizer: Erik R. Tou University of Washington

Many mathematical concepts experienced a long and complex evolution before arriving on the pages of today's undergraduate textbooks. Often, understanding some of this history can greatly enhance a student's understanding of mathematics. Moreover, an exploration of history can show how mathematics is connected to the wider world of human inquiry, affected by the same cultural values and prejudices as other subjects. This session seeks to share interesting historical episodes or developments linked to undergraduate mathematics, for the benefit of students and teachers alike.

Bill Linderman King University

Archimedes' Quadrature of the Parabola

Archimedes showed that the region bounded by a parabola and a chord is equal to four thirds of the area of the triangle with its base as the segment of the chord and with its height as the distance from the chord to the point on the parabola whose tangent is parallel to the chord. We explore the method of exhaustion Archimedes used to establish this result and then show how examples can easily be verified using a little calculus and linear algebra.

Holly Attenborough University of Wisconsin-Platteville

The Ideal Result of Fermat's Taunt

In 1637, Pierre de Fermat scribbled in the margin of a book what is now known as Fermat's Last Theorem. Directly below the conjecture he wrote, "I have a truly marvelous proof of this theorem, which this margin is too narrow to contain." These words taunted mathematicians for centuries; the theorem was not proven until 1995 by Andrew Wiles of Princeton University. This talk will explain how the struggle to prove this theorem shaped modern algebra with the introduction of ideals.

Daniel Otero Xavier University

Completing the Square with al-Khwārizmī: a TRIUMPHS PSP

Muammad ibn Mūsā al-Khwārizmī (ca. 780-850 CE) is one of the great legendary figures in the history of mathematics. Considered the "father of algebra," his treatise, *Al-kitāb al-mukhtaṣar fī ḥisāb al-ğabr wa'l-muqābala* (*The Compendious Book on Calculation by Restoration and Reduction*), was the first systematic approach to numerical problem solving and gave us the term "algebra." This talk will describe a new Primary Source Project by one of the principal investigators of the TRIUMPHS (TRansforming Instruction in Undergraduate Mathematics via Primary Historical Sources) project which uses text from al-Khwārizmī's *Algebra* to teach students the algebraic technique of completing the square and to help them derive the quadratic formula.

William Branson St Cloud State University

Rules and Demonstration in Cardano's *Ars Magna* (1545)

The interaction between rules and demonstrations in Cardano's *Ars Magna* (1545) can be taken to illustrate two aspects of mathematical work: discovery and justification. Perhaps the rules are what we would call conjectures, and the demonstrations proofs. However, I will suggest that the rules are connected to a broader trend in 16^{th} century thought, namely the artisanal epistemology, in which the rules of the various arts are justified by the tacit knowledge that artisans bring to their crafts. Cardano, I propose, takes this attitude towards his mathematical rules—his rules for algebra are justified by the knowledge skillful algebraists bring to their work, and that this is enough ground for taking the rules to be true, although they are not yet demonstrated.

Jerry M. Lodder New Mexico State University

Figurate Numbers from Nicomachus to Pascal

We outline material germane to both discrete mathematics and general education based on elementary properties of the figurate numbers. Beginning with the work of Nicomachus of Gerasa, we witness a verbal and geometric description of the numbers arising by placing dots in regularly shaped figures, such as triangles, squares, pyramids, etc. Nicomachus's strategy for constructing these numbers can be described (today) as either recursive or iterative, depending on whether the numbers are build up from just a single previous object or in series from some initial object. We then consider Fermat's statements about the higher dimensional figurate numbers, such as the triangulo-triangular numbers, and see how iteration (integration?) allows us to reach into these dimensions. Finally, Pascal constructs his arithmetical triangle by using a universal recursion relation for the figurate numbers in all dimensions. He finds many patterns in the resulting table, including a universal iterative formula for the figurate numbers and a ratio of numbers in consecutive dimensions subtle enough to give a formula for any entry in the table. Pascal then offers a verbal description for the computation of combinations, equivalent to his recursive formula. Together with the latter formula, we are led to the modern formula for combinations, known as n choose k.

Anne Duffee Sewanee: the University of the South

Introducing Topology via Euler's Formula

In this talk, I show how the conjecture at the heart of Euler's formula regarding polyhedra gives rise to modern algebraic topology, and how the process of investigating proofs and major counterexamples of the formula laid the foundation for this branch of mathematics. In particular, I endeavor to show how the natural questions about polyhedral characteristics give rise to considerations about a qualitative geometry–a rubber sheet geometry–and how this narrative can be used to motivated the "whys" of topology to fresh undergraduate topology students. I further argue that presenting the historical development of topology through investigation of a conjecture more accurately reflects the mathematical process, and that as a pedagogical tool, it serves the student better than a simple investigation of foundational definitions and theorems absent of context. The historical development of granular definitions reflects the mathematical process, one of conjecture and refinement; accordingly, the varied responses to Euler's "proof" of his polyhedra formula yield insight into how the mathematical community investigates new hypotheses within the discipline at large.

Part B: Friday, August 2, 1:30–4:30 PM, Rooms 207 & 208

Eugene Boman Penn State, Harrisburg Campus
Robert R. Rogers SUNY Fredonia

The History of Calculus as a Guide to Teaching Calculus

Most Calculus texts written since the mid 1950s invert the history of the subject by first presenting concepts and definitions which were developed long after Calculus was first introduced by Newton and Leibniz. Thus, for example, the modern definition of the limit, first stated by Weierstrauss in the late 1800s, is the first topic in a modern textbook, whereas Leibniz's "useful fiction" of a differential quantity (dx) is normally completely ignored, at least until the second semester where it appears – mysteriously – as an underlying concept supporting the integration techniques. This is despite the fact that the differential idea was the defacto foundation of Differential Calculus (hence the name) for nearly 200 years. This inversion is not only not necessary but, in our opinion is counter-productive.We will present the idea and goal of using the history of Calculus – specifically the introduction of ideas in their chronological order – as a guide to its teaching. Since there are no existing textbooks that support this approach, we have taken on the task of writing a Calculus text which specifically incorporates the history of the topic into its teaching.

Robert E. Bradley Adelphi University, Garden City, MY 11530

Because We Can: Proving the Generalized Binomial Theorem without Calculus

Newton discovered the General Binomial Theorem in the 1660s. Although he could demonstrate that it was true in many special cases, he did not initially have a general proof. Taylor's theorem provides a satisfactory proof that is within the grasp of a modern undergraduate, but an elementary proof (one not requiring the differential calculus) was considered desirable. Such a proof was finally given in 1775 by Euler (E465). It became widely known in a somewhat more polished form thanks to Cauchy's *Cours d'analyse* (1821). We investigate the historical and pedagogical reasons for preferring elementary proofs over calculus-based ones and present details of the Euler-Cauchy proof.

Alexander J. Barrios Carleton College

A Historical Approach to Infinite Series

In this talk, we outline the timeline in which the results covered in a first course on series and sequences were discovered. We also discuss how a calculus course can be restructured so that students experience the timeline and original questions that motivated mathematicians between the seventeenth and nineteenth century. This, in turn, humanizes the content matter by showcasing the many mathematicians involved in laying the foundations of infinite series.

Erik R. Tou University of Washington, Tacoma

The Totient Function Was Neither a Totient Nor a Function

Leonhard Euler's totient function, $\phi(n)$, is an important object in number theory, counting the number of positive integers less than or equal to n which are relatively prime to n. It has been applied to subjects as diverse as constructible polygons and Internet cryptography. In this talk, we trace its development through the centuries, from Euler to Carl Gauss to J. J. Sylvester. Along the way, we'll discover how and when the words *totient* and *function* were applied to this concept.

Janet H. Barnett Colorado State University - Pueblo

Gnomonic Explorations: A Primary Source Project in Number Theory for Mathematics Majors, Elementary Teachers and Others

In his commentary on Euclid's proof of the Pythagorean Theorem, Proclus (c. 411–485 CE) described two methods of generating Pythagorean triples. Although their actual discovery is now hidden in the long shadow of history, both methods remain of interest in number theory today. Proclus' simple description of how to generate Pythagorean triples using each method offered no speculation about how these algorithms may have been discovered. In this talk, we describe a mini-Primary Source Project that provides students the opportunity to explore how these methods might have become known through an intriguing theory related to the Greek notion of a *gnomon*. An overview of the rationale which guides the NSF-funded project Transforming Undergraduate Mathematics via Primary Historical Sources (TRIUMPHS) that is supporting the development of a collection of similar student projects across the entire undergraduate mathematics curriculum will also be provided.

Amy Ackerberg-Hastings Independent Scholar

Mathematics in Astronomy at Harvard College Before 1839

While it was by no means a universal phenomenon, mathematics professors in the 18th and 19th centuries in Western Europe and North America often were called upon to teach astronomy. This practice was especially notable and long-lived at Harvard, where John Winthrop (1714-1779) famously took two students to Newfoundland to observe the 1761 transit of Venus and John Farrar (1779-1853) wrote about comets and advocated for the construction of an observatory. The talk will explore the extent to which the astronomy instruction offered by these men and other holders of the Hollis Chair of Mathematics and Natural Philosophy was mathematical, although it will probably focus most on the 1827 translation of Jean-Baptiste Biot's *Traité élémentaire d'astronomie physique* (2nd ed., Paris, 1811), which had Farrar's name on the title page. The establishment of the Harvard College Observatory in 1839 provides a convenient ending point, in part because by then Benjamin Peirce (1809-1880) was also in the process of reshaping the Department of Mathematics.

Emily Dennett Ohio State
Chris Bolognese Columbus Academy

Humanizing Mathematics Via Student-Generated Math History Plays

Abstract Title: Humanizing Mathematics Via Student-Generated Math History Plays Abstract: Mathematics history is rarely integrated in mathematics classrooms. When presented, it often is in the form of anecdotes about prominent mathematicians, often white males (Hottinger, 2016). But teaching and learning *through* hi story provides many affordances. Wilson and Chauvot (2000) state that mathematics history connects periods of time, different cultures, and different regions. Pedagogically, there are increased assessment opportunities and cross-curricular connections such as the presentation of projects, writing, and reading (Fauvel & van Maanen, 1997). In this session, we will share our experiences developing and implementing a project that tasked students with writing one-act plays about a mathematician and a piece of mathematics they developed. The project was motivated by attending a few sessions at the ESU-8 *History and Epistemology in Mathematics Education Conference* where plays were used to tell various stories of math history. Yet, these plays were already researched and scripted, prompting the opportunity for students to generate and act out their own plays. We found this project helped students to connect personally to mathematics history, and generated motivation to think about mathematical topics that are usually beyond the scope of high school and early college classrooms. By sharing this project, we hope to inspire other mathematics educators to use mathematics history to challenge dominant narratives surrounding who does mathematics.

Charlie Smith Park University

Challenging the Establishment

Many great mathematical achievements have occurred as a result of breaking the rules, that is, defying authority. Examples include the Copernican Revolution, the discovery of non-Euclidean geometries by Bolyai and Lobachevsky, and Georg Cantor's theory of transfinite numbers. This presentation will highlight certain solutions of the classical construction problems. By the authority of Plato, all geometric constructions were to be performed using the compass and straightedge. This insistence on employing only lines and circles turned out to be inadequate for the future of mathematics. In fact, ancient Greeks and others found ingenious ways to break the rules in successful attempts to double the cube, trisect an angle, and square the circle. These creative "constructions" induced progress in geometry, notably by the invention of special curves and mechanical contrivances. Some examples of this are in the following list. Conchoid of Nicomedes Quadratix of Hippias Spiral of Archimedes Conic Sections Cissoid of Diocles Insertion Principle Trisectrix Note to Organizers Originally, I thought of including the discovery of non-Euclidean geometries by Bolyai and Lobachevsky (and Gauss), as well as Georg Cantor's theory of infinite magnitudes. In both cases, there was a titanic rebellion against the mathematical status quo and its historical foundations. In both cases, the results were controversial and there were repercussions against those who dared to explore the forbidden territory. However, I soon realized that I would need more time than the allowed 15-20 minutes.

Mark A. Branson Stevenson University

Exploring Mathematics, Art, and History in Spain

The history of Spain intersects with a number of interesting historical and artistic developments - the expansion of Islam around the Mediterranean, the spread of knowledge during the Renaissance, and the emergence of modernism in the early 20th century - which are also deeply tied to the historical development of mathematics. I'll talk about using these historical connections to help students understand the connections between mathematics and art in a faculty-led travel course. These historical connections help students understand why artists made the choices they did, and how historical developments supported the spread of mathematical and artistic movements.

General Contributed Poster Sessions

Given last year's success with the MAA Contributed Poster Session (CPS), the MAA is pleased to continue with this session at MathFest 2019 in Cincinnati. We will rotate the poster categories throughout the meeting and the number of rotations will depend on the number of accepted posters. The MAA will provide corkboards or trifolds for the posters – you just need to bring your poster.

General Contributed Poster Session I

Thursday, August 1, 10:00–10:45 AM, Grand Ballroom B

Courtney Fox Clermont Northeastern High School/University of Cincinnati

The Integration of Mathematics and Science: A Plan for a High School Integrated Pre-Calculus and Physics Course

This paper explores the integration of mathematics and science as a means to improve learning for high school students. Scholars have acknowledged the benefits of integration for over 50 years, but we have failed in large measure to adopt an integrative curriculum in public high schools across the country. This work provides a synthesis of the literature that supports these ideas and explores the barriers in our education system that prevent us from integrating curricula. The goal of this work is to provide a corrective to this problem by creating a practical curriculum for an integrated Pre-Calculus and Physics course. Included with this curriculum are suggestions for implementation, sample lesson plans, and a full curriculum map and pacing for both courses.

Diana Cheng Towson University
Rachael Talbert Towson University
Kimberly Corum Towson University

Towson University's Pre-Service Teachers' STEM Modeling Activities with Baltimore City Middle School Students

As one of the leaders in teacher preparation in Maryland, Towson University (TU) has a number of partnerships with K-12 schools across the state. One such partnership is the Math Education Club at TU and the Afya Public Charter School, a Baltimore City Public School. Since 2015, middle school students from Afya have attended daylong field trip experiences at TU, and have gained exposure to college life by interacting with faculty and students on campus. TU mathematics pre-service teachers have conducted after-school workshops at Afya, and have disseminated the activities they implemented with the Math Club through regional, state, and national conference presentations.

