ABSTRACTS OF PAPERS PRESENTED AT

MAA MATHFEST 2023

TAMPA-FLORIDA

MAA
MATHEMATICAL ASSOCIATION OF AMERICA

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Contents

Invited Addresses

MAA Earle Raymond Hedrick Lecture Series

Mary Lou Zeeman, *Bowdoin College*

Lecture Series: Resilience, Reactivity and Flow-Kick Dynamics

Lecture I - Flow-kick Systems for Studying Resilience
Thursday, August 3, 11:00 a.m. - 11:50 a.m., Ballroom B/C

As climate change and human activities deliver new disturbance patterns to urban and ecological systems, resilience questions make us look at familiar mathematics through a new lens. Resilience is a slippery concept that has different meanings in different contexts. It is often described as the ability of a system to absorb change and disturbance while maintaining its basic structure and function. There is, therefore, an inherent interplay between transient dynamics and perturbation in resilience questions, especially when the perturbations are repeated. One way to capture this interplay is to subject the "flow" of an autonomous system of ordinary differential equations to regular "kicks" representing repeated, discrete disturbances. The resulting "flow-kick" systems occupy a surprisingly under-explored area between deterministic and stochastic dynamics. In this talk, we describe some examples in ecology and epidemiology, and some of the open questions raised.

Lecture II - A New Framework for Harnessing Reactivity
Friday, August 4, 9:00 a.m. - 9:50 a.m., Ballroom B/C

It is a well-known but counter-intuitive fact that even for a two-dimensional linear differential equation with a globally attracting equilibrium at the origin, solutions of the differential equation may grow arbitrarily large in the short term before settling at the equilibrium in the long run. This phenomenon of transient radial amplification is called reactivity. It is especially important in resilience questions where reactivity may magnify disturbances of a system to an unhealthy level. In this talk, we describe a new framework for analyzing the radial and tangential dynamics of two-dimensional linear differential equations. We show how to recover the classical eigenvalue/eigenvector analysis for long term stability of the equilibrium, and then exploit a dual relationship between reactivity and eigenvalues to capture the transient reactivity properties of the system. To finish, we illustrate some ways this framework can provide insights into disturbance amplification via reactivity.

AMS-MAA Joint Invited Address

Sloan Evans Despeaux, *Western Carolina University*

Oswald Veblen: Success through Collaboration
Thursday, August 3, 9:00 a.m. - 9:50 a.m., Ballroom B/C

Oswald Veblen (1880-1960) made important contributions to mathematics in America as a mathematical researcher, architect, advocate, and diplomat. Collaboration played a central role in these successful initiatives. Following Veblen's lead, in December 2022, a group of historians of mathematics and mathematicians met for a week to organize a collaborative historical study of Veblen's life. This talk explores some of the collaborations in Veblen's career and some of the collaborative projects that grew out of the December workshop.

MAA Invited Address

Jason Brown, *Dalhousie University*

All You Need is Math: Connections Between Mathematics and Music
Thursday, August 3, 1:00 p.m. - 1:50 p.m., Ballroom B/C

Music is full of mathematics – from sums of trigonometric sound waves that comprise audio recordings to transitions between melody notes, between chords, and between onsets in a rhythmic pattern. A variety of mathematical tools (including calculus, linear algebra, number theory and combinatorics) are available for both musical analysis and generation. In this talk we discuss:
• how patterns and transformations play a significant role in musical aesthetics,
• why we are drawn to the repetitive nature of the blues,
• why the bridge to *I Want to Hold Your Hand* is so mathematically perfect,
• what statistics and machine learning can say about music authentication, and
• how Fourier transforms can unravel a few musical mysteries surrounding *A Hard Day's Night*.

Caroline Colijn, *Simon Fraser University*

How the COVID-19 Pandemic Raises the need for New Mathematics
Friday, August 4, 11:00 a.m. -11:50 a.m., Ballroom B/C

Mathematics has played a prominent role in the pandemic, and mathematical concepts have been in the press throughout, from "flatten the curve" to "herd immunity" to "Rt" and beyond. Mathematical models have also been used by decision-makers to forecast the numbers of infections and cases, project health care demand, and envision longer-term pandemic trajectories. But one of the driving features of the pandemic has been evolution: the virus has changed, increasing its transmissibility, changing its severity (both up and down) and evading our immunity. These changes have posed huge challenges for pandemic control.

In this talk, I will describe the challenges and opportunities that this brings to mathematicians. The capacity to read the genomes or large numbers of viruses offers a lot of information about how the virus spreads and evolves. But there is a real gap between genetic sequences and interpretable information that can be used to understand dynamics, make projections and support decision-making. I will describe how new mathematical tools help fill this gap, using a combination of discrete structures, estimation, and dynamic modelling. Mathematical innovations offer new ways to describe and summarize the information in genetic data, new methods to use those data to learn how pathogens move from person to person and around the world, and new ways to learn where the highest levels of transmission are occurring. I will conclude by outlining ongoing modelling challenges in the world of evolving infectious diseases.

Fern Hunt, *National Institute of Standards*

A Markov Chain Approach to Finding Effective Spreaders in a Network
Thursday, August 3, 10:00 a.m. - 10:50 a.m., Ballroom B/C
The speaker will discuss a very simple but popular random walk description of communication in a social network known as a consensus model. An individual in the network as represented by a vertex and is connected by edges to other vertices representing members with whom the individual communicates. Suppose one seeks to spread a message throughout the entire network by initially telling just a few members. Given constraints on the cardinality, what subset of nodes should be selected so the message spreads to the rest of the network at the fastest rate? We will describe an approach to this problem that uses a combination of discrete optimization and the mixing theory of Markov chains to identify optimal and close to optimal subsets.

MAA James R.C. Leitzel Lecture

Daniel Zaharopol, *Bridge to Enter Advanced Mathematics (BEAM)*

Nobody Majors in STEM Hoping to Fail
Friday, August 4, 10:00 a.m. - 10:50 a.m., Ballroom B/C

Really think about that: nobody plans to fail. Nobody! And yet, not only do many students drop out of STEM, but students from marginalized communities (especially Black, Latino, Indigenous, and other marginalized racial groups) switch out of STEM or drop out at especially high rates. We often find ourselves thinking *oppositionally* to our students, where if only they tried harder or communicated better with us or whatever else, we could give them a better grade. I want to shift that perspective to one of finding productive and workable solutions. I'll explore what factors go into the educations of young students, especially those in STEM majors. What kind of preparation and experiences have they had before college? What expectations do they have? What are academic factors and non-academic factors that contribute to leaving, and what solutions can we implement that will give them the tools and resources, and above all else be welcoming, so that they can succeed? Some tools are easy to do, and some will be more of a lift, but I hope that everyone comes away more prepared to effectively support students from all backgrounds.

AWM-MAA Etta Zuber Falconer Lecture

Tatiana Toro, *University of Washington, Mathematical Sciences Research Institute (MSRI)*

Geometry of Measures
Friday, August 4, 1:00 p.m. - 1:50 p.m., Ballroom B/C

In this talk I will describe the question that has motivated my recent work in Geometry Measure Theory. We will explore whether the behavior of a measure on balls in different metrics provides information about the structure of the support of the measure. Along the way we will see how concepts learned in calculus play an important role in this area of mathematics.

Chan Stanek Lecture for Students

Lara Pudwell, *Valparaiso University*

Patterns in Permutations
Friday, August 4, 2:00 p.m. - 2:50 p.m., Ballroom B/C

A permutation is a list where order matters. Despite this humble definition, permutations offer a wealth of beautiful mathematics that can be applied across scientific disciplines. Starting simply, with lists of numbers, we'll discuss how smaller permutations can be embedded into larger permutations along with a host of interesting counting problems with connections not just to mathematics, but to computer science, chemistry, and more.

Christine Darden Lecture

Ricardo Cortez, *Tulane University*

The Many Roles of Mathematical Modeling
Saturday, August 5, 9:00 a.m. - 9:50 a.m., Ballroom B/C

Mathematical modeling is a vibrant area of mathematical research that continues to expand as modelers find new ways of using mathematics to investigate a variety of phenomena. I will describe current research in the area of biological fluid dynamics, for which we have developed mathematical models and computational methods that advance our understanding of the observed swimming and feeding patterns of microorganisms. The presentation will focus on choanoflagellates, which are organisms that wave their flagellum to propel themselves or to create fluid currents that bring nutrients toward them. This work is in collaboration with experimental biologists, which allows for experimental data to be included in the models and for model results to suggest new experiments. Upon reflection on the process undertaken throughout our research, we find that the modeling process is essentially the same as the process experienced by students learning about modeling. In the last decade, we have seen a sharp increase in

mathematics education research related to all aspects of modeling, including determining effective ways of teaching it and ways of preparing undergraduate students who plan to become teachers or to use mathematics professionally. The final part of the presentation will describe research on teaching mathematical modeling, including using modeling to learn new mathematical concepts or reinforce concepts learned in other courses. Our approach places emphasis on pursuing student-generated ideas for models rather than on using previously established models. This work is in collaboration with mathematics educators.

Martin Gardner Lecture

Susan Goldstine, *St. Mary's College of Maryland*

Maps of Strange Worlds: Adventures in Topological Art
Saturday, August 5, 2:00 p.m. - 2:50 p.m., Ballroom B/C

In 1852, a math student posed a deceptively simple-sounding question: if you want to color a map so that bordering regions always have different colors, how many colors do you need? This opened a rabbit hole that has kept mathematicians, computer scientists, and philosophers occupied for over a century, igniting a fundamental debate about how we know what is true. The central result of this exploration is the Four-Color Theorem, which covers every map of our world.
Along the way, topological explorers found a collection of worlds more complex than our own, worlds where aspiring map makers need many more than four colors. We will take a guided tour of these worlds through contemporary artists' renditions in yarn, beads, ceramics, paper, and other media. The journey features visual and conceptual delights stretching from the nineteenth century up to now.