Rachel Schmitz Towson University

Dancing Through Mathematics: Kinesthetic Activities in Figure Skating Camps

A graduate student at Towson University designed and implemented activities relating mathematics and the art of figure skating for a summer camp in Baltimore, Maryland. These activities used geometric and algebraic concepts to analyze photographs of figure skaters and their movements. In order to spark interest in the mathematics that underlies ice skating, these activities embody kinesthetic and visual learning.

Rachel Balthrop Cheatham County Central High School
Kassi Rye Northwest High School
Jackie Vogel Austin Peay State University

Mathematical Misconceptions and Teaching Implications at the Secondary Level

Misconceptions in mathematics follow students throughout their education, all the way up to the secondary level. This paper focuses on several misconceptions that students bring to the classroom upon entering high school and highlights that these misconceptions can be combated with effective teaching practices such as modeling, exploration, and using contextual situations. By implementing more effective teaching practices, teachers are also able to teach more deeply in regards to the mathematical practice standards. The implication of identifying and addressing misconceptions at the high school level can only help students and teachers alike. Once the misconceptions have been brought to light, students will have a better understanding of the content as they continue to move through mathematics at a higher level.

Liz Andrus Utah Valley University
Daniel Horns Utah Valley University
Violeta Vasilevska Utah Valley University
Krista Ruggles Utah Valley University

UVU PREP - Intensive Summer STEM Program

To address the need for early preparation in mathematics, Utah Valley University (UVU) initiated the summer intensive program PREP (*https://www.uvu.edu/partnership/prep/*) in 2013, patterned after The University of Texas at San Antonio program. The PREP program identifies low-income, underrepresented, first-generation, and female students entering seventh grade who have an interest and aptitude in math and science and involves them in this seven-week, three-year summer intensive STEM program. In 2016, UVU was awarded an NSF-INCLUDES grant that allowed the creation of UTAH PREP collaboration with other PREP sites in Utah and the development of a shared measurement system. In this poster presentation, the structure and course content of the UVU PREP program will be discussed. In addition, some of the survey results and data collected as part of the NSF-INCLUDES grant will be shared.

Lauren DeDieu University of Calgary

Math Outreach Activities for Secondary School Students

During the past 3 years I have been very involved with enrichment and outreach initiatives for junior high and high school students. These activities include a weekly problem-solving session, coordinating competitions for junior high school students, and creating an interactive math session for Indigenous high school students from across Canada. This summer, I organized is the *2019 CMS Regional Math Camp (Alberta).* This week-long summer camp brought grades 7 - 10 students from across Alberta to the University of Calgary. This spring, I also created a brand-new enrichment program, *Girls Excel in Math (GEM) Calgary*. GEM is a Saturday morning program for grades 6 - 8 girls who are interested in having fun exploring mathematical topics that they would not normally see in the classroom. In this poster, I will share information about the events I have organized and the curriculum I've used. This poster is meant to spark a discussion about best practices in sharing mathematics with the wider community and how to reach underrepresented groups.

Iris Tong University of Illinois at Urbana-Champaign
Kagen Quiballo University of Illinois at Urbana-Champaign

Sorting: Easy as 1, 2, 3!

As a part of a semester-long project, we create outreach material for students in grades K-12. These lesson plans are tested out in local Champaign-Urbana schools. "Sorting: Easy as 1,2,3!" is a lesson plan designed for sixth through eighth graders. Sorting algorithms are used to rearrange a group of objects. In this activity, students explore four different sorting algorithms: bubble sort, merge, sort, selection sort, and insertion sort. The poster will include content objectives, teacher instruction, and classroom results. This project was created under the Illinois Geometry Lab at the University of Illinois at Urbana-Champaign Department of Mathematics.

Yasir Silviano Badillo Acosta University of Illinois Urbana-Champaign
Kelly A. Jezior University of Illinois Urbana-Champaign
Iris Y. Tong University of Illinois Urbana-Champaign
Kagen J. Quiballo University of Illinois Urbana-Champaign

Coloring Mapematics!

We are a part of a project that creates outreach material to share mathematical concepts with K-12 students. The project focuses on developing engaging lesson plans that will be available for others to use in various settings. This poster will present the Four Color Theorem lesson plan: aimed for 2nd and 3rd grade students. Using Melinda Lanius' Four Color Fest Activity Booklet, the team developed activities where students would explore map structure that need at most 4 colors to be properly colored in. The project team tested the lesson plan with a group of students form the DREAAM House organization at University High School. This year-long project was an undergraduate research project done through the Illinois Geometry Lab at the University of Illinois Urbana-Champaign. Through the activities we created, we hope to share exciting topics and spark a greater interest in mathematics.

Brian Winkel SIMIODE

Examples of real Time Modeling in Differential Equations Courses

We describe several real time modeling activities for use in differential equations course. These materials consists of Modeling Scenarios and are part of a larger body of resources from SIMIODE (*www.simiode.org/org*), a Community of Practice freely open to all and currently supported by the National Science Foundation. We will consider situations involving sublimation of carbon dioxide, m&m population dynamics, falling column of water, and estimating weight of rock samples. We will also point to activities which use data collected from the literature, e.g., LSD and math tasks, falling coffee filters, intraocular gas following eye surgery.

Joan Lubben Dakota Wesleyan University

Resequencing Calculus at a Small Liberal Arts College: Balancing the Needs of Math Majors and Pre-Meds within Staffing Budget Constraints

Traditionally, Calculus I and II are the prerequisites for other mathematics courses, yet in small colleges the budget dictates that only one "flavor" of these courses be offered and that the upper level (and lower enrollment) courses be taught on a 2-3 year rotating cycle. Furthermore, students majoring in the life sciences require a more applied approach and at our school, those students tend to out-number the mathematics majors in our first semester calculus class. In this talk, I will present how we at Dakota Wesleyan University restructured the calculus sequence in order to balance the needs of our mathematics majors with our biology/biochemistry majors, yet reduced the overall staffing load and added one more upper level course for our mathematics majors.

Chris Oehrlein Oklahoma City Community College

A POGIL-Style Activity to Introduce or Review Vectors

Understanding vectors is crucial for any student wanting to study physics, engineering, architecture, etc. However, even after students are repeatedly lectured and shown vector concepts and calculations (sometimes multiple times in different courses), they continue to make the same kinds of comprehension, calculation, and reporting errors. Maybe a different approach is needed. Instead of continuing to show-and-tell our students about vectors, let's guide them through understanding what vectors are and how to use them. I will show a guided inquiry activity that I use in trigonometry, calculus, and physics (for health professions students with NO trigonometry background required) that completely introduces (or in some cases, reviews) basic concepts and calculation techniques involving vectors.

Jenna P. Carpenter Campbell University

StatPREP: Transforming Intro Stat using a Data-Centered Approach

StatPREP is an NSF-funded project that aims to foster the widespread use of data-centered methods and pedagogies in introductory statistics courses. The goal is to enhance the preparation of students to meet the demands of a data-driven workplace and to use the newly available resources in our data-centric world. A collaboration between the MAA, AMATYC and ASA, StatPREP works directly with college-level instructors, both online and in community-based workshops, to develop the understanding and skills needed to work and teach with modern data. StatPREP provides tools to incorporate analyzing multivariable data into undergraduate statistics education. This project offers an extended professional development program for mathematics faculty, particularly at two-year institutions, who teach introductory statistics. It has established regional hubs to support these instructors, and it provides a national online support network with statistics education experts. This poster will review progress to date, as well as highlight the publicly-available resources and course materials, along with future workshop opportunities.

Alan Alewine McKendree University

Program-Level Assessment . . . Don't Run Away!

After much struggle, you finally have your program-level student learning outcomes exactly as you want them. Now what? This poster explores the "now what." Rubrics, assignments, and results will be presented.

Michele L. Joyner East Tennessee State University

Building Career-Ready Skills in Undergraduate Mathematics Majors

Mathematician is labeled #2 in the Best Business Jobs, #9 in Best STEM Job and #17 in 100 Best Jobs of 2019 by US News and World Report, only behind software developer, statistician and an assortment of health care jobs. It is projected by the Bureau of Labor Statistics that there will be an approximate 30% employment growth for mathematicians between 2016 and 2026. Are mathematicians ready to meet this challenge? Although many mathematics undergraduates are able to gain the *knowledge* necessary for being successful in an industrial career during their academic curriculum, many undergraduates still lack some of the fundamental *skills* employers in industrial and government jobs are seeking. In this talk, we will identify some of these key fundamental skills for success and how activities and projects can be incorporated into the current curriculum to aid in the development of these skills.

Daniel Ozimek Pennsylvania College of Health Sciences
John Clochesy University of Miami
Martha Ellis Charles A. Dana Center
Beth Kelch Delta College
Kathryn Stuck Boyd Cleveland Clinic
Anna Wendel Pennsylvania College of Health Sciences
Michelle Younker Owens Community College

Improving Mathematics Education for Nurses: Updates on a National Initiative

A recently launched initiative and national task force supported by the Charles A. Dana Center at the University of Texas at Austin, the Mathematical Association of America, and Quality Safety Education for Nurses (QSEN), is seeking to improve the mathematics education of nurses. Over the past year, members of this task force have initiated research projects, presented nationally, and continued to strengthen relationships between the mathematics and nursing communities. This poster will update attendees on the progress of this important initiative, and it will identify specific ways that the mathematics community can help to support the vision that "all students in nursing programs will gain the mathematical knowledge, skills, and attitudes to promote and provide safe, high-quality health care."

Eric Stachura Kennesaw State University

Modeling Scenarios via Writing Projects

Frequently, instructors struggle to cover enough material in class due to time constraints. So how can one introduce mathematical modeling in class, with already tight time constraints? In this talk I will discuss how I have previously used SIMIODE modeling scenarios as partner writing projects in a differential equations course. I will discuss the two scenarios I had students work through, what I learned, and plans for implementing new modeling scenarios which I am developing in future courses.

Patrice Tiffany Manhattan College

SIMIODE: Let Mathematical Modeling Inspire Your Differential Equations Class

This poster session is to showcase a faculty development and student engagement effort to enrich and use the SIMIODE (Systemic Initiative for Modeling Investigations and Opportunities with Differential Equations) community to drive a re-conception of the undergraduate differential equations course from technique driven to mathematical modeling inspired. It focuses on the plethora of resources available at the SIMIODE website that gives teachers all that is needed to take the leap into modeling in DE. The site gives teachers membership in an online community whose interest is to change the experience of learning differential equations. The poster session will also be a source of information on the NSF funded week long summer workshop opportunities for teachers to either experience for the first time how the scenarios available on SIMODE can be used in the classroom or the opportunity to write their own differential equations scenarios and publish them online. We not only promote the idea of modeling in DE but we show the teachers how to do it and provide the support, the mentorship and the community to be successful.

Rachel Epstein Georgia College

Homework Revisions vs. Meeting with the Professor: Which Better helps Precalculus Students Learn?

Introductory mathematics students often have difficulty with assignments that require critical thinking, writing, or applied knowledge. When students have unsuccessful results with such assignments, we, as instructors, typically want to help our students better understand their mistakes and how to succeed on similar assignments. Little research exists on effective methods of helping students improve their understanding of the material on an assignment after the assignment has been turned in. In this poster, I present preliminary results of a study comparing the effectiveness of two strategies to improve student learning: 1) allowing homework revisions and 2) offering extra points for meeting with the professor to discuss the assignment. In addition, I investigate the strategies Precalculus students use to revise assignments and the types of revisions they make.

Erin Griesenauer Eckerd College

Cooperative Learning in an Introduction to Topology Course

Faced with a Topology class filled with students ranging from those with no experience with proofs to senior mathematics majors who had completed several proofs-based classes, I decided to use cooperative learning with small groups. Weekly group work was an effective way to bridge the gap in experience, to build the confidence of all students, along with their skill at writing proofs, and to keep all students engaged. I will present the specifics of how cooperative learning was implemented to address the elements necessary for successful cooperative learning, such as positive interdependence, face-to-face interaction, individual accountability, and social skills. I will also offer my reflections on the success of the technique, and thoughts on improvements that can be made in the future.

Chamila Kumari Ranaweera University of Colorado Boulder

Developing students' mathematical background for university-level statistics course in a flipped classroom, in-class worksheets, peer interaction and class projects in an inclusive classroom environment

Often in introductory statistics classes, students are unable to link their learning of statistics to how the content applies in their day-to-day life. By engaging students in real-world projects and doing so in an inclusive educational environment, faculty can enhance students' critical thinking and practical skills, moving from only being able to perform calculations to being able to apply the calculations to make a logical conclusion about the data. In this poster session, information will be presented on how a university-level statistical class for non-STEM major students was structured to promote student achievement. This was accomplished through the introduction of a flipped classroom model where students got a chance to learn through reading the material outside of the class and doing in-class worksheets with peers. Inclusion is at the center of the course and can be seen through the physical environment, faculty availability, peer instruction, weekly feedback structures, and various community building activities. The course had two real-world statistics projects (using Excel and R software) where students worked together in groups, and each group created a project report and poster presentation. The students were then asked to present their results using a one-minute elevator pitch at a peer-research symposium.

Jonathan Keiter East Stroudsburg University

Using Art to Express Mathematics

This poster will detail several projects I have led on ESU's campus to show the community mathematical concepts using art. The goals are to show that math can be accessible to everyone and to show the beauty of mathematics through art. The first project created a 22ft by 8ft mural of an anamorphic image of Albert Einstein. Anamorphic art deals with projective math and perspective art; the image needs to be viewed from exactly one position to see the image as it should appear. Prior to the image's final rendering using the program *Mathematica*, students in the math club studied the mathematical properties of anamorphic art and created their own projections by hand constructions. The second project created large string art displays throughout the campus. Students in a geometry class worked together with students in an art and design class to create interesting mathematical string art am a large scale. The string art project allowed students with different perspectives and abilities in both math and art to share ideas and deal with challenges together.

Kristopher Pruitt U.S. Air Force Academy
Michael Brilleslyper U.S. Air Force Academy

Getting to the Top: Less Pain, More Gain

How much energy is required to walk up a hill? If the hill is wide enough, is there a benefit to using switchbacks to ascend? If so, how many switchbacks would lead to minimum energy use? It turns out, that under reasonable assumptions for energy consumption while walking up hill, that this problem has a straightforward solution using basic calculus methods. The resulting solution agrees with experimental results from exercise science. Our poster shows how a seemingly 3-dimensional problem is really a 1-dimensional calculus optimization problem suitable for first semester students!