NAM David Harold Blackwell Lecture

Ron Buckmire, *Occidental College*

Different Differences
Saturday, August 5, 11:00 a.m. - 11:50 a.m., Ballroom B/C

In this talk, I will discuss different examples and contexts of the word "difference." First, I will explain how different kinds of difference quotients known as nonstandard finite differences are used to approximate the derivatives that appear in differential equations as a solution technique. Second, I will provide some ways different aspects of my identity (may) have affected my career trajectory. Third, I will present comments on how the mathematics community treats "difference" and provide suggestions for how the future for other mathematicians who differ from the norm can be different from how we were treated in the past.

Student Activity Speaker

Kevin Knudson, *University of Florida*

Five Platonic Friends
Saturday, August 5, 1:00 p.m. - 1:50 p.m., Ballroom A

A Platonic solid is a polyhedron with the following properties: all its faces are congruent regular polygons, and the number of polygons meeting at each vertex is the same. Book XIII of Euclid's elements contains a proof that there are exactly five such solids, namely, the tetrahedron, cube, octahedron, dodecahedron, and (the MAA logo) icosahedron. During our hour together we will make origami models of these solids, talk about Euler's formula for convex polyhedra, and use it to prove that these are the only five Platonic solids.

MAA President Retiring Address

Jennifer Quinn, *University of Washington Tacoma*

Lessons that Really Count
Saturday, August 5, 10:00 a.m. - 10:50 a.m., Ballroom B/C

Reflection is an important practice to make sense of and grow from any experience—big or small. Whether attending a meeting, teaching a class, writing an article, leading an organization, or adapting to a pandemic, there are lessons to be learned. For this talk, I take stock of some important lessons inspired by a life in combinatorics.

Invited Paper Sessions

MAA Invited Paper Session

Special Functions and Constants in Geometry and Trigonometry

Thursday, August 3, 8:00 a.m. - 10:50 a.m., Room 118

The theme is to explore connections between geometric properties and the functions that model those properties. Trigonometry is the classical example of this and generalizations of trigonometric functions to other settings, such as "squigonometry" in the p-norm, invite new ways to explore the interplay of geometry and analysis. This session will focus on this analytic-geometric lens, inviting talks that illustrate how special functions and constants describe geometric objects, and vice versa.

Organizer:
Bill Wood, *University of Northern Iowa*

Interesting Squigonometric Series
8:00 a.m. - 8:20 a.m.
Squigonometric functions are generalized trigonometric functions that parameterize the curves $|x|^p + |y|^p=1$. As with the usual trigonometric functions, we would like to be able to approximate the values of squigonometric functions and their inverses. We discuss what Maclaurin series for these functions look like, and the oddities that arise in their common structure and their radii of convergence for $p > 2$. We also will look at some sums computed using these series.
Author:
Robert D. Poodiack, *Norwich University*

Fourier Analysis of Squigonometric Functions
8:30 a.m. - 8:50 a.m.
We view the unit p-squircles as lying in the complex plane. Fourier coefficients can easily be computed to derive complex exponential series for these shapes, and the real and imaginary parts are of course the squigonometric functions. But! There is an interesting degree of freedom introduced by how the squircles are parameterized. Typical choices are that the parameterizations come from arclength and area of the corresponding squircular sectors -- parameterizations that are identical when $p=2$ but become distinguishable for other values of p. We also consider the related problem of using the squine and cosquine functions as a basis for analternative version of Fourier analysis. There are intriguing differences in the rates of convergence of Fourier series and these alternatives for particular species of periodic functions.
Author:
Joseph Fields, *Southern Connecticut State University*

Analysis over Unit P-circles
9:00 a.m. - 9:20 a.m.
A unit p-circle is the set of all points in the cartesian plane whose distance from the origin equals 1 in the L_p norm. The generalized trigonometric functions parametrize these unit p-circles like their classical circular counterparts. We will explore the geometry of these p-circles, the properties of generalized trigonometric functions, and their analytic continuation.

Author:
Sunil K. Chebolu, *Illinois State University*

Zeta Functions and Sums in the Spirit of Ramanujan
9:30 a.m. - 9:50 a.m.
Zeta functions make an appearance across a variety of mathematical disciplines including algebra, analysis and geometry. In this talk I will discuss instances of zeta functions occurring in the work of Ramanujan where they make an appearance in the evaluation of infinite sums involving hyperbolic trig functions. I will show that these sums and their evaluation in terms of special values of zeta functions have a natural analytic interpretation. This interpretation leads to interesting expressions that generalize the equalities with which we begin.
Author:
Patrick MacDonald, *New College of Florida*

The Fundamental Theorem of Starithmetic
10:00 a.m. - 10:20 a.m.
A regular star polygon is a self-intersecting equilateral, equiangular polygon, and the study of such stars has a rich history in both plane and sacred geometry. In this talk we consider *oriented* star polygons, which admit a method for constructing new oriented star polygons from two existing ones. We examine the consequences of this construction and prove a ``fundamental theorem'' of sorts: every oriented star polygon can be decomposed into a unique sum of irreducible, laterally independent stars. We conclude with a few applications of ``starithmetic,'' including a result expressing rational numbers as unique sums of integers and positive proper fractions.
Author:
Travis Kowalski, *The South Dakota School of Mines & Technology*

'A Tale of Two Catenaries'
10:30 a.m. - 10:50 a.m.
This work pertains to a 'double catenary' that forms when a closed, ideal chain of length L is draped over two frictionless pins at the same vertical height and separated by horizontal distance D. Each of the two segments hanging at equilibrium under the action of gravity forms a catenary. The question studied is whether a given equilibrium solution is stable. We show that although the trivial solution of the two catenaries being identical is always an equilibrium configuration, it is not always stable. There exists a critical value LC for the length such that the trivial solution becomes unstable for L > LC. In such cases, the system is stable only for catenaries of differing lengths, and we present a method to calculate the two said lengths.
Author:
Subhranil De, *Indiana University Southeast*

MAA Invited Paper Session

Trends in Mathematical and Computational Biology
Thursday, August 3, 8:00 a.m. - 10:20 a.m., Ballroom A

Mathematical and computational biology encompasses a diverse range of biological phenomena and quantitative methods for exploring those phenomena. The pace of research at this junction continues to accelerate and substantial advancements in problems from gene regulation,

genomics, phylogenetics, RNA folding, evolution, infectious disease dynamics, neuroscience, growth and control of populations, ecological networks, drug resistance modeling, and medical breakthroughs related to cancer therapies have increasingly ensued from utilizing mathematical and computational approaches. Our session on current trends will sample from this diversity of important questions from biology and medicine and their mathematical treatments, with a goal of maximizing the range of topics and research methods presented at the session. Mathematical approaches will include deterministic and stochastic continuous dynamical models, as well as finite dynamical systems and combinatorial and algebraic methods.

Organizers:
Timothy Comar, *Benedictine University*
Anne Yust, *University of Pittsburgh*

Sponsor:
SIGMAA on Mathematical and Computational Biology (BIO SIGMAA)

Modeling Growth & Reproduction in Bromeliads: A Tour of Modeling Methods
8:00 a.m. - 8:20 a.m.
The plant family Bromeliaceae contains over 3000 species of rosette-structured flowering plants (commonly known as bromeliads), and includes the pineapple and Spanish moss. The long lifespan of many Bromeliaceae species (up to 100 years in some species) can make it difficult to *in situ* study the growth and reproduction of individual rosettes over their lifetime. However, this provides fertile ground for developing mathematical and computational models that can simulate and predict growth, reproduction, and population dynamics across many decades. These models have the additional benefit of allowing for simulations which consider the impact of changing environmental conditions, like climate change or the introduction of invasive species. In this talk, we will tour the variety of mathematical models being used to simulate bromeliad growth & reproduction, from simple single equation continuous functions and discrete difference equations to more intricate models of systems of differential equations and agents-based models. Each model provides a different lens from which to view and understand bromeliad growth and reproduction.
Author:
Erin Bodine, *Rhodes College*

Gut Instincts: A Data Driven Approach to Mouse Colon Modeling
8:30 a.m. - 8:50 a.m.
Colon motility, the spontaneous self-generated movement and motion of the colon muscle and its cells, is produced by activity in different types of cells such as myenteric neurons of the enteric nervous system (ENS), neurons of the autonomic nervous system (ANS) and interstitial cells of Cajal (ICC). Two colon motor patterns observed experimentally are proximal motor complexes (pMCs) often associated with the propulsion of fecal contents, and ripple contractions which are involved in mixing and absorption. It has been observed that the pMCs can occur without fecal matter present, but it is poorly understood how these spontaneous CMs occur. How ICC and neurons of the ENS and ANS interact to initiate and influence colon motility is still not completely understood. This makes it difficult to develop new therapies to restore function in pathological conditions. This talk will discuss the development of a data-driven model of the ICCs and neurons that also captures the spontaneous global dynamics like pMCs that are observed in the colon and give insight to how pMCs occur.