Philip B. Yasskin Texas A&M University
Matthew Weihing Texas A&M University
Joseph Martinsen Texas A&M University
Akash Rao Texas A&M University

MYMathApps Calculus Tutorials

MYMathApps Calculus is a totally online text, so far for calculus 2 and 3. * The text includes many animations in addition to the standard static graphics. * Examples in the text have full solutions. Exercises in the text have hints, answers and solutions which gradually appear after the students have a chance to try it themselves. * There are external links for background information, internal links to additional examples, and pop-up notes, for small comments and proofs, which do not obstruct the flow of the text but are available to those students who wish to learn more. * Exercise pages have links back to the pages where the material for each exercise is discussed. * Several topics have randomly generated Tutorials based on the Maplets for Calculus and written using HTML, CSS, JavaScript, Sage, ThreeJS, MathJax or KaTex, MathLex and React. Attendees will get to try the Tutorials. MYMathApps has grown out of the WebCalc project involving the author, Don Allen and Mike Stecher at Texas A&M University, and the Maplets for Calculus project involving the author and Doug Meade at the University of South Carolina. The work was supported in part by NSF DUE TUES-2 grant 1123255.

Mike Janssen Dordt University
Valorie Zonnefeld Dordt University

Delivering Pre-Class Activities ViaWeBWorK to Impact Student Learning

In a flipped or active learning classroom, students typically prepare for deep in-class work by completing some sort of structured pre-class activity. This pre-class activity often introduces a new idea or activates required prior knowledge to prepare students for work in class. The ubiquity of technology makes viable the delivery of these pre-class activities in electronic formats. Our research explores whether the use of structured pre-class activities delivered via WeBWorK in a first-year calculus course result in improvement in both direct and indirect measures of student learning by analyzing grade distributions and survey data.

Danny T. Lau University of North Georgia

Construction of an infinite square matrix to observe various forms of whole numbers

We start with a simple relation 1 + 2 = 3, 4 + 5 + 6 = 7 + 8, 9 + 10 + 11 + 12 = 13 + 14 + 15 and etc. to form a representation of a sequence of square numbers. We then develop similar relations using the idea of adding consecutive whole numbers to form other sequences. Putting these sequences of numbers into rows of a square matrix, we may observe a very simple pattern from the columns of this matrix. More interestingly, we can observe a sequence of hexagonal numbers from the diagonal elements. In addition, we may observe various patterns of whole numbers from the off-diagonal elements of such matrix. This infinite square matrix has a lot of embedded information with certain patterns that may worth further exploration.

Frank Patane Samford University
Raymond Herbert University of Alabama

There are 70 Finite Regular Ternary Quadratic Forms

We address a question posed in the 2015 paper *Essentially Unique Representations By Certain Ternary Quadratic Forms*. This question asks to find which regular ternary quadratic forms uniquely represent only a finite number of integers. We fully answer this questions as well as include several additional results involving representations by ternary quadratic forms.

Brian J. Shelburne Wittenberg University

Exploring Asymmetrical Results in Mathematics

A quote attributed to Isaac Asimov goes "The most exciting phrase to hear in *science* -the one that heralds new discoveries- is not *'Eureka!'* but *'That's funny...'*." With apologies to Archimedes, substitute *mathematics* for *science*. One of my favorite "that's funny" results in mathematics is the existence of a function which is continuous at all irrational points and discontinuous at all rational points whereas there is no function which is continuous at all rational points and discontinuous at all irrational points. The asymmetry of these two results is striking. Presenting the δ -ϵ proof of the former demonstrates the power of the modern definition of limit and continuity and is worthy of study. But why the asymmetry? That answer originates in Cantor's proof of the non-denumerability of the real numbers and subsequent demonstrations that the rational numbers are denumerable while the irrational numbers are not, an asymmetry which sheds some light on the asymmetrical result mentioned above. Another asymmetry in mathematics is the denumerability of the algebraic numbers versus the non-denumerability of the transcendental numbers. While Cantor's result proves that the transcendentals are more abundant than the algebraic numbers, finding a transcendental number is difficult which is why Liouville's 1851 proof that $l_0 = 1/10 + 1/10^2 + 1/10^6 + ... + 1/10^{n!}...$ is transcendental (based on a curious inequality about irrational algebraic numbers) is worth examining. Though e and π were proved to be transcendental it's not known if certain other numbers are transcendental. This brings to mind T.E. Bell's quote "The algebraic numbers are spotted over the plane like the stars against a black sky; the dense blackness is the firmament of the transcendentals."

Phil Blau Shawnee State University

Hensel's p-acid numbers

The talk will give an overview of the first four chapters of Kurt Hensel's 1908 "Theory of Algebraic Numbers" in which he introduces p-adic numbers and proves what is now called Hensel's lemma. Some biographical information about Hensel will also be included.

Abdulmajeed Abdurrahman Shippensburg University

CM Method and Expansion of Numbers

We show that an iterative method for computing the center of mass of q units of mass, placed on a unit interval [0,1] along the x-axis, give rise to a simple procedure for expanding rational number less than unity in powers of r/s, with $s > r > 1$. The method is then expanded to all numbers, real or complex, though the procedure for none rational numbers is more time consuming. We also see how our method provides a natural way to generalize Jacobsthal numbers and other numbers appearing in mathematics. We briefly explore the relationship between our system of q units of mass, our method and a quantum system of q particles.

Robert W. Vallin Lamar University

Preserving p-Adic Metrics

Several years ago there was much activity on metric preserving functions, functions whose composition with a metric still produces a metric. J. Dobos showed that if we restrict ourselves to functions that preserve the Euclidean metric on the real line we get some very interesting, complicated functions. In this talk we look at the other possible absolute value on the real line, the p-adic absolute value. We will show some examples and note the substantive differences between preserving Euclidean and p-adic absolute values.

Cameron G. Hale UAB
Jonathan R. Kelleher UAB
John C. Mayer UAB

Multiplicity of Hexagon Numbers

Imagine you have an unlimited supply of congruent equilateral triangles. *Polygon numbers* are the number of these triangles used to tile a convex polygon. *Triangle numbers* are n^2 where n is the side length of an equilateral triangle. We can use the method of removing equilateral triangles from a large tiled equilateral triangle to create equiangular hexagons, as well as certain parallelograms, trapezoids, and pentagons. Thus, $H = n^2 - (a^2 + b^2 + c^2)$ is a *hexagon number*, where a, b, and c are the side lengths of the equilateral triangles removed from the corners. It is known that all natural numbers $H \geq 85$ are hexagon numbers (OEIS A229757). The *multiplicity* of a polygon number P is the number of ways to construct P up to congruence. A polygon number P with multiplicity 1 is said to be *unique*. Previously, two of the authors had shown (1) there are unique trapezoid numbers, and (2) for every natural number n, there exists a hexagon number H_n that has multiplicity $m(H_n) \geq n$. One of our current results is the theorem: there exists a natural number $N \leq 288$ such that every hexagon number $H \geq N$ has multiplicity $m(H) \geq 2$. That is, there are only finitely many unique hexagon numbers. Numerical explorations suggest to us the following conjecture: for every natural number m, there is a natural number G_m, such that for every hexagon number $H \geq G_m$, $m(H) \geq m$.

Kerry O'Grady Johns Hopkins University

Mathematical and Artistic Creative Processes: Distilling Models, Mapping Interdisciplinary Intersections

This poster places models of the mathematical creative process in conversation with models of the artistic process in order to identify intersections, such that descriptions of creative processes in math and art may inform and illuminate each other. Drawing from the creativity literature, this poster will concisely overview a few theorizations of the creative process across disciplines to clarify the behaviors in these theorizations and to locate a few relevant ideas from the literature (i.e., domain generality/ specificity, problem finding/ solving, creative person/ process/ product). Then the poster will describe models of artistic and mathematical creative processes from discipline-specific literature and from accounts of artists and mathematicians. Within this section, I note parallels that mathematicians draw between their work and that of artists. Bringing these models together, I then map the intersections and apparent differences between the way mathematical and artistic creative processes are described, with attention to behaviors of ideation, revision, and iteration; thinking in a medium or symbol system; discussions of epistemology; the role of aesthetics and intuition within the processes; and the socio-emotional dispositions required and exercised in the work. These intersections avail of the opportunity to elucidate interdisciplinary connections with respect to process.

Danilo R. Diedrichs Wheaton College
Paul A. Isihara Wheaton College

Conjoint analysis approach for defining part worth utilities to criteria weighing into the "go/no-go" decision faced by NGOs in disaster response.

When a disaster relief non-governmental organization (NGO) receives an appeal for aid, the first dilemma it faces is a "go/no-go" decision. Assessment of needs, local expertise of volunteers, and available funding, among other concerns, weigh into the NGO's initial decision whether or not to respond to an appeal. Faith-based organizations (FBOs), an important subset of NGOs, often collaborate with non-faith-based NGOs, but use different criteria in their go/no-go decision. Here we use a mathematical approach to study the factors and tradeoffs that play a role in these decisions. Conjoint analysis, a statistical technique used in market research, is used to analyze survey responses from 19 NGOs and FBOs, and to determine a part worth utility to each appeal criteria. We then use these values to define an objective function for use in an optimization model. This tool provides a quantitative method that promotes responsible decision-making and better aid in disaster response.

Rigwed R. Tatu University of Cincinnati

Data Arising from Destructive Samples: The Case of Spina Bifida

A fetus is diagnosed with spina bifida. It is a condition where spinal elements are protruding outside the fetus' back, compromising the skin barrier. The spinal fluid is seeping out of the spinal column. Amniotic fluid is getting into the spinal column reaching the developing brain. This will have serious health consequences for the baby. A surgery (fetoscopy) on the fetus can be performed to cover the gap by a patch, hoping that skin gets generated over the patch. In our lab at the University of Cincinnati, we have created a biodegradable patch by fusing two polymers in certain proportions to strike a balance and attain optimum mechanical and barrier properties. In the course of our experiments, we need to measure how rough the patch is. The patch roughness influences the adhesion of cells and eventual growth of tissues around the

patch. Changes of patch roughness were studied over time via lab experiments, immersing the patch separately in phosphate buffered saline and amniotic fluid. In the course of measuring roughness, the patch becomes unusable after being subjected to drying steps and cannot be re-introduced in the experimental plan. A need arose as to estimate roughness of the patch before it is exposed to different fluids. These statistical problems and their solutions are discussed in a subsequent talk with the same title.

General Contributed Poster Session II

Thursday, August 1, 3:00–3:45 PM, Grand Ballroom B

Roza Aceska Ball State University
Crystal Lorch Ball State University

Universal Course Design for Linear Algebra Instruction

Linear algebra is one of the cornerstones of modern mathematics, with significant real-life applications, which is why it is required for college students in a variety of majors. The mixed bag of background knowledge students have makes teaching linear algebra difficult. The variety of new definitions and concepts can be overwhelming for students, and making sure that these are presented in a way which complements each student's learning style is important. Even for math majors, linear algebra brings new challenges, such as motivating, understanding,and executing proofs. We reflect on our struggles and successes in teaching linear algebra in-class and online to a diverse student body. We share ideas and future goals for incorporating technology, writing, and collaboration in meaningful ways, suitable for various teaching formats.

Ashley Johnson University of North Alabama

My Favorite (algebra based) Math Contest Questions

This poster will display several of my favorite problems from the past five years of the Alabama Statewide High School Math Contest. All problems shown will be creative applications of concepts from precalculus or lower and would make great challenge problems for a college algebra course!

L. Jeneva Clark University of Tennessee

Hands-On Learning in a Mathematical Reasoning Course

A newly revised course called Mathematical Reasoning includes many hands-on lessons. Use of perceptually rich concrete manipulatives benefit mathematics learning (Carbonneau, Marley, & Selig, 2013). Activities from this course include stacking paper cups to build tetrahedral numbers, using water displacement to measure golf balls, using balloons to investigate curvature, using pancakes to prove the area of a circle, using orange peel to demonstrate the surface area of a sphere, using modeling clay to learn knot theory, and designing hearing aids from recycled materials. This poster will display these lessons, with a QR code for each, and will present results from qualitatively analyzed student comments and classroom observation data.

Daniel Kiteck Indiana Wesleyan University

Using an Overview of All of Math History in a Math History Classroom: Highlighting Mathematicians and Mathematics

Over the years of teaching a history of mathematics class, I have developed an overview of all of math history on four (full) sheets of paper. My motivations for this is asking: "what is the bare minimum of mathematicians and mathematical events that I want my students to be familiar with?" and "how can we in a concise manner see common mathematical threads and themes and developments across history?" and "how can we put whatever our present lesson is in a 'big-picture' context?" I will present: 1. that we should be intentional in what we choose and do not choose to include in a math history class, and I will make a case that each math history class should at least briefly give snapshots from across history, as all mathematical development is inter-connected, even across cultures and time; 2. a few themes that stand out across history, such as algebra-vs.-geometry and, closely related, discrete-vs.-continuous; and 3. examples of thinking through a lesson in light of its context in the overview.

Kevser Erdem University of Cincinnati
Casey Monday University of Cincinnati

Active Learning Practices for First-Year Calculus

This poster will describe active learning efforts made in first-year engineering calculus as well as first-year business calculus at University of Cincinnati. We will describe: flipped classroom techniques including Blackboard lectures, pre-class quizzes, TA for the Day assignments, group work, assessment techniques, and how we adapted these techniques to make the fully online classroom more active. These efforts resulted in lower DFW rates as compared to other classrooms. We will also discuss the differences between active learning in the engineering calculus classroom and the business calculus classroom and share our plans for improving these efforts for the coming year.

Grace E. Cook Bloomfield College

Adventures in Online Teaching with First Year Students

Recently, there has been a push at Bloomfield College to develop online courses in an effort to reach more students particularly non-traditional students. In this Poster Presentation, I will share my experiences teaching a fully-online freshmen level College Algebra course using Open Education Resources on the Blackboard Learning Management System. Prior to teaching this course, I had taken two online courses that dealt with improving online teaching. I will share best practices that I implemented in the College Algebra course that I took away from my own coursework. These practices include organization of assignments and materials in Blackboard as well as providing feedback on homework and tests, administrating online tests in timed and untimed environments, and utilizing the discussion board for attendance and class participation. I will also discuss my use of Open Education Resources and Blackboard specific features such as learning modules, course links, mashups, and automatic scoring. Obstacles to be addressed include the potential for cheating and technical difficulties encountered by my students and myself. Future applications include development of a freshmen level PreCalculus course and Transitions to Collegiate Mathematics course as well as a sophomore/junior level Discrete Mathematics course.

Jennifer Szczesniak Hagerstown Community College

The Carrot and the Stick: Attempts to Get Homework Completed when Due

After having abysmal time getting students to hand in written assignments on-time and complete I attempted two experiments during the last academic year. The first was to encourage the on-time completion of homework by offering a juicy reward. The next semester I tried a punitive approach after consulting with a psychology professor. Under both systems late work was still accepted. Today we will examine the two systems used and look at the results.

Monica VanDieren Robert Morris University
Paul Seeburger Monroe Community College
Deborah Moore-Russo University of Oklahoma

Improving Student Understanding of Multivariable Calculus Concepts Using the CalcPlot3D Visualization Applet

CalcPlot3D is a freely available applet which provides students opportunities to dynamically visualize and experiment with 3D transformations, rotations and computations of multivariable calculus concepts. Through this project, we will (1) design, test, and disseminate through WeBWorK a series of new visual concept explorations using CalcPlot3D; (2) expand the features of CalcPlot3D to accommodate the new concept explorations and address applications in other areas such as differential equations, linear algebra, physics, and engineering; and (3) develop and test an assessment tool to measure student understanding of vectors. This research is partially supported by the National Science Foundation under Grant Numbers 1524968, 1523786, and 155216.

James M. Talamo The Ohio State University
Nela Lakos The Ohio State University

Changing the Culture of Calculus

Tight coordination of freshmen level Calculus courses provides an effective means to develop, implement, and change the culture of large courses. In Autumn of 2015, the Mathematics Department undertook a redesign of its first year calculus courses. Faciliatated largely by the coordinators of the courses, the redesign initially aimed to improve DEW rates by introducing more overarching course structure, creating common course resources for students to communicate our academic expectations, and improving communication between coordinators and instructors. Over the past several years, the added course structure from the redesign has allowed for the courses to serve for professional development for new instructors, create a calculus community, design and implement a free textbook and homework system with the Ximera Platform (delivered through our LMS), and facilitate the incorporation of active learning into large lectures. The poster will present the history of the redesign effort and elaborate on the many benefits described above.

Duane Farnsworth Clarion University of Pennsylvania
Jon Beal Clarion University of Pennsylvania
Carey Childers Clarion University of Pennsylvania
Daniel Shifflet Clarion University of Pennsylvania
Marcella McConnell Clarion University of Pennsylvania
Michael McConnell Clarion University of Pennsylvania
Kate Overmoyer Clarion University of Pennsylvania
Adam Roberts Clarion University of Pennsylvania

The Traveling Mathematics Department

In 2015 a group of 8 members of the Mathematics Department at Clarion University journeyed to a local high school for a day to talk about careers, do some activities, and give a presentation. Since then a subset of this group has traveled to nearly a dozen different local schools to run a variation of this production 20 times over. Now they have to decline almost as many invitations as they accept! In this poster the group of 8 will highlight some of the techniques that work (and don't work) with this type of outreach. They will also offer tips for starting and maintaining such a program at other colleges.

Nicole M. Panza Francis Marion University

Teaching Introductory Mathematical Modeling for Mathematics Majors

Mathematical modeling can be taught at various levels of the mathematics curriculum and should be differentiated to that particular audience. At Francis Marion University, Math 310: Mathematical Modeling and Applications is a mathematics elective intended for mathematics majors and minors. The prerequisite course for the class is integral calculus. In spring 2019, Math 310 was redeveloped to include a major paper/presentation requirement and the use of LaTeX. Experiences and ideas from this course will be discussed.

Matthew J. Haines Augsburg University

Developing a Mathematics through Illusion Course

The work of Professor Kokichi Sugihara provides mind-boggling visual illusions created from a mathematical perspective. Various areas of mathematics can be used to understand the illusions. This poster introduces a course-in-development that provides a pathway for undergraduate mathematics students to describe and analyze visual illusions. The course will culminate in the design and creation of illusions using CAD software.

Russell Goodman Central College

An Exit-Polling Project in a First-Year Seminar

This talk presents the details of an exit-polling project connected to the fall 2018 midterm elections. The presenter taught a first-year seminar at his small, liberal arts college and was impressed at the student buy-in and leadership in completing the project. The presenter will share the logistics and results of the exit-polling in a way that will hopefully encourage others to take on a similar project at their own institutions.

James Quinlan University of New England

Factors and Methods of STEM student retention

Retention of STEM students is a known problem and of critical importance. The poster showcases several programs and initiatives developed at the University of New England that has aided in retaining students in STEM fields as well as highlights the impact undergraduate research has had on retention.

Jill Shahverdian Quinnipiac University

Implementing Inquiry Using POGIL (2.0)

Process-Oriented Guided Inquiry Learning (POGIL) offers a particular structure for IBL activities and aims to address both content knowledge and process skills. This poster will include an introduction to POGIL, my experience with POGIL in both a foundations course class for mathematics majors and a geometry course for presecondary teachers, and sample activities for both courses. I will share feedback from students and invite discussion of POGIL and IBL.

Mark Bly Coastal Carolina University

Cubic Curve Classifications: From Newton to Modern Day

Cubic curves, solutions to defining equations that are two-variable polynomials of total degree three, have been a historically rich object of study in mathematics, with a classic example being the modularity theorem that helped resolve Fermat's Last Theorem. During the eighteenth century, Isaac Newton provided a first significant effort to classify cubic curves viewed in two-dimensional real space with respect to distinctive features of their graphs. Later classification efforts of cubic curves were provided by Arthur Cayley and Julius Plucker in the nineteenth century. From the mid-twentieth century into the twenty-first century, this problem of cubic curve classification was readdressed with more modern techniques from linear algebra and differential geometry by Burington, Forough, Korchagin, Nadjafikah, and Weinberg among others. Recent results on the matter set the stage for an attempt at a definitive modern treatment of cubic curve classification. The nature of these recent developments and the form of this potentially definitive treatment will be discussed.

Alvin Chi Hi Ng Diligence(Tutor Centre)

A Proof for the Algebraic Method to Find the Square Root of a Number

Before computers and calculators caught on, people could use hand calculations to find the square root of a number. Since the root-mean-square value is used to represent the voltage of a sinusoidal wave, this method can be found in an electrical engineer handbook. However, to the author's knowledge, no written formal proofs have been presented. In this article, the author attempts to present such a proof by using a method imitating the mathematical induction. The process of finding the square root of a number can be extended further to find the cube root of a number as well, by using the binomial expansion of a cube. It can also be programmed in a computer, if there aren't any square root functions.

Jillian Honea University of Tennessee
Jackie Vogel Austin Peay State University

Pythagoras and Music Theory

The connections between music and mathematics are abundant and diverse. One such connection involves Pythagoras and music theory. This paper addresses those connections. Pythagoras experimented with taut strings of the monochord, water filled glasses, bells, and pipes to develop tones and the ratios of notes on a scale. Pythagoras developed what became the basis of modern music theory. That is, by dividing the length of a string into ratios of halves, thirds, quarters, and fifths, you create the musical intervals of an octave, a perfect fifth, a second octave, and a major third respectively. However, Pythagorean tuning and the Pythagorean scale was flawed and did not hold up over time.

Chad Awtrey Elon University

Galois Groups of Even Quartics and Doubly Even Octic Polynomials

Let $h(x) = x^2 + ax + b$ be an irreducible polynomial with rational coefficients. Let $g(x) = h\left(x^2\right)$ and $f(x) = g\left(x^2\right) = h\left(x^4\right)$, and let G_g and G_f denote their respective Galois groups. It is well known that G_g depends on the squareness of both b and the discriminant of h. Is there a similar determination of G_f? Our main result shows that, in general, knowledge of G_g does not determine the G_f, except when G_g is cyclic of order 4. We also show that G_f is completely determined when G_g is dihedral of order 8 and -1 times the discriminant of h is a perfect square.

G. Gerard Wojnar Frostburg State University

Cubics, Triangles, Cardano, & Statistics

For any degree D Complex polynomial consider a uniform discrete random variable taking on values of the roots with probability $1/D$, so repeated roots get probability M_r/D, with M_r the multiplicity of root r. Then various statistics, especially central moments, have surprising significance for polynomials & their graphs. For quadratics things are trivial, but it is not widely known that the quadratic formula gives roots $x = \mu \pm \sigma$ where μ & σ are the mean & standard deviation, resp., and any quadratic is of the form $f(x) = a\sigma^2(z^2 - 1)$ for $z = (x - \mu)/\sigma$. Similarly, we have shown that Cardano's cubic fomula gives roots $r_k = \mu + \omega^k T_+ + \omega^{-k} T_-$ ($k = 0,\ 1,\ 2$) where $\omega = -1/2 + i/2\sqrt{3}$ & $T_\pm = (W/2 \pm \sqrt{((W/2)^2 - (V/2)^3)})^(1/3)$ where V is the variance (the 2^{nd} central moment) & W is the 3^{rd} central moment (the unscaled skewness). Using a quasi-binomial representation $f(x) = a(1x^3 - 3\mu x^2 + 3\lambda x - 1\nu)$, these moments are easily computed: $V = 2(\mu^2 - \lambda)$, $W = 2\mu^3 - 3\mu\lambda + \nu$. Graphical features are naturally: extrema at $x = \mu \pm \sigma/\sqrt{2}$, the inflection point is $(\mu, -aW)$ with slope $f'(\mu) = -3aV/2$. The statistical representation is $f(x) = a\sigma^3(z^3 - 3z/2 - W/\sigma^3)$. When the 3 Complex roots are non-collinear many intimate connections to triangles arise: $T_\pm$ viewed as centroid-based vectors, point to centroidal antipodes of paired vertices of the 2 equilateral triangles constructed in Napoleon's theorem, with lengths equal to the centroid-to-Fermat-Torricelli points distances; $W/2$ is the antipode of the Schoute center, X_{187}; cubed vertices yield a congruent triangle; the mean of the vertex-to- primary Fermat-Torricelli point distances matches the centroid-to- secondary F-T point distance, while the mean of signed vertex-to secondary F-T point distances matches the centroid-to- primary F-T point distance; & more!

Max Lind USP
Eugene Fiorini Muhlenberg College

h

Consider a configuration S_G of pebbles on a simple, connected graph G. For $m, k \in \mathbb{N}$, $k < m$, an (m, k) pebbling move removes m pebbles from a vertex in $V(G)$ and adds k pebbles to an adjacent vertex. A context $\Sigma = \{(m, k) \,|\, m, k \in \mathbb{N} \text{ and } k < m\}$ is the set of allowable pebbling moves on a graph with given configuration. A configuration graph $[S_G]_\Sigma$ associated with a configuration S_G is a Hasse diagram whose vertices represent subsequent configurations that can be reached from S_G, and whose edges correspond to a single pebbling move in Σ. We show that $[S_G]_\Sigma$ is bipartite with girth 4 for all Σ and prove under what conditions $[S_G]_\Sigma \cong [S_H]_\Sigma$ for simple, connected graphs G and H. Furthermore, we prove for which configurations $[S_G]_\Sigma$ is a symmetrical Hasse diagram and which sub-configurations are associated with subgraphs of $[S_G]_\Sigma$. Finally, we address the question: When is $[S_G]_\Sigma$ pebblable?

Michael Brilleslyper U. S. Air Force Academy
Ethan Berkove Lafayette College

Co-prime Labelings of Complete Bipartite Graphs

A *co-prime* labeling of a simple graph *G* with *n* vertices is an assignment of *n* distinct integers to the vertices such that adjacent vertices are relatively prime. If the integers are the numbers 1, 2, ,.., *n*, then the labeling is called *prime*. Here we restrict to a set *A* of *n* consecutive integers with some starting value *k¿*1. We then ask which complete bipartite graphs with *n* vertices admit a co-prime labeling using the labels in *A*. We find several surprising results including periodicity of the number of graphs as a function of the starting value *k,* and even sets of consecutive intervals for which no complete bipartite graph admits a co-prime labeling. Such sets are called *stapled intervals* and they are quite rare. Along the way, we encounter *common factor graphs*, *modular tables*, and discuss our computational methods.

Norman Bradley Fox Austin Peay State University

Neighborhood-Prime Labelings of Hamiltonian Graphs

A *neighborhood-prime labeling* of a graph of order *n* is a variation of a prime labeling in which the vertices are labeled with the integers *f*1*;* 2*; : : : ; ng* so that the following is true. For each vertex *v* with degree greater than 1, the gcd of the set of labels assigned to the vertices in the neighborhood of *v* is 1. New approaches for *nding neighborhood-prime labelings based on the Hamiltonicity of the graph and by examining connections to prime labelings through a neighborhood graph will be presented. In particular, labelings will be discussed for generalized Petersen graphs, grid graphs, and certain classes of lobster graphs. 1

Darren Narayan Rochester Institute of Technology

Breaking Graph Symmetry

A graph is asymmetric if its automorphism group on its vertices or edges is trivial. A graph is *G* is called mimimally non-asymmetric if *G* has at least one non-trivial automorphism but the removal of any edge results in an asymmetric graph. These graphs tend to be beautiful - but fragile, as the removal of a single edge breaks all symmetry.

Christopher N. Swanson Ashland University

Bounds on Number of Positive First Differences for Algebraically Generated Costas Arrays

A Costas array is a permutation matrix such that all vectors between pairs of ones are distinct. Equivalently, a permutation matrix is a Costas array if the difference triangle corresponding to the permutation has distinct entries in each row. On this poster, I will present bounds on the number of positive entries in the first row of the difference triangle corresponding to some algebraically constructed Costas arrays.

John C. Wierman Johns Hopkins University

Percolation Threshold Values and Bounds for Archimedean Lattices

Percolation models are infnite random graph models which have applications to phase transitions and critical phenomena. In the bond percolation model, each edge in an infinite graph G is retained independently with probability p and deleted otherwise. The site percolation model is defined similarly, with the vertices being retained independently. The percolation threshold is the critical probability $p_c(G)$ such that if $p > p_c(G)$ there is positive probability that the random subgraph of retained elements has an infinite connected component, while the probability that all of its components are finite is one if $p < p_c(G)$. There are a few lattice graphs for which the percolation threshold is exactly known, and rigorous bounds for unsolved lattices are not particularly accurate. The substitution method for computing bounds has made recent progress in improving rigorous bounds, including determining the three leading digits of the bond percolation threshold for one lattice. Exact solutions or bounds for the Archimedean lattices, which are vertex-transitive tilings of the plane by regular polygons, will be surveyed.