Author:
Andrea Welsh, *University of Pittsburgh*

An Evolutionary Game Theory Model of Altruism via Arrhenotoky
9:00 a.m. - 9:20 a.m.
Arrhenotoky is a unique biological mechanism in which unfertilized eggs give rise to haploid male offspring, while fertilized eggs give rise to diploid female offspring. In this work, we build a mathematical model for the arrhenotoky replicator dynamics of a beehive by adopting an evolutionary game theory framework. Using this model, we investigate the evolution of altruistic behavior in a beehive, looking particularly at hive success over a variety of parameters, controlling for altruism in workers and the queen. We find that the most reproductively successful hives have completely altruistic workers that donate all of their resources to the queen, as well as a somewhat altruistic queen that donates a small proportion of her resources to drone bees. Through these results, our model explains in part the evolutionary adoption of altruistic behavior by insects with arrhenotoky reproductive dynamics.
Authors:
Olivia J. Chu, *Dartmouth College*
Zachary Nathan, *Dartmouth College*

Algebraic Methods for Detecting Convex Combinatorial Neural Codes
9:30 a.m. - 9:50 a.m.
A major problem in neuroscience is to understand how the brain uses neural activity to understand the external world. Combinatorial information in the firing patterns of neurons often reflects important features of the stimuli that generated these patterns. How can we efficiently extract such information from the neural code? This talk will introduce some of the algebraic methods currently in use for understanding the combinatorial structure of neural codes, and also discuss how this structure can be used to infer features of the underlying space.
Author:
Nora Youngs, *Colby College*

Exploring the Roles of Interneuron Subtypes in Network Dynamics
10:00 a.m. - 10:20 a.m.
Neural modulation in aroused states can provide insights into the specific roles of synaptic connections and unique populations that compose the network. Modulation of input is necessary for processing and interacting with our surrounding environment. Three interneuron inhibitory subtypes populations, Parvalbumin (PV), Somatostatin (SOM), and Vasoactive Intestinal Peptide (VIP) have been identified as key players of the modulation of input. Optogenetic stimulation of inhibitory subtypes demonstrates different responses across different subtype populations such as modulation power of dominating frequency or the appearance of gamma oscillations. To investigate each population's contributing role in modulation of synchrony, we begin by imposing static current to individual cell populations representing an aroused state observed experimentally. Initial probing of individual populations with imposed static input result in three distinct network states: *(i)* subcircuit activity, *(ii)* weak synchrony activity, and *(iii)* strong synchrony activity. The three network states are consistently generated for each population receiving static input. Transitions from state *(i)* to *(ii)* to *(iii)* are consistently generated by applying activating input to E or SOM, or by applying inactivating input to PV or VIP. Our model is a spatially organized spiking neuron model with a single excitatory population, three distinct inhibitory populations, and feedforward input. The connectivity of the network is randomly generated and distance dependent. Each population is modeled as an exponential integrate and fire neuron with parameters specific to each population type influenced by biologically observed characteristics. We will describe the specific functions of each population in the network across arousal states. We will be able to elucidate changes in dynamics due to changes in the connectivity for each population. This work provides a

foundational understanding for the modulation of network activity with respect to four unique populations where the results can provide further inside into future experiments.

Author:

Madeline M. Edwards, *University of Pittsburgh*

MAA Invited Paper Session and Jam Session (aligned with an MAA Invited Address)

Applications of Mathematics to Music

Thursday, August 3, 2:00 p.m. - 5:20 p.m. and 5:30 p.m. - 7:00 p.m., Ballroom B/C

Mathematics and music have a long-standing affinity for each other. In this session, our speakers will talk about many topics, including vowel production and a question at the intersection of mathematics, music, physics, communication, and perception; the application of natural Pythagorean intervals to the closure for scales generated by three or more intervals; the circle of fifths and the twelve-tone scale on a torus; the Piano theorem; graphs for music events, including modulation; and a musical pythagorean theorem that Pythagoras missed.

Organizers:

Jason Brown, *Dalhousie University*
Ezra (Bud) Brown, *Virginia Tech*

How do vowels work?

2:00 p.m. - 2:20 p.m.

In this session, we'll think about a question at the intersection of mathematics, music, physics, communication, and perception. We'll do a quick version of an activity I do in many Calculus courses that uses my training in music theory and vocal performance, and then we'll talk a little about why I value making these aspects of my identity explicit in class.

Author:

Brian Katz, *California State University - Long Beach*

Closure and Symmetry in Generalized Tonal Systems of more than Two Dimensions

2:30 p.m. - 2:50 p.m.

Carey and Clampitt proved that the well-formedness of a musical scale created from iterated series of fixed intervals can be characterized by two equivalent conditions: "symmetry" and "closure". Zabka generalized each of these conditions to Generalized Tonal Systems generated from two or more intervals. He proved that the conditions are still equivalent for two dimensional Generalized Tonal Systems and identified scales from human muscal traditions that can be formulated in two dimensions that cannot be generated from just one interval. Zabka asked if the two conditions remain equivalent for higher dimensions. We show that the symmetry condition implies the closure for scales generated by three or more intervals and provide counterexamples in three dimensions to the equivalence. These counterexamples are generated by natural pythagorean intervals.

Author:

Brett Stevens, Carleton University

Using Mathematics to Compose Popular Music
3:00 p.m. - 3:20 p.m.
An investigation of the best compositional techniques in pop music highlights a role that mathematics plays surreptitiously. In this talk we'll highlight a number of ways that seeing the math in the background can allow us to write musical "hooks". Yeah, yeah, yeah!
Author:
Jason Brown, *Dalhousie University*

Comparing Songs without Listening: From Music to TDA and Back Again
3:30 p.m. - 3:50 p.m.
The multidisciplinary field of Music Information Retrieval (MIR) is motivated by the comparisons that we, as humans, make about music and the various contexts of these comparisons. By defining tasks such as building better song recommendation systems or finding structural information in a given recording, MIR seeks to algorithmically make these musical comparisons in the same manner that a human being would, but on a much larger scale. In this talk, we will introduce the field of MIR, including popular tasks and cutting edge techniques. Then we will present *aligned hierarchies*, a structure-based representation that can be used for comparing songs, and new extensions of aligned hierarchies that leverage ideas from topological data analysis (TDA).
Author:
Katherine M. Kinnaird*, Smith College*

Symmetry and Group Theory in Bach's Canons
4:00 p.m. - 4:20 p.m.
Mathematics and music come from different spheres (arts and sciences), yet they share an amazing array of commonalities. Group theory gives modern language to the symmetrical structures beneath the surface of Bach's magnificent canons and fugues. These structures will be described mathematically and demonstrated on violin and piano.
Authors:
Brianna Donaldson, *American Institute of Mathematics*
David Kung, *Charles A. Dana Center, The University of Texas at Austin*

Mathematics and the Aesthetics of Music: Insights from Algorithmic Information Theory
4:30 p.m. - 4:50 p.m.
At first glance, questions of musical aesthetics do not seem mathematical in nature. But it turns out that algorithmic information theory provides a bridge between mathematics and a range of questions about the experience of listening to and hearing music. Why is it that tonal music that has been more widely embraced than atonal music? How it is that we can sing along with music we have not heard before, or that even those untrained in music are able to distinguish genres and styles? The key tools that I will use to provide insight into these and other questions will be Kolmogorov complexity and Solomonoff's notion of inductive inference. These mathematical concepts not only provide a richer understanding of the ingredients that shape how people respond to and experience music, but, as I will argue, also provide an effective framework for understanding the aesthetic impact of various musical genres.
Author:
Nora Youngs, *Colby College*

Music Is Mathematical, Mathematics Is Musical
5:00 p.m. - 5:20 p.m.
Music has scales, intervals, chords, melodies, harmonies, and rhythms -- which are of mathematical origin. Mathematics has patterns, themes, variations, and converses -- which are of musical origin. Topics in this talk (time permitting) include the Pythagorean scale, good and bad vibrations, the Piano Theorem,

odd and even harmonics, the circle of fifths and the twelve-tone scale on a doughnut; musical theater, science fiction, and one of those bad vibrations; a musical Pythagorean theorem that Pythagoras missed; and what you get when you play a certain famous theme backwards.
Author:
Ezra Brown, *Virginia Tech*

Jam Session
5:30 p.m. - 7:00 p.m.

MAA Invited Paper Session

Frontiers in Differential Equations and Applications
Friday, August 4, 8:00 a.m. - 10:20 a.m., Room 118

This session seeks to explore problems and techniques at the interface of differential equations and applied mathematics. Topics of interest include multiscale analysis, inverse problems, numerical methods, and spectral analysis, with applications in materials science, fluid dynamics, mathematical biology, and medical imaging. Our main goal is to showcase new research in applications of differential equations and to promote collaboration between established and early- career mathematicians.

Organizers:
Robert Viator Jr., *Swarthmore College*
Chee Han Tan, *Wake Forest University*

Maximal Total Population of Species in a Diffusive Logistic Model
8:00 a.m. - 8:20 a.m.
We investigate the maximization of the total population of a single species which is governed by a stationary diffusive logistic equation with a fixed amount of resources. For large diffusivity, qualitative properties of the maximizers like symmetry will be addressed. Our results are in line with previous findings which assert that for large diffusion, concentrated resources are favorable for maximizing the total population. Then, an optimality condition for the maximizer is derived based upon rearrangement theory. We develop an efficient numerical algorithm applicable to domains with different geometries in order to compute the maximizer. It is established that the algorithm is convergent. Our numerical simulations give a real insight into the qualitative properties of the maximizer and also lead us to some conjectures about the maximizer.
Author:
Chiu-Yen Kao, *Claremont Mckenna College*

Modeling Microtubule Assembly and Polarity in Neurons
8:30 a.m. - 8:50 a.m.
The microtubule cytoskeleton is responsible for sustained, long-range intracellular transport of cellular cargo in neurons. However, microtubules must also be dynamic and rearrange their orientation, or polarity, in response to injuries. While mechanisms that control the minus-end out microtubule orientation in Drosophila dendrites have been identified experimentally, it is unknown how these mechanisms

maintain both dynamic rearrangement and sustained, long-term function. To better understand these mechanisms, we introduce a spatially-explicit mathematical model of dendritic microtubule growth dynamics using parameters informed by experimental data. We explore several hypotheses of microtubule growth using both a stochastic model and a continuous ordinary differential equation model. Using fluorescence microscopy experimental data, we validate mechanisms such as limited tubulin availability and catastrophe events that depend on microtubule length. By incorporating biological data, our modeling framework can uncover the impact of various mechanisms on the collective dynamics and polarity of microtubules in Drosophila dendrites.