Adam Coffman Purdue University Fort Wayne

Complex Linear Algebra Without Complex Numbers

Can you do complex linear algebra without using complex numbers? Yes, but why? This expository poster will show how a real vector space can be given a complex structure. The interesting algebra and geometry happens when there is more than one such structure.

William Feldman University of Arkansas

Disjointness preserving nonlinear and point-wise determined maps on Banach lattices

Abstract Maps between Dedekind complete Banach lattices that exhibit disjointness preserving properties and a weak additivity property are discussed. Here, the Banach lattices in ques- tion are identified with spaces of extended real-valued functions on compact extremally disconnected spaces. These operators are then compared to those that are either locally or point-wise determined when viewed as maps on spaces of continuous functions. Vec- tor lattices of functions generated by characteristic functions are critical to establishing the results.

Austin Mohr Nebraska Wesleyan University

An Extended Deletion-Contraction Recurrence for the Chromatic Polynomial

A proper coloring of a graph is an assignment of colors to the vertices in such a way that adjacent vertices receive different colors. Determining the number of proper colorings of a graph using only elementary counting methods often results in a hopeless mess of cases. The well-known deletion-contraction recurrence breaks the problem down into one involving two simpler graphs, but this may cause a combinatorial explosion in larger graphs. We introduce an extension to the deletion-contraction recurrence that allows for the deletion of multiple edges simultaneously, thereby significantly reducing the depth of recursion.

Michelle Ghrist Gonzaga University

Experimental Estimation of a Sequence's Order of Convergence

A common technique in numerical analysis is to estimate a number L via some sort of iterative process that leads to a sequence of estimates x_n that (hopefully) approach L as $n \to \infty$; examples include rootfinding methods (e.g., Newton's method), solving systems of equations (e.g., Gauss-Seidel), and approximation of eigenvalues (e.g., power method). A sequence's order of convergence p indicates how fast $x_n \to L$; in general, p indicates the approximate number of significant figures gained in x_n from one iteration to the next. Let $e_n = |x_n - L|$ be the error in x_n. If $p = 1$ (linear convergence), e_n is roughly an arithmetic sequence, whereas for $p <$ (superlinear convergence), e_n is roughly a geometric sequence. Formally, the order of convergence p is the number for which $\lim_{n\to\infty} \frac{e_{n+1}}{(e_n)^p} = \lambda$ for some constant λ. Given a sequence x_n of approximation, I discuss a novel method for approximating p and λ. These estimates can be useful when trying to accelerate a sequence, either directly as part of the accelerated method (e.g, bootstrapped Newton's method) or indirectly in trying to decide which acceleration method to use (e.g., Steffensen vs. Aitken acceleration). I give a derivation of the approximation formulas as well as several examples illustrating their success.

Bhuvaneswari Sambandham Dixie State University

Numerical results for linear sequential Caputo fractional differential equations with initial and boundary conditions of order 2q using Laplace transform method.

Solutions of linear Caputo fractional differential equations with constant coefficients and with initial conditions can be obtained using the Laplace transform method. In this work, we develop the numerical simulations for linear sequential Caputo fractional differential equations with initial and boundary conditions of order 2q. This will be used as a tool to develop the result for non-linear Caputo fractional differential equations of order 2q. All our results yield the integer order result as a special case.

Peggy Slavik Baldwin Wallace University
Brent Daniel Strunk Baldwin Wallace University

Program Review at Baldwin Wallace

Baldwin Wallace University requires programs complete a program review every five years. Our poster will present the process and outcomes of our program review in the 2016-2017 academic year.

General Contributed Poster Session III

Friday, August 2, 1:30–2:15 PM, Grand Ballroom B

Robert R. Rogers SUNY Fredonia

Riemann Sums Belong at the End of Integral Calculus, Not the Beginning

The integration symbol and Fundamental Theorem of Calculus existed some 133 years before the birth of Riemann. The idea of summing infinitesimals is even older, so it is curious that we introduce the idea of integration with Riemann sums. This talk will show how the topics of Integral Calculus can be rearranged to develop students' intuitive understanding of integration before delving into foundational matters. As time permits, we will talk about rearranging the topics in sequences and series as well.

Mary B. Walkins The Community College of Baltimore County

Take a Deep Breath and Behold the Mathematics

In spring 2016 I enrolled in a three-session Mindfulness Workshop at the Community College of Baltimore County (CCBC). Originally, my participation in these sessions was for my own professional growth. However, before we ended the workshop, we were challenged to share at least one contemplative practice with our current students. Starting in the middle of that semester, I encouraged my students to be more mindful, focused and present in the mathematics classroom using innovative classroom techniques. Since then, I have continued to intentionally employ activities to facilitate learning and reflection in all of my mathematics classes. I inspire my students to take a deep breath, look intensely at each mathematical question, and write down what they behold. In addition, since becoming the CCBC Dundalk Mathematics Coordinator in the fall 2018, I have included one contemplative practice in each monthly mathematics faculty meeting to encourage my colleagues to incorporate inventive techniques in their professional lives. This session is interactive, and I will share the activities used to boost student learning and give results from students' responses on a Questionnaire and a Student Survey.

Richard (Abe) Edwards Michigan State University

Revolution and Romance: Mathematics in the Romantic Age

In the wake of the French Revolution, Europe entered an era known as the "Romantic Age". Artists such as Delacroix and Géricault, poets like Wordsworth and Blake, and musicians like Wagner and Chopin infused their art with intense emotions and the spirit of the sublime. But what effect did the Romantic Age have on the development of mathematics? How did it influence the ideas of Cauchy, Galois, and Bolyai? To find out, I led fifteen students on a history of mathematics study abroad program to Europe. We found that the spirit of the Romantic Age had a profound influence on mathematics, and continues to affect mathematical thinking to this day. In this talk I describe some of our discoveries, and reflect on the pedagogy of teaching the interplay between culture and mathematics.

Jean Coltharp Missouri Southern State University

Instruction Type and Student Major as they Relate to Student Success in College Level Developmental Mathematics Classes

The low success rate of developmental (or remedial) mathematics courses is a hot topic at the higher education level. In this research, student success is considered in terms of final grade, D/F percentage, and withdrawal percentage. The author is interested in looking at student success at a Midwestern university as it relates to instructional delivery type (online vs traditional) and student major (arts and humanities, STEM, and undeclared). It was found that final grade and D/F percentage were statistically significant while withdrawal percentage was not when the data were analyzed with a two-way analysis of variance.

Jane F. Reed Way to Succeed

Confronting Underachievement in Introductory Math Classes: Improving Learning for All Students through Self-Regulation

Mathematics is a gatekeeper class for many first-year college students. Colleges and universities have implemented partially effective top-down fixes to improve pass rates. However, what the student brings to the classroom is the most important factor determining whether or not they will be successful. Students bring three things to classrooms that influence their success: 1) their background knowledge from previous coursework, 2) their intelligence or aptitude, and 3) their ability to self-regulate their learning. The first two components are fixed, but students control how they approach learning. Four major areas of student-controlled self-regulated learning (goal-setting, metacognition, use of strategies and effective learning behaviors, and planning for study) are emphasized as behaviors and ideas that can and should be integrated into mathematics courses so students will be more successful. The author's study demonstrated significant increases in student achievement using a three-step self-assessment process designed encourage growth in self-regulating behaviors.

Kelly Black University of Georgia
Guangming Yao Clarkson University
Michael Ramsdell Clarkson University
Craig Wiegert University of Georgia

Calculus in Context - Results From Bringing Calculus and Physics Together

The introductory Calculus and Physics courses are important stepping stones for Engineering students. Unfortunately, the two courses often represent a barrier for too many students. We present a full program designed to address specific student needs, and we seek to identify student needs prior to matriculation. The program addresses student needs by classifying their performance on a conceptual physics pre-test and a precalculus level, skills based mathematics pre-test. Based on student performance students students are placed in one of three tracks. We focus on the results of one track, for students performing well on the conceptual physics pre-test and not as well on the skills based mathematics test. We present the results of our students' performance over three years.

Duk-Hyung Lee Asbury University

Mathematics of Paper Airplanes

Most of us have a childhood memory of folding paper airplanes and throwing them for fun or in friendly competitions. Paper airplane competitions are on-going events for people of all ages all over the world. Joe Ayoob (a former quarterback of an Arena football team) threw a paper airplane designed by *John Collins*, breaking the Guinness World Record for distance in 2012. His distance was 226 feet, 10 inches, shattering the previous record of 207 feet, 4 inches. In this brief talk session, we will examine what paper airplane can do for math classes. Paper airplanes are an example of the so-called "flat-folding" origami and may serve as an introduction to computational origami, or as a tool to discuss center of gravity, center of lift, and basic aerodynamics. This talk hopes to convey that paper can be a useful mathematical object.

Alan O'Bryan Arizona State University

Emergent Symbolization as a Student Learning Goal: Gathering and Responding to Students' Mathematical Meanings

Two key aspect of effective teaching include 1) that instructors frame the goals of lessons in terms of targeted productive student reasoning and 2) that instructors strive to develop in-the-moment models of their students' current mathematical understandings and respond in appropriate ways to support students in shifting from their current meanings to more productive meanings. Effective student-centered approaches to teaching include opportunities for instructors to gather feedback on their students' mathematical meanings and to engage in a cycle of reflection and redefinition of student learning goals and instructional activities based on this feedback. This talk focuses on the role of *emergent symbolization* (O'Bryan, 2018), a set of expectations about mathematical representations, in designing and enacting instruction in undergraduate mathematics courses (particularly in developmental courses and Calculus). Instructors who target emergent symbolization as a student learning goal for their courses and for daily lessons have demonstrated positive shifts in their ability to articulate student learning goals and the frequency of their noticing of and responding to the meanings students currently possess for various mathematical ideas. This talk will define emergent symbolization, provide examples of activities to support its development, and will share some examples of its impact on instructors' attention to their students' meanings.

Joshua Holden Rose-Hulman Institute of Technology

Between the Two Cultures: Teaching Math and Art to Engineers (and Scientists and Mathematicians)

C.P. Snow famously categorized modern intellectual life as being split between the culture of the sciences and the culture of the humanities, and said that solving the world's problems requires bringing these two cultures together. Math and art classes inherently try to do that. However, most math and art classes we have heard of focus primarily on introducing liberal arts students to mathematics. In the Spring Quarter of 2019 Soully Abas and I team-taught a different sort of course in mathematics and art at the Rose-Hulman Institute of Technology. Rose-Hulman is a private, undergraduate-focused institution, all of whose students major in engineering (predominantly), science, or mathematics. We wanted to build on the mathematical knowledge that our STEM students already have with a focus on having them make physical art objects. Soully is an art professor specializing in oil painting and printmaking. Josh is a math professor interested in the mathematics of fiber arts such as embroidery, knitting, crochet, and weaving. Our goal was for students to use their existing mathematical (and perhaps artistic) knowledge to reinforce new artistic (and perhaps mathematical) experiences. Ideally, the knowledge and experience gained will increase their appreciation for both the beauty of mathematics and the importance of art and help them prepare for productive lives solving the world's problems.

Sarah L. Mabrouk Framingham State University

Quantitative Reasoning: Everyday Considerations for Exploring Mathematics

Getting some students to value the power and usefulness of mathematics can be a challenge. Many view "math" as arithmetic or as "solving for x" and, therefore, not useful in everyday life, now or in the future. Having students consider scenarios related to their interests and their future needs adds dimension to learning and reveals the practicality of mathematics. Involving students in the development of the mathematics they apply to these scenarios enables them to experience the exploration of abstract ideas and the formation of theorems and formulas. Via this poster, I will share my use of a variety of explorations and projects related to everyday considerations as a means through which to empower

students to develop the skills necessary to analyze and interpret real-world quantitative information and help them to gain an appreciation for the utility of mathematics.

Margaret Rahmoeller Roanoke College

Breaking 'R' Code: A First Attempt at Implementing R in Quantitative Biology

At Roanoke College, Quantitative Biology is one of two required math courses for biology majors, and half of the course focuses on applying statistical methods from a biological standpoint. After attending two minicourses at JMM presented by Randall Pruim and Shonda Kuiper on teaching statistics using R and participating in a Faculty Mentoring Network through Passion Driven Statistics and QUBES, I decided to fully implement R Markdown into the course. I will share my strategy for introducing second-year biology majors to coding and reflect on this first implementation of using R in the class.

Daniel L. Kern Florida Gulf Coast University
Galen Papkov Florida Gulf Coast University

Differences in Educational Gain for Calculus Concepts

Students in Calculus I completed pre- and post-tests based on the Calculus Concept Inventory. Pre-tests were given during the first two weeks of classes and the post-test was administered about three months later, towards the end of the semester. A four-way Analysis of Covariance (ANCOVA) was conducted to determine if post-test scores differ by gender, prior experience in Calculus I, most recent exposure to prerequisite material (Precalculus), and time of class, after controlling for performance on the pre-test. Since almost all sections were "short" , the factor corresponding to *time* was not included in the ANCOVA. Significant differences were observed based on the levels of prior experience with Calculus I ($F[3,68]=2.858$, $p=0.043$), last exposure to precalculu*s* concepts ($F[2,68]=6.645$, $p=0.002$), and gender ($F[1,68]=7.192$, $p=0.009$), after controlling for performance on the pre-test. Post-hoc tests showed a significant difference between students that had no prior experience with Calculus I, and those that had taken the course in high school. Those that had last taken precalculus in high school performed statistically different on the post-test compared to those that last took precalculus in College. Lastly, males were more likely to outperform females on the post-test. Additional analyses will be included comparing the score distribution for the levels of each of several factors given above. Initial data indicates some differences may be present.

Heidi Hulsizer Benedictine College
Angela Broaddus Benedictine College

Math Mindset in Early Courses

Math Mindset is a person's belief that mathematical intelligence is fixed or able to change with effort. Is there a relationship between Math Mindset and success in a course? Can Math Mindset change over the course of the semester? What activities can affect mindset? One data set that will be analyzed is from a Mathematics for Liberal Arts course.