Author:
Anna C. Nelson, *Duke University*

Homogenization of Nonlinear Deformable Dielectrics

9:00 a.m. - 9:20 a.m.

In this talk, I will present the rigorous periodic homogenization for a weakly coupled electro-elastic system of a nonlinear electrostatic equation with an elastic equation enriched with electrostriction. Such coupling is employed to describe deformable (elastic) dielectrics. It is shown that the effective response of the system consists of a homogeneous deformable dielectric described by a nonlinear coupled system of PDEs whose coefficients depend on the coefficients of the original heterogeneous material and geometry of the composite and periodicity of the original microstructure. A classical corrector result for the homogenization of monotone operators is improved, and two Lp–gradient estimates for elastic systems with discontinuous coefficients are also shown.

Author:
Thuyen Dang, *University of Chicago*

Computation of Free Boundary Minimal Surfaces via Extremal Steklov Eigenvalue Problems

9:30 a.m. - 9:50 a.m.

Recently A. Fraser and R. Schoen showed that the solution of a certain extremal Steklov eigenvalue problem on a compact surface with boundary can be used to generate a free boundary minimal surface, i.e., a surface contained in the ball that has (i) zero mean curvature and (ii) meets the boundary of the ball orthogonally. In this talk, I'll discuss recent work on numerical methods that use this connection to realize free boundary minimal surfaces. Namely, on a compact surface, Σ, with genus γ and b boundary components, we maximize $\sigma_j(\Sigma, g)\, L(\partial\Sigma, g)$ over a class of smooth metrics, g, where $\sigma_j(\Sigma,g)$ is the j-th nonzero Steklov eigenvalue and $L(\partial\Sigma,g)$ is the length of $\partial\Sigma$. Our numerical method involves (i) using conformal uniformization of multiply connected domains to avoid explicit parameterization for the class of metrics, (ii) accurately solving a boundary-weighted Steklov eigenvalue problem in multi-connected domains, and (iii) developing gradient-based optimization methods for this non-smooth eigenvalue optimization problem. The corresponding eigenfunctions generate a free boundary minimal surface, which we describe. This is joint work with Chiu-Yen Kao and Èdouard Oudet.

Author:
Braxton Osting, *University of Utah*

Analyticity of Steklov Eigenvalues of Nearly-Hyperspherical Domains in Rd+1

10:00 a.m. - 10:20 a.m.

We consider the Dirichlet-to-Neumann operator (DNO) on nearly-hyperspherical domains in dimension greater than 3. Treating such domains as perturbations of the ball, we prove the analytic dependence of the DNO on the shape perturbation pa- rameter for fixed perturbation functions. Consequently, we conclude that the Steklov eigenvalues are analytic in the shape perturbation parameter as well. This is joint work with Robert Viator.

Author:
Chee Han Tan, *Wake Forest University*

MAA Invited Paper Session

Quantitative Justice: Incorporating Social Justice in Research, the Classroom, and More

Friday, August 4, 8:00 a.m. - 10:50 a.m. Ballroom A

Quantitative Justice is an emerging field that lies at the intersection of quantitative science and social justice. Quantitative Justice encompasses all forms of mathematical, computational, and statistical analysis of problems that are sourced in the real world, often in domains that are considered "social science." The key component that differentiates Quantitative Justice from typical quantitative analysis of social science phenomena is that either the topic under investigation or the rationale for the analysis are rooted in addressing societal inequities. These methods used include: data science, statistics, natural language processing, network analysis, topological data analysis, dynamical systems, combinatorics, computer science, database analysis, mathematical biology, environmental science, and scholarship of teaching and learning.

This session will help address the common question: "how can math be used for social justice?" By inviting speakers with experience in quantitative justice, participants can see how metric geometry and markov chains show up in electoral redistricting, how graph theory can help us understand connections between bill sponsors in Congress, how statistics can highlight patterns in policing, and how applied algebraic topology can be used to study access to polling sites and equitable distribution of public resources.

Organizers:
Ranthony A.C. Edmonds, *Duke University*
AJ Stewart, *AAAS Science and Technology Executive Fellow*

An Introduction to Quantitative Justice
8:00 a.m. - 8:20 a.m.
Quantitative Justice is the application of techniques from quantitative sciences in the social sciences to study existing social systems and derive potential tools to improve social justice, fairness, and equality. The intersection between quantitative techniques and social sciences is not new, but research by mathematicians in quantitative justice has experienced significant growth during the last five years with an increased interest in topics such as gerrymandering, voting methods, using data science to study bias in healthcare and the arts, as well as the study of algorithmic fairness. In this talk we will define quantitative justice, discuss its recent growth, and give current examples of how mathematics is being used today to shift societal systems.
Authors:
Ranthony A.C. Edmonds, *Duke University*
AJ Stewart, *AAAS Science and Technology Executive Fellow*

Quantifying Communities of Interest in Electoral Redistricting
8:30 a.m. - 8:50 a.m.
Communities of interest are groups of people, such as ethnic, racial, and economic groups, with common sets of concerns that may be affected by legislation. Many states have requirements to preserve

communities of interest as part of their redistricting process. While some states collect data about communities of interest in the form of public testimony, there are no states to our knowledge which systematically collect, aggregate, and summarize spatialized testimony on communities of interest when drawing new districting plans. During the 2021 redistricting cycle, our team worked to quantify communities of interest by collecting and synthesizing thousands of community maps in partnership with grassroots organizations and/or government offices. In most cases, the spatialized testimony collected included both geographic and semantic data—a spatial representation of a community as a polygon, as well as a written narrative description of that community. In this talk, we outline our aggregation pipeline that started with spatialized testimony as input, and output processed community clusters for a given state with geographic and semantic cohesion.

Author:
Parker Edwards, *Florida Atlantic University*

Topological and Geometric Methods in Redistricting
9:00 a.m. - 9:20 a.m.
I will discuss some novel mathematical approaches to study the redistricting problem; i.e., the problem of recognizing and characterizing political districting plans which were designed for political advantage at the cost of fair representation. In particular, I'll introduce methods from the fields of topological data analysis and optimal transport, which are able to give new insights into the 'shape' of the space of all districting plans.

Author:
Tom Needham, *Florida State University*

Topological Data Analysis of U.S. City Demographics
9:30 a.m. - 9:50 a.m.
In recent years, Topological Data Analysis (TDA) has been used to analyze complex data and provide insights that other research techniques cannot. TDA is a newer form of data analysis which analyzes trends of data from a topological perspective by way of the main visualization tool of persistence diagrams. TDA has been used to measure breast cancer transcriptional DNA, voting patterns in precincts, gerrymandering, and even texture representation.
In this paper, we apply TDA to geospatial data from the census to more accurately describe racial segregation among the Black and Hispanic demographics across one hundred cities in America. Our goal was to complete city to city comparisons in 2010 and 2020 as well as compare city similarities over the course of ten years for each race and note the respective trends. We were able to find seven clusters of cities in the black population that shared common characteristics and five for the Hispanic population. After doing a comparison of cities across the span of a decade, we also found commonalities of each racial demographic. In summary, this project represents a first step in uncovering trends in demographic data using TDA. We hope to continue exploring this data set in an effort to expand our understanding of various demographic patterns in America.

Author:
Jakini Kauba, *Clemson University*

Accelerating and Scaling Community Centered Research
10:00 a.m. - 10:20 a.m.
Nuevas Voces is a program run by the Woonasqatucket River Watershed Council in Providence, RI. Nuevas Voces creates a leadership cohort from a low-income, primarily immigrant neighborhood along the river to understand environmental issues such as neighborhood flooding and water contamination. Researchers at ICERM in Providence at Brown and IMSI at Chicago began a partnership with Nuevas Voces to provide some tools they might need to help advocate for their communities. In this talk we focus

on how we developed this partnership, choices we made to center community needs, and resulting data projects.
Author:
Carrie Diaz-Eaton, *Bates College*

#Metamath: The Mathematics of Mathematics
10:30 a.m. - 10:50 a.m.
We present and discuss a curated selection of recent literature related to the application of quantitative techniques, tools, and topics from mathematics and data science that have been used to analyze the mathematical sciences community. We engage in this project with a focus on including research that highlights, documents, or quantifies (in)equities that exist in the mathematical sciences, specifically, and STEM (science, technology, engineering, and mathematics) more broadly. We seek to enhance social justice in the mathematics and data science communities by providing numerous examples of the ways in which the mathematical sciences fails to meet standards of equity, equal opportunity and inclusion. We call our project the "mathematics of Mathematics," explicitly building upon the growing, interdisciplinary field known as "Science of Science" to interrogate, investigate, and identify the nature of mathematical sciences itself. We aim to promote, provide, and posit sources of productive collaborations and we invite interested researchers to contribute to this developing body of work.
Author:
Ron Buckmire, *Occidental College*

MAA Invited Paper Session

Recent Advances in Mathematical and Computational Biology, Highlighting Contributions from Undergraduate Researchers
Friday, August 4, 3:00 p.m. - 5:50 p.m., Room 118

Some of biology's most complex questions are best answered through mathematical modeling, using tools which range from stochastic and statistical models to deterministic differential equations models. The utility of mathematical models within biology is also vast, answering questions within subfields such as ecology, neuroscience, immunology, physiology, and more. Furthermore, mathematical biology contributes to mathematics as the complex models formed to represent biological phenomena drive the creation of new mathematical tools for model analysis. With this symposium we hope to highlight mathematical descriptions from a large range of biological disciplines. Including a variety of biological disciplines underscores the versatility of mathematical modeling as the cutting edge tool throughout biology and makes known the commonality of analytical tools and methods across fields of application. Additionally, we hope to highlight the contributions of undergraduate researchers within mathematical biology research through this symposium. Because mathematical biology is placed within an application, the research may be accessible to undergraduate students, and oftentimes undergraduate researchers can be involved easily in these projects. By highlighting the specific role of undergraduate researchers within larger research projects, we aim to clearly depict ways to involve undergraduate researchers in future research projects.