Chris Camfield Hendrix College

Modeling and Assessment of Student Retention at Hendrix College

Wanting to improve student retention, Hendrix College turned to its own Mathematics and Computer Science Department to model current trends and help design new retention initiatives. Using statistical models, machine learning, and a deep knowledge of our own institution, we were able to identify trends and intervention points that make sense for Hendrix. This data analysis has improved the identification of retention-risk populations. Earlier assessment has also been successfully implemented across the college due to greater faculty buy-in. Many colleges could benefit from using the talents and passions of their own faculty to study and design new initiatives.

Diane Cass Lussier Pima Community College
Daniel E. Plummer Howard University

The Application of the Microsoft Office Suite to Enhance Mathematics Learning

Innovation is continually emphasized throughout society. In particular, educators are required to implement new technology in order to enhance student learning and engagement. This process can be strenuous and stressful for educators. Most educators in the technical sciences to not know where to begin and how to implement the new technology. As a result, most mathematics instructors neglect to apply this new media in a meaningful manner. Our research suggests and outlines methods and pedagogy that thoroughly introduce how to implement technology in the classroom, as well as enhance student learning in mathematics. The Microsoft Office suite is offered as a platform that aides STEM faculty into implementing multi-media into the curriculum. The integration of the Microsoft products into the curriculum provide a way for students to master tools that help them academically and professionally, while also serving as a conduit to greater mathematics reasoning. The presenters will describe an activity that includes on-line research, aggregating data, making mathematical computations, and drawing conclusions about mathematical concepts based on their results.

Curtis Kunkel University of Tennessee Martin

Positive Solutions to Singular Second Order BVPs for Dynamical Equations

We study singular second order boundary value problems with mixed boundary conditions on an infinitely discrete time scale. We prove the existence ofa positive solution by means of a lower and upper solutions method and the Brouwer fixed point theorem, in conjunction with perturbation methods used to approximate regular problems. (This work was done with an undergraduate and I will be more than willing to discuss that aspect of the process as well as the theoretic differential equations involved.)

Jacob P. Duncan Winona State University
Monica McGrath Saint Mary's College, Notre Dame
Teresa Aubele-Futch Saint Mary's College, Notre Dame

Breaking the Vicious Limit Cycle: Addiction Relapse-Recovery as a Fast-Slow Dynamical System

Symptoms of addictive disorders often manifest as periodic episodes of sudden relapse followed by relatively long periods of recovery. For certain types of addiction, a relapse is precipitated by a state of elevated well-being wherein cravings supersede cessation efforts. A relapse satiates cravings temporarily, but is usually followed by a state of depression, which slowly improves as cravings reintensify. To analyze the underlying mechanisms driving relapse-recovery cycles, we construct a fast- slow dynamical system model of the interaction between an addict's propensity to relapse and their current disposition, i.e., craving and mood. The model captures the dynamics of addiction relapse and recovery phenomenologically by admitting relaxation oscillations, which we prove exist by exploiting timescale separation. We derive predictions of cycle period and amplitude to measure relapse frequency and intensity, respectively. As a parameter identified as being responsive to treatment is varied, the system transitions from a state of periodic relapse-recovery to a relapse-free state through reverse Hopf bifurcation. We calculate the threshold value of the treatment parameter, which corresponds to the equilibrium point passing through the fold of the critical manifold.

Jennifer Miller Bellarmine University

The effect of an environmental toxin on competing species

We extend a differential equations model for competitive species to include an environmental toxin that affects one of the species. As such, we begin with a system of three differential equations corresponding to the two species and the toxin. We examine the long-term system behavior when the toxin affects the birth rate, death rate, or both. Without the toxin, species X would thrive and species Y would die out. We analyze the system to determine whether the addition of the toxin would allow for a stable steady state where Y becomes the dominant species or where X and Y coexist.

Sedar Ngoma SUNY Geneseo

An inverse source problem with an integral overdetermination

We consider an inverse time-dependent source problem for a parabolic partial differential equation with a Neumann boundary condition and subject to an integral constraint. We show the existence, uniqueness, and continuous dependence of solutions. Our proof of the existence and uniqueness of solutions yields an algorithm that we used to approximate solutions of the inverse problem using a finite element discretization in space and the centered difference formula in time. The errors resulting from our experiments show that the proposed scheme approximates solutions of this inverse problem accurately.

Semere Kidane Gebresilasie Wentworth Institute of Technology
Matthew Sears Wentworth Institute of Technology

Pricing Variance Swap for a Discrete BN-S Model

We introduce a discrete Barndorff-Nielsen and Shephard stochastic volatility model where the non Gaussian Ornstein-Uhlenbeck process describes the instantaneous variance of an underlying asset. We developed a closed form solution for the variance swaps for financial markets driven by a Barndorff-Nielson and Shephard (BN-S) type Levy process. We present a discrete-time model to determine the arbitrage free pricing of variance swaps alongside simulations to provide numerical results in support of our findings. Model fitting and parameter estimation are included.

Bianka Wang Saginaw Valley State University
Hasan Al-Halees Saginaw Valley State University

In to the power functions

The functions and , for $n \geq 2$, $n\varepsilon$; $\mathbb{N}$, whose graphs are symmetric with respect to the line and they intersect each other at the points (0, 0) and (1, 1) in the plane. We explored three properties that these curves are sharing: areas between the two curves that turned to be polynomials of specific zeros; figures, associated with centroids between and off the two curves, that nicely related to each other; and the unique vertical line between two curves, that intersects two parallel lines which are tangent to the two curves.

Hudson Akewe University of Lagos

Equivalence Results for implicit Junck-kirk type iterations

Abstract We show that the implicit Jungck- Kirk-multistep, implicit Jungck Kirk Noor, implicit Jungck- Kirk Ishikawa,and implicit Jungck Kirk Mann iteration schemes are equivalently used to approximate the common fixed points of a pair of weakly compatible generalized contractive like operator defined on normed linear spaces. Our result contribute to the existing results on the equivalence of fixed points iteration schemes by extending them to pair of maps. An example to show the applicability of the main result is also included.

Nicholas Gewecke Dalton State College

Using a Prerequisites Test to Improve Success in Applied Calculus

At Dalton State College, Applied Calculus is a gateway course for aspiring business majors, as it is required to gain "Upper Division Eligibility" in the School of Business. One of the most serious obstacles to student success in the course is student weakness in algebra. Factors contributing to such deficiencies in algebra include students waiting a long time between math courses and students not being directed through one specific prerequisite course, as students have the option of taking either College Algebra or Introduction to Mathematical Modeling. In order to isolate whether algebra skills at the start of the term were predictive of course success, the author developed a "Basic Skills Test" to assess prerequisite skills early in the term. During the first two semesters of implementation, the test showed some predictive ability. During the last academic year, an opportunity for a retake was implemented based on the completion of a prerequisite skills assignment, to encourage students to work on those skills early in the semester. Students scoring well on the test during their first attempt have shown a high level of success in the course, as have students who score poorly on the initial attempt but improve their score with the retake. Students who score poorly on their initial attempt but then do not attempt the retake, or do worse on the retake, have continued to struggle in the course.

Buthinah Bin Dehaish University of Jeddah

On the existence of fixed points for monotone Lipschitzian mappings

Abstract In this work, we will introduce new classes of Lipschitzian mappings defined on nonlinear spaces. Moreover, we will discuss the existence of fixed points of these kinds of mappings and study the behavior of their fixed points.

Andrew Rich Manchester University

Cotangent Averaging and Euler's Product Formula

The cotangent has the unusual property that if you chop it into pieces, stretch each piece over the interval and average the pieces, the result is the original function. Do any other functions have this property? This property can be used to derive Euler's product formula for the sine.

Dennis G. Collins UPR-Mayaguez

Rainbow geometry: Newton's second longbow

A second main topic (besides gravity) where Newton was first was the analysis of light into the spectrum, exemplified by its mnemonic ROY G BIV (re-orange-yellow-green blue-indigo-violet). Here again Newton would take advantage of the rainbow image. Genesis 9:13 has God saying "I will hang my bow in the heavens," referring to the rainbow and the military or hunting weapon. The rainbow energy levels increase linearly from red to violet according to E= h*nu but the energy required to pull the bow increases quadratically (as the integral) (Rhett Allain 2014) as the curvature increases to violet, showing how Newton may have developed calculus (Whiteside Vol.1, p.34).

Jeff Johannes SUNY Geneseo

Nineteenth Century Normal Mathematics

In the nineteeth century many normal schools were founded across the United States to train teachers. In this talk we will explore the mathematics taught in these normal schools and along the way explore how mathematics and mathematics education (for both teachers and children) were different in these nascent days.

Donna Beers Simmons University

Visualizing the Transformative Role of Mathematics in the Fin de Siècle Culture with Social Network Analysis

Recently we have collaborated with a Chemistry faculty member to develop and co-teach a sophomore, interdisciplinary learning community, *Visualizing Cultural Change Using Social Network Analysis: The Birth of the Modern Era*. The central question of the learning community is: How can social network analysis be used to visualize the drivers for the cultural changes that took place between the fin de siècle and the birth of the modern era? In this talk we will describe how social network analysis has led us to discover how the new, higher dimensional spatial thinking of mathematics became a transformative idea, impacting writers, philosophers, and artists in the period 1880-1920. In addition, for Albert Einstein and Pablo Picasso, the icons of the twentieth century, we will describe the networks of individuals who influenced them, particularly singling out the mathematicians in their networks and the nature and extent of their interactions and contributions.

Camille A. McKayle University of the Virgin Islands
Nadia Monrose University of the Virgin Islands
Robert Stolz University of the Virgin Islands

On-cognitive Psychological Variables of Gender Inequalities in Developmental and Introductory Mathematics Courses

The University of Virgin Islands' (UVI) Growth model was designed to address systemic inequities in undergraduate STEM education, and in particular in the mathematics classroom. This study shows how peer led team learning (PLTL) serves as a moderator of mathematics anxiety and stereotype threat, two non-cognitive psychological variables that influence performance in undergraduate STEM courses. The objectives of the intervention were to (1) increase overall mathematics self-efficacy (2) decrease mathematics anxiety, and (3) nullify stereotype threats in mathematics. PLTL pairs groups of six to eight students with a 'near peer' to solve mathematics problems. Mathematics anxiety, before and after PLTL, is reported. The Mathematics Anxiety and Self-Efficacy Beliefs Questionnaire was administered before and after students participated in 12-weeks of PLTL. Data were analyzed to determine the impact of PLTL on mathematics anxiety. Pre-post mathematics anxiety means were analyzed for statistical significance. Mathematics anxiety scores and gender were compared. The working hypothesis is that stereotype threat is lower for African American students within the HBCU context vs. at primarily white universities. This study shows that men and women in developmental mathematics courses attending PLTL sessions, at an HBCU, have similar mathematics anxiety scores. This finding is important. It shows that in an HBCU context, women are not at a psychological disadvantage when compared to men.

Haley A. Yaple Carthage College

Adding Synthesis Tests to Mastery Based Testing

Mastery Based Testing promises to promote growth mindset and reduce student anxiety, while improving learning outcomes. However, testing course topics separately limits opportunities to demonstrate understanding of connections between ideas and may promote siloing in student understanding. To overcome this, I have begun introducing Synthesis Tests specifically devoted to connections between topics and broad conceptual understanding. Unlike midterm and final cumulative exams, Synthesis Tests allow for focused assessment and retakes as necessary, and fit naturally into a grading scheme and course philosophy structured around Mastery Based Testing. I will discuss my experiences this year introducing this new type of assessment and describe its advantages and pitfalls.

Steven Wilkinson Northern Kentucky University
Taraneh Wilkinson Foundation for Religious Studies, Bologna, Italy

Dialogical Learning

Dialectics has a long history in Western philosphical discourse. Broadly speaking, the dialectical method is a way of establishing truth by reasoned discourse between two or more people. It lies at the heart of knowledge production in the humanities. Here we go a step further and investigate dialectics as a dynamical system, where the back and forth of the discussions are the iterations of the procedure. By defining dialectics this way, we can analyze this type of reasoning even if we cannot quantify the process itself. Applying a mathematical framework to this philosophical concept may allow for predictions about the types of behaviors and outcomes we might be able to expect for various dialectical starting points.

Seth Chin-Parker Denison University
Sam Cowling Denison University
May Mei Denison University

Explanation, Existence, and Indispensability

One powerful line of argument in the philosophy of mathematics is that we ought to believe in that and only that which is "indispensable" to our best scientific explanations. And it is certainly the case that numbers play a rather ubiquitous role in explanations of scientific phenomena. But, are the mathematical entities themselves explanatory, or is mathematical talk simply shorthand for talk about the physical entities we are concerned with? Put differently, there seems to be a difference between the role that "eight" plays in the statement "there are eight planets" and in the statement "eight is a perfect cube." We examine whether this distinction that has motivated philosophical debate plays a role in everyday explanation. With two experiments, a philosopher, a cognitive psychologist, and a mathematician begin an inquiry into the perceived explanatory value of mathematical entities in everyday explanations.

Megan Wawro Virginia Tech
Jess Ellis Hagman Colorado State University
Stacy Musgrave California State Polytechnic University, Pomona

The MPWR Seminar: Mentoring and Partnerships for Women in RUME

The purpose of MPWR: Mentoring and Partnerships for Women in RUME (Research in Undergraduate Mathematics Education) is to create a sustainable support system for women at all career stages in the field of undergraduate mathematics education research. Started in 2014, the MPWR seminar is a one-day meeting held the day before and in the same location as the Annual Conference on RUME. This seminar consists of activities such as panel discussions led by women in the RUME community and beyond, professional development workshops, time to form and deepen connections within small networks known as MPWRment groups, and both formal and informal networking opportunities. Over the past six years, over 300 women have attended MPWR. In this poster, we will we provide a summary of the structure and demographics of the seminar, share participant feedback about their experiences at MPWR, examine research inquiries aligned with the seminar, and discuss possibly future directions for MPWR.