Organizers:
Anna Nelson, *Duke University*
Kelly Buch, *Austin Peay State University*

From Flashing Fireflies to Bursting Neurons: Finding Sync with Undergraduate Collaborators.
3:00 p.m. - 3:20 p.m.
Biological and physical oscillators, ranging from fireflies, to neurons, to power-grid networks, often exhibit large, collective dynamics arising from mere pairwise interactions. Analysis of the emergence of synchronization or other pattern formation is challenging due to the non-linear and high dimensional nature of their mathematical models. In this talk we discuss recent advances using a variety of analytical and numerical approaches. We will particularly highlight how undergraduate collaborators have been integral to these projects.
Author:
Matthew Mizuhara, *The College of New Jersey*

A Bit of Biology for the Mathematicians, a Bit of Math for the Biologists, Some Programming for Everyone
3:30 p.m. - 3:50 p.m.
I will present an overview of 2-3 long-term student mathematical biology research projects. In one project, a motivated biology major gained experience and skill with data-wrangling, data visualization, and application of an intricate mathematical and statistical modeling technique: capture-mark-recapture analysis. This project, part of a larger collaborative effort within the College, set a motivated student on a path to data-intensive research at a biomedical research foundation and opened the door to his pursuit of a post-graduate degree in Bio-Statistics. In another project, I highlight the appreciation gained by mathematics students learning about application and interpretation of mathematical modeling to biological systems. Finally, I will discuss how several undergraduate students from multiple disciplines and institutions have contributed to a long-term project on modeling blood clot degradation.
Author:
Sean Laverty, *University of Central Oklahoma*

Pulsing Corals and Swimming Jellyfish: Including Undergraduates in Biological Fluid-Structure Interaction Research
4:00 p.m. - 4:20 p.m.
Fluid-structure interaction simulations of biological organisms offer a steep learning curve to undergraduate researchers. Many undergraduates, particularly mathematics majors, have not had a fluids course or substantial coding experience. I will highlight two projects I am working on with undergraduate researchers, simulating the motion of pulsing soft corals and blue blubber jellyfish. Both pulsing soft corals and blue blubber jellyfish generate motion by activating their muscles, resulting in fluid flow. These projects can be particularly challenging for undergraduate research. 1) The governing equations are a system of non-linear partial differential equations called the incompressible Navier-Stokes equations. Solving them on a three-dimensional domain requires high computational cost, requiring HPC tools. 2) These organisms are elastic and deforming, requiring specialized numerical methods to reconcile an evolving boundary condition and the fluid-structure interface. The immersed boundary finite-element method, developed by Boyce Griffith, is an extension of the classical immersed boundary method. It allows for a fully three-dimensional structure, making it desirable for many biologically complex organisms. Using existing open-source software, undergraduates can run simulations, assist with parameter tuning, and develop intuition and insight into problems.

Author:
Matea Santiago, *University of Arizona*

A Global Sensitivity Analysis Framework for Rumen Fermentation Modeling Identifies Key Modifiers of Enteric Methane Production
4:30 p.m. - 4:50 p.m.
Ruminant animals rely on microbes to convert complex plant material into metabolizable compounds. During the enteric fermentation process a group of archaea produce methane (CH4), which is then eructated and released into the atmosphere by the ruminant. The emitted CH4 has a global warming potential 28-fold higher than carbon dioxide, leading to significant efforts to reduce enteric CH4 roduction. The red seaweed Asparagopsis taxiformis has been identified as a promising feed additive that reduced enteric CH4 by over 80% when added to regular cattle diet. This significant response has been partially attributed to a compound known as bromoform and its ability to inhibit the key enzyme of archaeal methanogenesis, however, the entire mode-of-action is still not fully understood. Quantitative methods incorporating mechanistic mathematical models describing microbial interactions and responses to feed additives are urgently needed for development of more sustainable strategies for the reduction of methane from ruminant animals. In this work, we developed a modeling framework in which we xtended an existing rumen fermentation model and calibrated it with functional microbial groups and gas emission data. We then identified the optimal distribution of functional microbial groups, including microbes of unknown functions, that then explained the observed reduction of enteric methane in the presence of A. taxiformis. Lastly, we utilized both local and global sensitivity analysis approaches to identify rumen arameters as key drivers in enteric methane production and potential targets for advanced methane mitigation strategies.
Author:
Kathryn Link, *Pfizer Inc.*

Undergraduate Research Aimed at Solving *Clostridioides difficile*: Mathematical Models of Transmission and Control in Healthcare Settings
5:00 p.m. - 5:20 p.m.
Clostridioides difficile (*C. difficile*) is the leading cause of infectious diarrhea and the most frequently identified healthcare-acquired infection in United States hospitals. *C. difficile* is typically contracted after antibiotic use, when healthy gut microbiota that prevent colonization is compromised. Colonized patients, both symptomatic and asymptomatic, shed *C. difficile* endospores that can survive for long periods on surfaces outside the host and are resistant to many commonly-used disinfectants. Transmission pathways can include contact with endospores on fomites, objects likely to carry infection.
This talk will focus on various mathematical models aimed at quantifying the transmission of *C. difficile* in healthcare settings ranging from systems of ordinary differential equations to agent-based models – all developed by undergraduate student researchers! We will discuss the progress and results from these student projects. Results can be applied by healthcare professionals by focusing on precautionary measures that reduce patient colonization with *C. difficile*.
Author:
Cara Sulyok, *Lewis University*

An Ounce of Prevention Is Worth a Pound of Cure?
5:30 p.m. - 5:50 p.m.
The spread of drug use throughout a community can be represented through epidemiological models typically found in studies on infectious disease dynamics. These mathematical models are based on the idea that similar to infectious diseases, drug use spreads through interactions between individuals. Previous models of drug use don't take into consideration the preferences an individual may have in their

interactions. We propose a compartmental model for heroin use that accounts for preferred mixing as well as the element of choice in seeking or avoiding individuals based on their drug use habits. In this talk, I will introduce the compartmental model framework, derive the preferential mixing function, and highlight a few interesting effects while discussing the process undertaken by undergraduate scholars. This work was completed during a 6-week REU by 3 undergraduate students from various majors under the direction of Benjamin Morin at Vassar College.

Author:
Ben Morin, *Vassar College*

AMS-MAA Invited Paper Session

Mathematics is Not Done in a Vacuum: Collaborations in Mathematics and History of Mathematics

Friday, August 4, 4:00 p.m. - 5:50 p.m., Ballroom A

This invited paper session will feature talks on collaborations. In particular, the talks will focus on collaborations by mathematicians of the past and present-day collaborations by historians of mathematics who study the past. This session will explore the benefits and special challenges that collaborations can bring.

Organizer:
Sloan Evans Despeaux, *Western Carolina University*

Collaboration in Ancient and Medieval Times
4:00 p.m. - 4:20 p.m.
In modern times, mathematicians collaborate either by physically working together – exchanging ideas – or, more likely, by the use of the internet and various forms of electronic media. But they do this in real time, probably going back and forth frequently within a limited time frame, reading and commenting on each other's work, each one trying to improve the ultimate product. Of course, mathematicians in ancient times could not do this. In general, the mathematicians we know about were scattered both geographically and temporally. So one person would learn of another's work through some form of oral or written communication and then react to it. And although sometimes this communication would garble the ideas somewhat, often this form of collaboration was productive. In this talk, we will discuss several examples of this kind of collaboration in ancient times in the eastern Mediterranean and in the medieval period in Europe. In particular, I will show that different languages and cultures ultimately did not prove to be a barrier to collaboration.

Author:
Victor Katz, University of the District of Columbia

Editorial and Epistolary Collaborations Among Mathematicians
4:30 p.m. - 4:50 p.m.
The publication of research works in various guises plays an important role in the development and dissemination of mathematical ideas. Among the interesting historical examples of collaborations associated with such publications is the editorial work undertaken by Gaston Darboux and Jules Hoüel on the *Bulletin des Sciences mathématiques et astronomiques* in the decades following its founding in 1870. Another such example is the joint effort of Richard Dedekind and Heinrich Weber to complete the

publication of Bernard Riemann's *collected works* which began in 1874. These two particular examples are also among the many collaborations that have been carried out by mathematicians primarily through the exchange of letters. In this talk, we consider what editorial and epistolary collaborations such as these may reveal about the benefits and special challenges of mathematical collaborations more generally.
Author:
Janet Heine Barnett, Colorado State University Pueblo

Beginnings: How to Start---and Sustain---a Mathematics Initiative
5:00 p.m. - 5:20 p.m.
This talk explores how the *American Mathematical Monthly* and the Institute for Advanced Study came into existence. Despite the very different aims of the journal and the institute, the similarities and differences of these processes suggest ideas, including collaboration, for starting and sustaining mathematics initiatives.
Author:
Della Dumbaugh, *University of Richmond*

Collaboration Typologies in 19th-century American Mathematics Textbook Series
5:30 p.m. - 5:50 p.m.
Collaborations in the history of mathematics have not necessarily been intentional or even consensual. Indeed, the preparation of American textbook series in the early 19th century involved a wide variety of types of collaboration, such as: administrative collaborations in which the plans and expectations of governing boards did not always align with the educational materials produced by professors; informal collaborations conducted through correspondence networks that exchanged both gossip and advice; unacknowledged collaborations by student translators and other assistants; unwitting collaborations of original authors whose works were appropriated or plagiarized; and promotional collaborations between authors and publishers. The talk will offer several examples of these collaborations and reflect on the use of collaboration as a historiographical construct.
Author:
Amy Ackerberg-Hastings, *MAA Convergence*

Invited Paper Session organized by the Leitzel Lecturer

Building STEM Success From K-12 Through College
Saturday, August 5, 8:00 a.m. - 11:20 a.m., Ballroom A

Students enter college with a variety of backgrounds and life experiences that shape their trajectory. For students from historically marginalized backgrounds, it can be especially difficult to navigate college life and academics within an environment that was not made for them. As faculty members, there is a great deal that can be done to better understand and support our students. This session will introduce insights about the student experience and how we can support them, with ideas from both researchers and practitioners who work from K-12 through college.

Organizer:
Daniel Zaharopol, *Bridge to Enter Advanced Mathematics (BEAM)*

Real Analysis: Gateway or Gatekeeper?
8:00 a.m. - 8:20 a.m.
There may be many factors that influence why a student fails, withdraws from, and/or chooses to repeat a course. However, our claim is that these factors are not all internal. In this project, we examine external factors that contribute to minoritized students' experiences in proofs-based mathematics courses, particularly real analysis. We report on narratives from our data and implications for instructors and departments for supporting minoritized students.
Authors:
Amy Bennett, *University of Nebraska-Lincoln*
Yvonne Lai, *University of Nebraska-Lincoln*

Demographic Gaps or Preparation Gaps?: The Large Impact of Incoming Preparation on Performance of Students in Introductory Physics
8:30 a.m. - 8:50 a.m.
We have studied the impact of incoming preparation and demographic variables on student performance on the final exam in the standard introductory calculus-based mechanics course at three different institutions. Multivariable regression analysis was used to examine the extent to which exam scores can be predicted by a variety of variables that are available to most faculty and departments. The results are surprisingly consistent across the institutions, with only math SAT or ACT scores and concept inventory prescores having predictive power. They explain 20%–30% of the variation in student exam performance in all three cases. In all cases, although there appear to be gaps in exam performance if one considers only demographic variables (gender, underrepresented minority, first generation), once these two proxies of incoming preparation are controlled for, there is no longer a demographic gap. There is only a preparation gap that applies equally across the entire student population. This work shows that to properly understand differences in student performance, it is important to do statistical analyses that take multiple variables into account, covering both subject-specific and general preparation. Course designs and teaching better matched to the incoming student preparation will likely eliminate performance gaps across demographic groups, while also improving the success of all students.
Author:
Shima Salehi, *Stanford University*

Welcoming Students into a Math Community
9:00 a.m. - 9:20 a.m.
Have you ever opened a door, walked into a room full of people, looked around, and said "I'm sorry, I must be in the wrong room"? Have you ever actually been in the right room, but felt internally that you were in the wrong place?
In this session we'll talk about why creating a sense of belonging is so critical for student learning and success. Black, Latine, Indigenous, female, and/or first generation students often face unique challenges in feeling a sense of belonging in their STEM classes. In this session we'll discuss these challenges and what we can do to reduce them. What proactive steps increase a sense of belonging? What practices benefit marginalized students? How can we create a welcoming community for all learners? This session will help participants deepen their understanding of the classroom environment, and learn practical steps to improve it.
Author:
Sarah Hunt, *Bridge to Enter Advanced Mathematics (BEAM)*

How Do K-12 Schools Prepare Top Math Talent for Advanced Math Studies?
9:30 a.m. - 9:50 a.m.
Math talent, or high interest and aptitude for deep problem solving, exists in every school and can be cultivated in every student. How do K-12 schools support their top math talent students who are not fully

challenged by the traditional math learning pathway? The answer varies widely depending on numerous factors - notably the location of the school. This talk will discuss lessons learned from the pilot years of an advanced math enrichment program in a network of high needs schools in Los Angeles. We'll examine the traditional model of math success in K-12 schools and offer alternative means to support growth of math talent. Lastly, we'll offer insights into supporting top math talent students from high needs communities in their postsecondary advanced math studies.

Author:
Al Lucero, *The Partnership for Los Angeles Schools*

Examining Mathematical Narratives and Supporting New Students in Mathematics
10:00 a.m. - 10:20 a.m.
In this talk we will think about the narratives that we hold in our discipline and how those narratives may hinder our ability to cultivate, and strengthen our relationships with our incoming students. We will dive into ways in which we can interrupt these narratives that will allow for us to create better, more equitable pathways to the mathematics major for all.

Author:
Aris Winger, *Georgia Gwinnett College*

Panel Discussion: Supporting Students on Pathways to STEM
10:30 a.m. - 11:20 a.m.
What factors lead to STEM success for students through college? What can we do to facilitate that success? This panel brings together the speakers from this invited paper session, including both researchers and practitioners, to consider these issues and share how we can live up to our ideals. Come prepared to ask questions and learn from a variety of experiences and knowledge from all along students' journeys.

MAA Invited Paper Session

The Mathematics of Data Science

Saturday, August 5, 3:30 p.m. - 5:50 p.m., Ballroom A

The fundamentals of data science are drawn from mathematics, statistics, and computer science. However, there is a lack of clarity on what it actually means to *be* a data scientist and how to prepare students in data science. Given that real-world data lies in a context domain, the work of data science requires interdisciplinary domain expertise that may include the humanities, social sciences, and health sciences. To carry out the data lifecycle, the context domain must be considered throughout the data acquisition, analysis, and interpretation of findings. Even though many mathematical faculty have either taken or taught the 'foundational courses' in the fundamentals of data science, others may still be resistant to incorporating data science into their academic programs due to the myriad of challenges.

This session will feature mathematicians who will share how they are advancing data science teaching and research, along with their tools and applications. From developing academic programs to engaging students in culturally relevant data science, health informatics, sports analytics, etc., the session will demonstrate how mathematics catalyzes innovations. The presenters will showcase work being done across a range of academic institutions with industry

partners from the mathematical perspective. We envision talks on probabilistic tools in data analytics for sports, complex systems and adaptive networks in data science, culturally responsive and justice-oriented approaches to teaching data science, and statistical tools in data analysis for quantitative social justice, among others. This session will also highlight the data science focus and anticipated findings of the February 2024 Special Issue of the *American Mathematical Monthly,* with Anna Haensch and Talitha Washington serving as Guest Editors.

Organizers:
Talitha Washington, *Clark Atlanta University*
Anna Haensch, *Tufts University*
Della Dumbaugh, *University of Richmond*

A Bayesian Hierarchical Model for On-Demand Digital Media
3:30 p.m. - 3:50 p.m.
We model "On-Demand" - or asynchronous impressions - of digital media inventory as two-stage, phase shift process. We discuss idiomatic features of a Bayesian Hierarchical Model for this process.
Author:
Kobi Abayomi, *Seton Hall U and Gumbel Demand Acceleration*

Mathematical Models in the Sociological Imagination
4:00 p.m. - 4:20 p.m.
This talk presents an abstract study of mathematical and statistical modeling using methods from mathematical sociology that are rooted in the ideas of the sociological imagination. The sociological imagination allows us to examine how social systems interact and influence one another and we consider interpretations of these social systems using an integrated and critical approach to mathematical modeling. More specifically, we explore integrated modeling approaches focused on neighborhood composition and land ownership in the U.S. context.
Author:
Nathan Alexander, *Morehouse College*

Community-driven Data Science for Social Justice Research Practices
4:30 p.m. - 4:50 p.m.
Community-research partnerships have been to drive impactful scholarship across many fields such as healthcare and education. These collaborative relationships should also drive impactful and insightful work in data science for social justice research. We discuss some principles behind developing such collaborations, using as an example of supporting local community advocacy in Providence, Rhode Island with partners Nuevas Voces and the Woonasquatucket River Watershed Council.
Author:
Carrie Diaz Eaton, *Bates College*

Non- family Reason Internal Migration and Their Socio-economic Characteristics
5:00 p.m. - 5:20 p.m.
Among the internal migrants a large proportion migrates due to family reasons, and they are less attracted by the gap in available opportunities between the place of origin and destination. This study analyzes internal migration data from the national living standards household survey 2010/11 data from Nepal. There are a small proportion of the migrants who migrated because of non-family reasons like higher salary, opportunities, easier urban lifestyle, higher education, but they have different characteristics than other populations. This study shows that though the non-family reason internal migration populations are

small, they occupy a good proportion in the top rich quintile group of the nation and shows that they have better socio-economic status than other populations.
Author:
Binod Manandhar, *Clark Atlanta University*

The Role of Mathematics in Undergraduate Data Science Programs
5:30 p.m. - 5:50 p.m.
While data science is in high demand both in research and in the workplace, what is needed to prepare students for a data-driven workforce remains unclear. Even though mathematics is essential in data science, the role of how mathematics contributes to undergraduate data science programs remains unclear. This presentation will provide insights into how mathematics contributes to undergraduate data science education and how to build and leverage transdisciplinary and industry partners to enhance the undergraduate experience.
Author:
Talitha Washington, *Clark Atlanta University and Atlanta University Center*

AWM-MAA Invited Paper Session

Geometric Measure Theory, Harmonic Analysis, and Partial Differential Equations
Saturday, August 5, 2:00 p.m. - 5:50 p.m., Room 118

Geometric measure theory provides a useful framework for studying the geometry and regularity of sets and measures in Euclidean and non-Euclidean settings, and has many useful applications to interesting problems in various fields of mathematics. This invited paper session aims to showcase the vibrant interactions between geometric measure theory, partial differential equations, and harmonic analysis. In this session, we will see exciting new developments at the interface of these areas, highlighting the ways in which they intertwine to produce deep insights.