Christian Orr-Woods Rutgers University

Mathematicians' Perceptions of their Teaching

Recent research in mathematics education has uncovered a host of teaching behaviors that are commonly enacted by instructors of advanced mathematics courses. While these descriptive accounts of math teaching are useful, little investigation has been conducted into the reasons for why these practices are so prevalent. We believe that the mathematicians who teach these courses are not simply passive actors, but are reflective of their own teaching and thus have a unique perspective that can help us make sense of the research findings concerning their classroom behaviors. Under this assumption, we conducted a study in which we interviewed eight mathematicians about regularities that have been observed in the literature on the teaching of advanced mathematics. We then coded their transcribed responses using thematic analysis (Braun & Clarke, 2006) to identify themes that emerged regarding each set of teaching practices that they talked about. After identifying themes, we applied Schoenfeld's (2010) resources, orientations, and goals (ROG) framework for in-the-moment decision-making to uncover possible explanations for why these mathematicians engage in certain classroom practices. In this presentation we share the themes and ROG explanations that developed out of the mathematicians' discussion of why they engage in "chalk talk" (Artemeva & Fox, 2011) and why the formal content they share with their students is almost always written on the blackboard, and why informal mathematical content is usually only presented orally (Fukawa-Connelly et al., 2017).

Graduate Student Session

Great Talks for a General Audience

Saturday, August 3, 9:00 AM–1:00 PM, Junior Ballroom D

Adam Wood University of Iowa

Modular Representation Theory of the Space of Holomorphic (Poly)differentials

Modular representation theory is the study of linearized snapshots of a group, realized as matrices with entries in a field of positive characteristic. When a group G acts on a geometric curve, one can define the space of holomorphic (poly)differentials of the curve, which provides a representation of G. It is a classical problem to determine the decomposition of this representation into indecomposable pieces. We discuss introductory representation theory and relevant geometric notions. We then use methods from linear algebra and geometry to describe the structure of the space of holomorphic (poly)differentials in the modular case, extending previous work on the subject.

Christian Corbett Florida Atlantic University

Noncommutative *p*-extensions

We consider extensions of noncommutative rings. We define an extension $R \hookrightarrow S$ to be a left (right) p-extension if every principally generated left (right) ideal of S is generated by an element of R. The p-extension $R \hookrightarrow S$ where R and S are unital commutative rings has been well-studied. We aim to generalize the theory of p-extensions to the noncommutative case.

Claire Merriman The Ohio State University

Cutting Sequences of Lehner and Farey Expansions

Continued fractions are frequently studied in number theory, but they can also be described geometrically. I will talk about continued fraction expansions as dynamical systems, and connect this symbolic system to tessellations. The first part will focus on the "regular" or "simple" continued fractions, where all of the numerators are 1. Then I will talk about the Lehner continued fractions, where every denominator is 1 or 2.

Deependra Budhathoki Ohio University

Peer- and Self-Assessment in Quantitaive Reasoning

In this session, I will report on my observations of two Quantitative Reasoning (QR) classes during 2018–2019 while focusong on peer- and self-assessment. In a traditional freshman mathematics class, students use sophisticated mathematics and elementary reasoning to solve standard problems, but in QR, students use elementary mathematics and sophisticated reasoning to solve novel problems. Consequently, the assessment practices in QR courses should focus on monitoring and enhancing students' higher-order reasoning. Two related aspects of such formative assessment are for students to monitor their own learning (self-assessment) and to assess the work of other students (peer assessment). Within such a formative-assessment approach, instructional tasks and assessments tasks become one and the same. According to the Mathematical Association of America (1996), QR courses should employ collaboration, real-world situations, and opportunities to understand and interpret numbers and data. Peer- and self-assessment naturally align with these instructional practices. In particular, team activities and projects that involve making sense of data, communicating results, and justifying conclusions provide students with many opportunities for peer- and self-assessment. *Keywords:* Quantitative reasoning, formative assessment, and peer- and self-assessment.

Fatemeh Norouzi Morgan State University

Parameter Estimation Using MLE and MM: Application in Transportation Network

In this research, we aim to use Maximum Likelihood Estimation (MLE) combined with the method of moments (MM) to estimate parameters of some random variables that follow Gamma distribution. An application in urban transportation network will be presented using data collected on a small network in downtown Baltimore.

Harman Aryal Ohio University
Otto Shaw Ohio University

Examining the Effects of Inquiry-Based Learning on Mathematics Anxiety

Despite the importance of mathematics in human life, some people experience frustration, annoyance, and anxiety with mathematics. Once established, it can impact people's everyday activities involving numeracy and higher-level thinking. Students' mathematics anxiety can lead to feelings of nervousness, and anger while solving mathematical problems, completing quizzes and tests, and participating in mathematical discussions. If these feelings continue, students might take fewer mathematics courses, try to avoid mathematics in everyday life, or drop out from college. Students, parents, and teachers should work together to minimize these situations. Teachers can contribute to a reduction in mathematics anxiety by integrating student-centered approaches to learning and by engaging students in group work through inquiry-based learning (IBL). This study investigated the mathematics anxiety of students enrolled in an IBL course. A total of 71 students who were enrolled in an IBL Calculus I course at a public university in the Midwest were the participants of this study. The 25-item Abbreviated Mathematics Anxiety Rating Scale (AMARS) (Alexander & Martray, 1989), was used to investigate students' level of mathematics anxiety. Of the total students, 37% responded that they were not math-anxious at all and 19% responded that they were very much math-anxious while taking tests. However, 72% of students reported being not at all anxious while completing numerical tasks and 55% of students reported being not at all anxious about mathematics courses. The results of this study suggest that mathematics test anxiety continues to be a problematic issue for university students, even those experiencing an IBL course.

Michael A. Hill Kansas State University

Abe Homotopy Groups

In condensed matter physics and elementary particle physics there are certain singularities called topological excitations that can be classified using homotopy groups. Sometimes these singularities can interact, requiring stronger invariants known as Abe homotopy groups. After reviewing some examples of homotopy groups and their connection to Abe homotopy groups, we will compute the Abe homotpy of the order parameter space associated to uniaxial nematic liquid crystal systems.

O'Neill Kingston Iowa State University

Combinatorial Properties of Crystal Bases for sp(4)

Quantum groups are algebraic structures whose study links many areas of mathematics and physics together, including the representation theory of Lie algebras. By way of the theory of quantum groups, particularly nice representations of classical Lie algebras may be given in the form of crystal bases: their combinatorial simplicity and compatibility with tensor products give them a wide array of applications. In this talk I will describe a bijection between two different crystal basis realizations for the Lie algebra sp(4).

Reeve Garrett The Ohio State University

"What's the point of studying ideals anyway?", a historical introduction to ideal theory motivated by solving equations

In the course of studying mathematics, one very often runs into definitions that are declared by fiat and with little context for their creation: "$A(n)$ [object being defined] is $a(n)$ [object defined earlier] meeting the following conditions..." As a student, such a definition is pretty unsatisfying. What led the creator(s) of this definition to it? Why did (s)he/they decide this was worth studying in its own right? Unfortunately, textbooks at the upper undergraduate and graduate levels don't have the best track record answering these questions when they might naturally pop up. Among these definitions is the definition of "ideal" in abstract algebra: given a larger collection of things R with addition and multiplication (R is called a ring; examples include the integers, polynomials in one variable with fraction coefficients, and many others), a collection I of things inside R is called an ideal if (1) I (and R) includes 0, (2) whenever an element *a* is in I, -*a* must also be in I, (3) given any element r in R (not necessarily in I) and any element a in I, the product ra will always be in I. If you've never seen this definition before, you're probably asking the same questions I posed above. In this MAA Mathfest Talk intended for a general audience with only a precalculus background, I will provide the answers to these questions in a natural way rooted in first principles: In order to find integer solutions to certain polynomial equations, I will build rings from the integers and specially chosen zeroes of polynomials with integer coefficients, follow the road map laid by Ernst Kummer and Richard Dedekind to try to fix the failure of unique factorization that happens in some of these rings, and show how the definition of an "ideal" was naturally arrived at as a result.

Sarah Klanderman Michigan State University

Tools for Studying Topological CoHochschild Homology

Algebraic topology is an area of mathematics that focuses on studying topological spaces using techniques and objects from abstract algebra. We will see this interplay between algebra and topology in a specific tool called topological coHochschild homology (coTHH). Hochschild homology (HH) is a classical algebraic invariant of rings that can be extended topologically to be an invariant of ring spectra, called topological Hochschild homology (THH). There exists a dual theory for coalgebras called coHochschild homology (coHH), and in recent work Hess and Shipley defined coTHH as an invariant of coalgebra spectra. In this talk we will discuss coTHH computations and the tools needed to do them.

Simone Sisneros-Thiry University of Illinois at Urbana-Champaign

Building with Boxes and Beads

A partition is a way of breaking up a positive integer into positive integer parts. For example, the partitions of three are 3, 2 + 1, and 1 + 1 + 1. Partitions can be represented by diagrams, some made of boxes and some made of beads. We study different families of partitions by studying their diagrams. Our result builds partitions in a certain family from other partitions in that same family. This talk is the outcome of a 2+ year collaboration with Hannah Burson and Armin Straub across several states (and sometimes an ocean). The presentation will include comments on our collaborative process as one example of how mathematicians come together and share ideas.

Humberto Bautista Serrano Kansas State University

Untitled

In a popular paper in 1994, Cohn defined the covering number of a finite group as the minimum number of proper subgroups whose union is equal to the whole group. Lately, this topic has become relevant due to several discoveries made in this direction. We define a dual concept to that of the covering number. More specifically, we define the intersection number of a finite group as the minimum number of maximal subgroups whose intersection is equal to the Frattini subgroup. We also define the related notion of an inconjugate intersection number. First we explore some general properties and implications of these definitions. Then we calculate intersection numbers for certain infinite families of finite groups.Finally, we compare intersection numbers to the equivalent properties of the covering numbers as well as point to some directions of further development.

PosterFest 2019

PosterFest 2019: Early Career Scholarship

Friday, August 2, 3:00–4:30 PM, Grand Ballroom B

Ahmad Alhammouri Jacksonville State University

Mathematical Modeling: Teacher's Instruction

When students engage in mathematical modeling, they can notice the importance of mathematics in their lives and be active learners. However, engaging students in mathematical modeling requires substantial effort from teachers because of the nature of this process. In this poster, the audience will be introduced to a framework that links the mathematical modeling process with suggested teachers' practices. The framework aims to help mathematics teachers to engage their students in effective mathematical modeling.

Adam Castillo Florida International University
Charity Watson Florida International University
Pablo Duran Florida International University
Eddie Fuller Florida International University
Geoff Potvin Florida International University
Laird Kramer Florida International University

Findings from One Year of Implementation of the Modeling Practices in Calculus Curriculum at a Hispanic-Serving Institution

The STEM Transformation Institute, along with the Department of Mathematical Sciences, at Florida International University is developing and conducting research on the Modeling in Practices in Calculus (MPC) curriculum, a student-centric design in which students engage in the authentic practices of mathematicians to learn calculus. These authentic practices include students actively working in groups to develop modeling and problem-solving skills, facilitate sense making and build a classroom community; a culturally responsive learning environment that features multiple representations, argumentation and fosters constructive perseverance; and building proficiency with mathematical terminology, language constructs and symbols. This presentation will focus on curriculum artifacts, common final exam questions, research-validated instruments, and results from the first year of implementation of the MPC curriculum. The presentation will also highlight the ongoing process of evaluating, modifying, and implementing curricular materials and research instruments.

Benjamin D. Jackson Walla Walla University
Jonathan D. Duncan Walla Walla University
John E. Foster Walla Walla University
Ross E. Magi Walla Walla University

Standards Based Grading: Performance Outcomes and Student Perspectives

Students today seem more susceptible to testing anxiety and less prepared for high-stakes testing environments than ever before. At the same time, instructor may face mounting frustration assigning partial credit and have the sense that assessment does not lead to improved student outcomes. To confront these challenges, we implement standards-based specification grading (SBSG) schemes in freshman and sophomore level classes over a three-year period. We preliminarily assess measurable changes in student performance as well as students' perceptions of their learning as compared with traditionally taught courses. Initial results show that students did no worse (and sometimes better) in SBSG courses as compared to traditionally graded courses. Students also report experiencing lower levels of stress in SBSG courses.

Veronica Ciocanel The Ohio State University

Insights and Strategies for starting local Mathematical Contest for Modeling contests

In this poster, I will highlight strategies for founding local mathematical contests for modeling for undergraduate students. I will focus on my experience at Brown University and at The Ohio State University, where these contests introduced undergraduate students to smaller scale versions of the international competition. I will particularly focus on strategies for building strong student teams, for establishing the contest as a recurring event, and for taking advantage of the institution's resources (such as SIAM or other student chapters). The local contests offer ample opportunities for feedback and student training and can be framed as competitions where the top teams are sponsored to participate in the international contests. Students have enjoyed the contest experience and were more likely to seek research experiences during college.

Diana Thomas United States Military Academy
Daniel P. Baller United States Military Academy
Kevin Cummiskey United States Military Academy
Nadav Schwartz Division of Maternal Fetal Medicine, Philadelphia, PA
Kelly Orzechowski Division of Maternal Fetal Medicine, Philadelphia, PA
Richard C. Miller The Department of Obstetrics and Gynecology, St. Barnabas Medical Center, Livingston, NJ
Anthony Odibo Division of Maternal Fetal Medicine, University of South Florida
Ruchit Shah Placental Analytics, Larchmont, NY
Carolyn M. Salafia Placental Analytics, Larchmont, NY

Gestational Growth Trajectories Derived from a Dynamic Fetal-Placental Scaling Law

Fetal trajectories characterizing growth rates in utero have relied primarily on goodness of fit rather than mechanistic properties exhibited in utero. Here we utilize a validated fetal-placental allometric scaling law and a first principles differential equation model of placental volume growth to generate biologically meaningful fetal-placental growth curves. The growth curves form the foundation for understanding healthy versus at-risk fetal growth and for identifying the timing of key events in utero. A nonlinear least squares approach was used to fit these growth curves to both healthy and growth restricted pregnancies. Parameters for each of these models were shown to be different through non-overlapping confidence regions.

Eric Stachura Kennesaw State University

Balancing Research and Teaching at a Newly Designated R2 University

Having completed my first year as a new Assistant Professor at Kennesaw State University, which has recently been designated as an R2 University, I will discuss the balance I attempt to strike between teaching innovation and research, as the University strives to grow its research profile. I will provide a brief outline of my research in partial differential equations (for non-specialists), as well as my new venture into the scholarship of teaching and learning. This new endeavor includes participation in a Faculty Learning Community as well as a new project on the effectiveness of exam wrappers. Finally, I will describe my involvement with the SIMIODE community for teaching differential equations via a modeling approach, and some of the materials I have used in class.