Organizers:
Max Goering, *Max Planck Institute Leipzig*
Anna Skorobogatova, *Princeton University*
Mariana Smit Vega Garcia, *Western Washington University*

Dorronsoro's Theorem and Vertical Versus Horizontal Inequalities on Carnot Groups
2:00 p.m. - 2:20 p.m.
The classical Dorronsoro theorem expresses the L^p $(1<p<\infty)$ norm of the $\alpha(>0)$-fractional Laplacian of an L^p function on a Euclidean space as a certain singular integral measuring the average deviation of the function from being a polynomial around every point and at every scale. We prove a version of Dorronsoro's theorem in the setting of Carnot groups. This extends and strengthens the work of F\"assler and Orponen (2020), who proved a one-sided Dorronsoro theorem in the setting of the Heisenberg groups, with a restriction $\alpha<2$ on the fractional power of the Laplacian. One consequence of the Dorronsoro theorem is that it gives “vertical versus horizontal inequalities” on nonabelian Carnot groups, which quantify the extent to which nonabelian Carnot groups fail to embed into the L^p $(1<p<\infty)$ spaces.
Author:
Seung-Yeon Ryoo, *Princeton University*

Tensorization of Sobolev Spaces
2:30 p.m. - 2:50 p.m.
A classical - and routinely exploited - fact about Sobolev spaces in \R^n is that their structure is induced by the structures of Sobolev spaces on their components. This is believed to be true for generalized Sobolev spaces on metric measure spaces, however it is not proven in the full generality. We'll survey some definitions, their equivalences, and discuss results for Cartesian and warped products of metric measure spaces. The talk is based on a joint upcoming work with V. Giri and E. Negrini.
Author:
Silvia Ghinassi, *University of Washington*

Carnot Groups and Bi-Lipschitz Embeddings into L^1
3:00 p.m. - 3:20 p.m.
The classical Dorronsoro theorem expresses the L^p $(1<p<\infty)$ norm of the $\alpha(>0)$-fractional Laplacian of an L^p function on a Euclidean space as a certain singular integral measuring the average deviation of the function from being a polynomial around every point and at every scale. We prove a version of Dorronsoro's theorem in the setting of Carnot groups. This extends and strengthens the work of F\"assler and Orponen (2020), who proved a one-sided Dorronsoro theorem in the setting of the Heisenberg groups, with a restriction $\alpha<2$ on the fractional power of the Laplacian. One consequence of the Dorronsoro theorem is that it gives ``vertical versus horizontal inequalities" on nonabelian Carnot groups, which quantify the extent to which nonabelian Carnot groups fail to embed into the L^p $(1<p<\infty)$ spaces.
Author:
Lisa Naples, *Macalester College*

Low Dimensional Cantor Sets with Absolutely Continuous Harmonic Measure
3:30 p.m. - 3:50 p.m.
The relationship between harmonic measure and surface measure of a domain is largely connected with the geometry of the domain itself. In many fractals (for example, in domains with relatively ``large" boundaries, and outside self-similar ``enough" cantor sets), these measures are mutually singular, and in fact, have different dimensions. After recalling some of these results I will present joint work with G. David and A. Julia where we demonstrate examples where the exact opposite occurs: we construct Cantor-type sets in the plane that are Ahlfors regular (of small dimension) for which their associated harmonic measure and surface measure are bounded equivalent.
Author:
Cole Jeznach, *University of Minnesota*

Decoupling and Restriction for Ruled Hypersurfaces Generated by a Curve
4:00 p.m. - 4:20 p.m.
In this talk, we shall address the decoupling theory and restriction theory of the ruled Euclidean hypersurfaces generated by a curve. We shall think of these surfaces as "parabolic cylinders of smoothly varying orientation" and see how much mileage this perspective attains for us. In particular, we shall achieve an effective ℓ^2 decoupling theorem (of optimal L^p range) and a reverse square function estimate. Attention shall also be given to possible applications to maximal averages over curves.
Author:
Dóminique Kemp, *Institute for Advanced Study*

A Definition of Fractional k-Dimensional Measure
4:30 p.m. - 4:50 p.m.

I will introduce a fractional notion of k-dimensional measure, with $0 \leq k < n$, that depends on a parameter σ that lies between 0 and 1. When $k=n-1$ this coincides with the fractional notions of area and perimeter, and when $k=1$ this coincides with the fractional notion of length. We will see that, when multiplied by the factor $1-\sigma$, this σ-measure converges to the k-dimensional Hausdorff measure up to a multiplicative constant. This is based on a joint work with Brian Seguin.

Author:
Cornelia Mihaila, *Saint Michael's College*

A Singular Integral Identity for Surface Measure

5:00 p.m. - 5:20 p.m.

Using only the classical methods of geometric measure theory, we prove that the integral of a certain Riesz-type kernel over $(n-1)$-rectifiable sets in $\mathbb{R}^n$ is constant, from which a formula for surface measure immediately follows. Geometric interpretations are given, and the solution to a geometric variational problem characterizing the family of convex sets follows as a corollary.

Author:
Ryan Bushling, *University of Washington*

A Local Bernstein Inequality for Laplace Eigenfunctions

5:30 p.m. - 5:50 p.m.

A powerful heuristic in the study of Laplace eigenfunctions is that they behave like polynomials of degree proportional to the square root of the eigenvalue. We present an instance in which this polynomial behaviour can be made precise, namely we discuss a version of the classical (for polynomials) Bernstein inequality. Along the way we show that analogous inequalities hold for solutions to nice elliptic PDEs, which also resemble polynomials once an appropriate notion of degree is introduced. Based on joint work with Eugenia Malinnikova.

Author:
Stefano Decio, University of Minnesota

Contributed Paper Sessions

Inquiry-Based Learning

Part A: *Thursday, August 3, 1:00 p.m. - 3:55 p.m., Room 115/116*
Part B: *Saturday, August 5, 2:00 p.m. - 5:15 p.m., Room 115/116*

The goal of Inquiry-Based Learning (IBL) is to transform students from consumers to producers of mathematics. Inquiry-based methods aim to help students develop a deep understanding of mathematical concepts and the processes of doing mathematics by putting those students in direct contact with mathematical phenomena, questions, and communities. We invite you to successfully share classroom-tested IBL experiences.

Organizers:
Lee Roberson, *Colorado State University*
Mel Henriksen, *Wentworth Institute of Technology*
Mami Wentworth, *Wentworth Institute of Technology*
Joe Barrera, *Converse College*
Parker Glyn-Adey, *University of Toronto*

Sponsor:
SIGMAA on Inquiry-Based Learning (SIGMAA IBL)

Part A: *Thursday, August 3, 1:00 p.m. - 3:55 p.m., Room 115/116*

IBL Texts in Analysis and Geometry for Future Teachers
1:00 p.m. - 1:15 p.m.
This talk will report on three recently published textbooks, each written entirely in IBL format, for preparing future teachers: a sophomore/junior level geometry, a junior/senior level real analysis and a graduate level geometry. Each of these books is focused entirely on giving a college/university level background in exactly those aspects of these subjects that they will teach in high school. By presenting their solutions and proofs to their peers, students acquire an in-depth knowledge of the content of these subjects while developing skills in problem solving, theorem proving and teaching.
Authors:
David Clark, *SUNY New Paltz*
Xiao Xiao, *Utica College*
Samrat Pathania, *Wallkill High School, NY*

Combinatorics Problem Task and Mathematical Cybersecurity Activity
1:20 p.m. - 1:35 p.m.
Inquiry-based tasks promote student engagement and critical thinking. During a longitudinal study, students worked on a classical combinatorics problem task to account for all possible pizzas when selecting from 4 different toppings. A basic understanding of counting has strong implications for reasoning about issues of cybersecurity. A pilot research study with middle-school-aged students explored how the "Guess My Password" activity elicited knowledge about counting. The activity has important

implications for building understanding in the domains of Counting/Combinatorics and its application to issues dealing with cybersecurity. The presentation will provide data from the longitudinal study showing students building on the concept of counting in mathematics and the current pilot study showing the implications of combinatorics mathematical ideas in cybersecurity.

Authors:
Rasha Abadir, *Rutgers University*
Suzanna Schmeelk, *Saint John University*

A Meta-Study of the Relationship between Inquiry-Based Learning Methods and Mathematics Students' Motivation
1:40 p.m. - 1:55 p.m.
This study takes an overview of the literature on the motivation of secondary school mathematics students. In particular, the relationships between the use of inquiry-based learning techniques both inside and outside the classroom and student motivation are examined. We also examine the student-teacher dynamic as it relates to the motivation of mathematics students. Students' expectations of teachers and teachers' expectation of students are compared and contrasted. Disconnects between students are teachers are highlighted, and a model is proposed to bridge this divide.

Authors:
Elizabeth Shire, *Neumann University*
Ryan Savitz, *Neumann University*

Equity in Inquiry: Power Dymanics in the IBL Math Classroom
2:00 p.m. - 2:15 p.m.
The prevailing impression of IBL math classes are that they are a more equitable space for students to learn mathematics; gender and racial dynamics seem to be less of a factor in the IBL mathematics classroom. However, more recent research demonstrates that not all inquiry-based classes or activities eliminate or reduce differences between marginalized and non-marginalized groups. In this talk, we will explore how power dynamics can be used as a framework to create or troubleshoot inquiry-based mathematical activities to ensure a more equitable outcome. We will specifically explore how structuring the power dynamics inherit in any activity can provide more equitable interactions between students, providing a space for all student to participate and thrive.

Author:
Geillan Aly, *Compassionate Math*

Open Inquiry-based Precalculus, Pre-pandemic and Now
2:20 p.m. - 2:35 p.m.
In 2019, with the help of an Affordable Learning Georgia Textbook Transformation Grant, we redesigned our Precalculus course using open educational resources and inquiry-based learning consisting primarily of small group work. After using our new materials for a semester and a half, the pandemic hit. This led to our pedagogy turning temporarily away from inquiry, but resulted in the adoption of standards-based grading. We have recently returned to IBL methods while preserving standards-based grading. In this talk, we will discuss the changes that we made from the original pre-pandemic course design, the reasons for them, and the successes and challenges of teaching inquiry-based Precalculus both before the pandemic and now.