Frank Patane Samford University

A Proof of Hecke's Formula for Binary Quadratic Forms

We prove a formula regarding the explicit action of Hecke operators on binary quadratic forms. In *Mathematische Werke*, Hecke gives information regarding which theta series are involved in this formula, but does not give the explicit action of the Hecke operator. In fact, one can view Hecke's theorem as one from algebraic number theory due to the isomorphism from $\mathrm{CL}(\Delta)$ to the ideal class group of $\mathbb{Q}(\sqrt{\Delta})$ when Δ is a negative fundamental discriminant. This is the approach in *A Theorem of Hecke* where the author gives a proof of Hecke's formula for fundamental $\Delta < -4$ using the correspondence between ideals and classes of forms. Our treatment involves all discriminants (fundamental and nonfundamental) and give explicit formula for the action of the Hecke operator T_p on any class of forms of negative discriminant Δ. Lastly we note that our proof is contained fully in the theory of binary quadratic forms and does not employ the correspondence to the ideal class group.

Hasala Senpathy K. Gallolu Kankanamalage Roger Williams University

Lyapunov Descriptions of String Stability of Automobile Platoons

String stability of interconnected systems plays an important role in control system design. This serves as a major theoretical component of adaptive control designing, including adaptive cruise controls, intelligent automobile platoons and smart traffic flow systems. Current work introduces characterizations of string stability for systems with delays together with applications to efficient automobile platooning. In this we employ Lyapunov based approach to describe string stability with applications.

Ivan Dungan Francis Marion University

Improving Topological Intuition Using Discrete Topologies

Topology is considered by many students a very difficult math class due to its abstractness and lack of intuition. We argue that this is more likely a flaw of the standard approach to presenting the subject rather than a flaw of the subject. In short, topology is the study of objects with a notion of proximity. We will show how following the standard approach for teaching topology, but focusing on the simplest such objects gives deep intuition behind the subject resulting in a better understanding and appreciation of the subject.

Ehigie Julius Osato University of Lagos, Nigeria
Luan Vu South Methodist University, Dallas, USA
You Xiong Nanjing Agricultural University, P.R. China
Okunuga Solomon University of Lagos, Nigeria

A Novel Exponential Partitioned Runge-Kutta Schemes for Effective Simulation of Genetic Regulatory Systems

To study the dynamics of complicated networks, which areformed by DNA, mRNA, proteins and their complexes, ordinarydifferential equations are used to describe the rates of change inthe concentration so that quantitative and qualitative propertiessuch as the effect of concentrations of the species, the timeevolution of the biochemical events and possibly the limit cycleoscillations exhibited by biological systems can be studied. Thispaper introduces a novel Exponential Partitioned Runge-Kutta(Exp-PRK) method for the effective simulation of geneticregulatory systems such that the structure of the system ispreserved. We introduce a new set of Tetra-Rooted-trees andpresent the order conditions of the method up to order four. Wegive some novel Exp-PRK as extensions to some PRK methods in theliterature. Finally, we present some simulation of one gene network.

Leyda Almodovar Stonehill College
Amanda Harsy Lewis University
Cory Johnson California State University San Bernardino
Jessica L. Williams Converse College

Optimal Pots for Modular DNA Self-Assembly

Self-assembling DNA complexes can be modeled using concepts from graph theory. New design strategies have resulted in significantly increased efficiency for laboratory processes. One recent focus in DNA nanotechnology is the formation of nanotubes using lattice structures. These nanotubes are thought to have wide-ranging potential, serving as containers for nano-cargos and as drug-delivery vehicles. Rules governing the self-assembly of these nanotubes are not yet well understood, and this naturally creates open problems in applied graph theory. In this work, we give an overview of lattice-based nanotube construction and explore related design strategy problems. We begin by studying grid graphs with regular tiling patterns, such as square grids and triangle grids. Next, we form tubes by identifying edges along one pair of opposite grid graph sides. Strategies and preliminary results will be discussed.

Johannah L. Crandall Washington State University
Kristin Lesseig Washington State University

Investigation of Learning Contexts for and Perceptions of Mathematical and Modeling Software Among Undergraduate Engineering Students

This work contributes to the foundation for a larger project exploring development of mathematical understanding and computational reasoning by students in "non-math" fields that are nonetheless dependent upon sophisticated mathematical software tools. Open-ended surveys were distributed to engineering students and faculty within a Pacific Northwest university. Responses were retained from n=53 undergraduate students and n=14 faculty members primarily from the fields of mechanical, electrical, computer, and biological engineering. In the cases of both mathematical and modeling software tools as well as structural programming tools, data was collected regarding learning contexts and use contexts, perceptions of tool usefulness, and perceptions of industry-relatedness. In the discussion, special attention is given to the extent to which MATLAB is perceived as a mathematical or programming tool among engineering disciplines. Both student and faculty comments regarding the relationship between the current suite of tools advanced in engineering education and those deemed critical for industry are presented. Awareness and perception of mathematical and modeling software tools are discussed, as are avenues of continuing inquiry.

Joseph Barrera Converse College

Asymptotic Expansion of the L^2-norm of a Solution of the Strongly Damped Wave Equation

The Fourier transform, $\mathcal{F}$, on $\mathbb{R}^N$ $(N \geq 3)$ transforms the Cauchy problem for the strongly damped wave equation $u_{tt} - \Delta u_t - \Delta u = 0$ to an ordinary differential equation in time. We let $u(t,x)$ be the solution of the problem given by the Fourier transform, and $\nu(t,\xi)$ be the asymptotic profile of $\mathcal{F}(u)(t,\xi) = \hat{u}(t,\xi)$ found by Ikehata in the paper *Asymptotic profiles for wave equations with strong damping* (2014). The goal of the research is to study the asymptotic expansions of the squared L^2-norms of $u(t,x)$, $\hat{u}(t,\xi) - \nu(t,\xi)$, and $\nu(t,\xi)$ as $t \to \infty$. With suitable initial data $u(0,x)$ and $u_t(0,x)$, we establish the rate of decay of the squared L^2-norms of $u(t,x)$ and $\nu(t,\xi)$ as $t \to \infty$. By noting the cancellation of leading terms of their respective expansions, we conclude that the rate of convergence between $\hat{u}(t,\xi)$ and $\nu(t,\xi)$ in the L^2-norm occurs quickly relative to their individual behaviors. This observation is similar to the diffusion phenomenon, which has been well studied.

Kerry O'Grady Johns Hopkins University

Mathematical and Artistic Creative Processes: Distilling Models, Mapping Interdisciplinary Intersections

This poster places models of the mathematical creative process in conversation with models of the artistic process in order to identify intersections, such that descriptions of creative processes in math and art may inform and illuminate each other. Drawing from the creativity literature, this poster will concisely overview a few theorizations of the creative process across disciplines to clarify the behaviors in these theorizations and to locate a few relevant ideas from the literature (i.e., domain generality/ specificity, problem finding/ solving, creative person/ process/ product). Then the poster will describe models of artistic and mathematical creative processes from discipline-specific literature and from accounts of artists and mathematicians. Within this section, I note parallels that mathematicians draw between their work and that of artists. Bringing these models together, I map the intersections and apparent differences between the way mathematical and artistic creative processes are described, with attention to behaviors of ideation, revision, and iteration; thinking in a medium or symbol system; discussions of epistemology; the role of aesthetics and intuition within the processes; and the socio-emotional dispositions required and exercised in the work. These intersections avail of the opportunity to elucidate interdisciplinary possibilities with respect to process.

Jakob Kotas University of Portland
Andrew Bracken Horizon Air

Optimal Airline De-Ice Scheduling

We present a decision support framework for optimal flight re-scheduling on an airline's day of operations when de-icing suddenly becomes necessary due to snow and ice events. Winter weather, especially in areas where such weather is not commonplace, can cause cascading delays and cancellations throughout the system due to the unforeseen need to add de-ice time to each aircraft's turnaround time. Our model optimally re-schedules remaining flights of the day to minimize system delays and cancellations. The model is formulated as a mixed integer linear program (MILP). Structural properties of the model allow it to be decomposed into a finite set of linear programs (LP) and a computationally tractable algorithm for its solution is described. Finally, numerical simulations are presented for a case study of Horizon Air, a regional airline based in the Pacific Northwest of the United States.

Richard G. Ligo Gannon University

Curves, Total Curvature, and Conformal Transformations

The total absolute curvature provides a measurement of how much a curve is "turning" over the entirety of its length. Conformal transformations of $\mathbb{R}^n$ are those constructed from translations, rotations, reflections, dilations, and inversions. We show that the effect of conformal transformations on the total absolute curvature of a curve is uniformly bounded. This is accomplished with elementary tools from analysis and differential geometry.

Michelle Cordier Doyle Chatham University
Maria Alfonseca-Cubero North Dakota State University
Dan Florentin Kent State University

Characterizing the Disc in Hyperbolic Geometry

Following Santalo's approach, we prove several characterizations of a disc among bodies of constant width, constant projections lengths, or constant section lengths on given families of geodesics on the hyperbolic plane.

Abdulahi Ndzi Njah University of Lagos
Abidemi E. Adeniji University of Lagos
Olusokanmi I. Olusola University of Lagos

Application of the Mathematical Concept of Recurrence Techniques for the Nonlinear Time Series Analysis of some Atmospheric Data Across Nigeria

This work applies the mathematical concepts used in nonlinear time series analysis, in particular, the recurrence techniques (recurrence plots (RP), cross recurrence plot (CRP), recurrence quantification analysis (RQA) and correlation coefficient between probabilities of recurrence (CPR)) to analyse the dynamics underlying some atmospheric time series data, (solar radiation data and wind speed data) from various stations across Nigeria as well as the nonlinear relationship between the solar radiation and wind speed data. The recurrence techniques reveal that the dynamics underlying solar radiation and wind speed data are characterized by nonlinearity, non-stationarity and deterministic chaos. Furthermore, the chaoticity in the solar radiation and wind speed data is observed, from different RQAs, to be low[high] for dry[wet] season and for northern[southern] regions with low[high] annual rainfall. Using CRP of the two meteorological data, it is observed that the distribution of deterministic structure on the CRP is high[low] in the dry[wet] season which implies high[low] predictability of the two meteorological parameters in the dry[wet] season. The CRP also reveals that intermittency, which is a natural phenomenon inherent in solar radiation and wind speed, is more pronounced in the wet season and southern regions than the dry season and northern regions. Computation of CPR values to determine the degree of phase synchronization between the two meteorological data gives high[low] CPR values, which indicate strong[weak] synchronization, for dry[wet] season and northern[southern] regions. This is due to strong[weak] coupling between the two meteorological parameters which is attributed to strong[weak] effect of west African monsoon during dry[wet] season. Therefore,

the mathematical techniques (RP, RPQ, CRP, CPR) for nonlinear time series analysis are able to reveal the underlying dynamics and phase synchronization relationship between the two meteorological parameters, which are important in the design of hybrid power generating plant utilizing wind energy and solar energy as well as the most suitable region to site such a plant.

Nathan N. Alexander Morehouse College

"Each One, Teach Many": Explorations in Graph Theory and Small-world Networks in Early College Mathematics

Network analysis is the method of representing a complex problem using a graph $G(V, E)$, where V are the vertices of the graph and E represents the edges of the graph, and analyzing the graph as a network. A network graph (N, g) consists of nodes $N = \{1, 2, ..., n\}$ and an n x n matrix $g\{0, 1\}$ which represents the availability of an edge from node i to node j. (N, g) is considered a directed graph (or digraph) if $g_{ij} \neq g_{ji}$ and a undirected graph when $g_{ij} = g_{ji}$ for all $i, j \in N$; a graph is considered weighted when the edge weight $g_{ij} > 0$. This study examined mathematical models of small-world network graphs in early college mathematics courses using applications in graph theory and social network analysis. The purpose of this study was to develop models of graphical networks which will allow us to better understand the ways in which peer interactions can contribute to and influence student thinking.

Derek J. Sturgill University of Wisconsin: Stout
Xue Gong University of Wisconsin: Stout

Reinforcing Algebra Skills to Support Student Learning of Calculus

Algebraic competency is essential to students' success in a Calculus I course. Students with a weak understanding of algebra and underdeveloped algebraic skills can struggle in this course, dampening their achievements in future mathematics courses. This study examined the benefits of an intervention: meeting students individually or in groups to review algebra content and assessing them via a mastery exam. Throughout the 2018 Fall semester, we monitored student performance and, at the end of the semester, distributed an electronic questionnaire. Four different sections (two different instructors) participated in this study with n = 68 students providing feedback. Result are shared and serve as an avenue for reflection and change.

Tuyin An Georgia Southern University

Student Conceptions of Counterexample in Dynamic Geometry Environments

As an important aspect of mathematical reasoning and proof, disproof by counterexample (or refutation), can be used as an effective instructional tool in helping students generate conjectures. In my teaching and research of various levels of geometric reasoning and proof, I noticed students were challenged by the role and use of counterexamples. Their ability to visualize and create counterexamples was also limited by using traditional paper and pencil. Since previous studies have shown that incorporating the dragging feature supported by dynamic geometry environments (DGEs) can promote student understanding and reasoning and proof ability in learning geometry, I designed a set of DGE-incorporated tasks and conducted a case study through individual task-based interviews with six undergraduate math major students. The goal of the study is to answer the research question: What are students' conceptions of disproof by counterexample in the context of DGE-incorporated geometry? Interview data are analyzed using the inductive and deductive qualitative analysis methods alternately. The analysis focuses on identifying learners' goals of the given tasks and their available goal-directed activities, which both are structured and governed by learners' current conceptions. Data analysis is currently in progress. Preliminary findings and conclusions will be presented at this poster session.

Rachel Webb University of Michigan

Mentoring Undergraduate Research Presentations

Undergraduate research programs often require some kind of oral presentation at the culmination of the program, but students often receive little or no guidance from their mentors in creating these presentations. Consequently, the talks are mediocre and we lose an opportunity to teach about communication and research. Using techniques known to be effective from writing pedagogy, I have developed a simple three-part program that mentors students through the creation of their talk. Both students and instructors report that this program improves their understanding both of how to give a talk and of the research process. As a bonus, everyone gets to listen to better talks!

Index of Speakers