Authors:
Rachel Epstein, *Georgia College*
Marcela Chiorescu, *Georgia College*

The Team-Based Inquiry Learning Resource Library
2:40 p.m. - 2:55 p.m.

Crucial to the successful implementation of inquiry-based learning in classrooms is the availability of well-edited student activities. As part of our NSF-funded "Transforming Lower Division Undergraduate Mathematics Through Team-Based Inquiry Learning" (TBIL.org), our team created the TBIL Resource Library to provide free and complete course materials for implementing TBIL in single-variable calculus and linear algebra classrooms. This talk will overview how to use the materials, the technologies they are built upon, and the infrastructure that allows a community of contributors to freely use and remix these materials, as well as contribute their improvements back upstream.

Authors:
Steven Clontz, *University of South Alabama*
Drew Lewis, *University of South Alabama*

Leveraging Reflective Readings to Support Coherence in an IBL Math for Liberal Arts Course
3:00 p.m. - 3:15 p.m.
A goal of our Math for Liberals Arts course at Pepperdine is to share the beauty of mathematics with students who aren't required to learn any particular mathematical content. However, the students enrolled in this course have typically experienced mathematics as boring and irrelevant to their lives or, in worse cases, traumatizing. Positive experiences with mathematical inquiry can do a great deal to shift their attitudes about doing mathematics; and integrating reflective readings to support these inquiry experiences can pivot this shift towards a richer understanding of mathematics as discipline and the positive role it can play in their lives. In this talk I'll focus on how I've leveraged readings from Cathy O'Neil's book Weapons of Math Destruction to both motivate and bring coherence to our units on mathematical modeling.

Author:
Elizabeth Thoren, *Pepperdine University*

Project-based Programming in a Mathematics Course
3:20 p.m. - 3:35 p.m.
Modern mathematicians understand the importance of computer programming in many facets of mathematics: research, problem solving, industry, and even recreation. In fact, many math majors have a computer science requirement. While computer science courses allow for creative ways to solve computer science problems, I wanted to design a course where that creativity could dovetail with a mathematically rigorous concept. My goal was to develop a course where students could use programming to solve problems related to mathematics—in particular, my students were tasked with producing fractal images. In this talk I will discuss the methods I used to build a project-based course centered on mathematical problem solving. I will also discuss lessons learned and how those may inform future iterations of the course. And yes, there will be plenty of fractal images throughout.

Author:
Joe Barrera, *Converse University*

What do Calculus I Students' Have to Say About the Effect of Inquiry-Based Learning on Their Mathematics Anxiety?
3:40 p.m. - 3:55 p.m.
Highly math-anxious students exhibit mental, physical, and emotional symptoms. These symptoms often have short-term and long-term consequences. In the short term, they tend to dislike the subject; in the long run, they are more likely to avoid mathematics and mathematics-related situations. This study investigated students' experiences of learning Calculus I via inquiry-based versus lecture-based instruction. Math anxious students were identified using the short version of the Mathematics Anxiety Rating Scale (MARS-S). Then, they were interviewed to understand their perceptions and experiences. Findings revealed that the group work, optional and ungraded homework, and the instructor's welcoming nature decreased IBL students' anxiety. On the other hand, the instructor's readiness to reexplain the

material in class and his care for student success decreased lecture-based students' anxiety. However, the tests and exams and the instructor's questions increased both groups' anxiety.
Author:
Harman Aryal, *Stockton University*

Part B: *Saturday, August 5, 2:00 p.m. - 5:15 p.m., Room 115/116*

The Active Learning Pedagogy Sequence (ALPS), a Framework for Developing Equity-based Active Learning Strategies to Engage Students in Mathematical Inquiry
2:00 p.m. - 2:15 p.m.
How can we create a classroom where all of our students are engaged, working hard, asking and answering each other's questions, learning mathematics deeply, and wanting to learn more? For many of us, active and inquiry-based learning strategies are an essential part of the answer. In this talk we present a framework, called the Active Learning Pedagogy Sequence (the ALPS), for understanding the ease/difficulty of implementing different structures and how to use structures in ways that build equity. Whether you are just getting started in inquiry-based mathematics education or an "old pro" looking for new ideas, come ready to learn about different active learning structures and critically reflect on your practices through an equity lens.
Authors:
Suzanne Dorée, *Augsburg University*
Jennifer Quinn, *University of Washington Tacoma*

Creating Models and Problem Solving Strategies using Induction, Corner Cases and Asymptotic Behavior
2:20 p.m. - 2:35 p.m.
Inductive Mathematical Modeling from very simple cases, analyzing multiple corner cases, and examining asymptotic behavior of prospective models can enable students to grapple with, understand and solve mathematical problems in surprising ways. Specific examples of how students have created and analyzed models in Mathematical Literacy, Statistics, and Linear Algebra will be presented.
Author:
Alexander Atwood, Suffolk County Community College

A Scaffolding Spectrum in IBL
2:40 p.m. - 2:55 p.m.
A wide variety of IBL techniques exist with varying levels of scaffolding for students. I'll start with a definition, and then provide several examples of low to high scaffolding including student presentations, Process-Oriented Guided Inquiry Learning, Inquiry Oriented Linear Algebra & Inquiry Oriented Differential Equations, and what I'll call "No Safety Rails" IBL. We'll have a discussion about the pros and cons of various levels of scaffolding, and how to determine a level that fits the needs of your particular situation. If you've never tried IBL, I hope you get some ideas for good entry points. And if you're already doing IBL in your classes, I hope you'll get some ideas for what kind of IBL to try next.
Author:
Joseph Spivey, *Wofford College*

A Brief Introduction to the World of Inquiry-Based Learning
3:00 p.m. - 3:15 p.m.
What is Inquiry-based Learning (IBL)? How can you get started using IBL in your classroom? The leadership of the SIGMAA on IBL will provide a brief introduction to IBL and a strategy to help you introduce IBL in your classroom. IBL refers to a style of teaching and learning that emphasizes student inquiry. IBL instruction differs from traditional lecture-based classes for both students and instructors; in

an IBL class, students learn mathematics through collaborative active learning. Instructors provide guidance and facilitate discussions. Our goal is to encourage novice instructors to incorporate one or two inquiry-based lessons into their classes. We will start with the four pillars of IBL, present examples of course material that employ IBL, and share strategies for using IBL materials. We will also include resources and networking opportunities with local and national IBL communities. We welcome all levels of IBL practitioners, but especially those who are new to IBL.

Authors:
Mel Henriksen, *Wentworth Institute of Technology*
Joe Barrera, *Converse University*
Lee Roberson, *University of Colorado Boulder*
Mami Wentworth, *Wentworth Institute of Technology*

An Active, Collaborative, and Comprehensive Approach to the Teaching and Learning of Proof Writing

3:20 p.m. - 3:35 p.m.

In this talk, we present a collaborative active learning approach to an Intro to Proofs course, designed by a team of faculty and graduate students at UCI. The activities, ranging from interactive reading assignments to in-class groupwork and collaborative out-of-class peer reviews, are designed to increase students' engagement with both the class material and with their peers. Our goal is to create an inclusive learning environment where students can learn with each other and from each other. The comprehensive approach fosters groupwork and individual exploration of mathematical concepts both in lectures and discussions, and outside the classroom. Preliminary results regarding the impact of the project will be presented. Because the Intro to Proof course is a gateway to upper division mathematics, the success of this project has the potential to impact students' success, engagement and perception of belonging in more advanced mathematics courses.

Authors:
Alessandra Pantano, *University of California, Irvine*
Christopher Davis, *University of California, Irvine*
Yasmeen Baki, *University of California, Irvine*
Jennifer Pi, *University of California, Irvine*

A Better Teaching Method for Taylor Series

3:40 p.m. - 3:55 p.m.

Taylor series are notoriously difficult for students to understand and calculate. Most commonly included in a second semester integral calculus course, the typical derivation assumes that function is equal to a power series and uses derivatives to determine the coefficients. This results in an answer, but it is not meaningful to most students. This talk with present a new method for teaching Taylor series that uses integrals, rather than derivatives, to provide students with an intuitive reason and calculation method behind the answer. The specific activities presented use an IBL format, but the method would be applicable in other teaching styles.

Author:
Katie Horacek, *Frostburg State University*

Inquiry-Based Actuarial Science

4:00 p.m. -4:15 p.m.

Actuarial science courses rarely use inquiry-based learning. This is likely due to what Yoshinobu and Jones (2012) refer to as the "coverage issue." The importance of external exams make this issue particularly acute for actuarial science. In this talk, I will share my story of how I evolved from a fully lecture-based Theory of Interest course to a fully inquiry-based course. I will share what this course looks

like, the reasons for my choices, my challenges and concerns, successes in the process, and what I hope for in the future.

Author:
Victor Piercey, *Ferris State University*

Incorporating Inquiry-Based Learning in Large Coordinated Courses: Challenges, Ideas, and Conversation

4:20 p.m. - 4:35 p.m.

In effort to ensure students receive a quality experience in their introductory mathematics courses across multiple sections, in particular precalculus through multivariable calculus courses, there has been an increased push to tightly coordinate these courses. This coordination places a variety of constraints on one attempting to implement IBL practices within their instruction, such as pacing, assessment choices, and grading schemes. In this talk, we will explore the challenges implementing IBL practices experienced at different roles within a coordinated course from the course coordinator organizing the logistics of course, the instructors guiding lectures, and to the graduate student leading recitations. We will offer ideas for incorporating the pillars of IBL into coordinated courses at each position. Throughout the talk we welcome conversation from those in attendance to collaborate and sustaining each other's efforts for enacting IBL in large coordinate courses.

Author:
Lee Roberson, *Colorado State University*

Do and Review: Facilitating Learning through Self-Assessed Homework Assignments

4:40 p.m. - 4:55 p.m.

Part of grading in IBL teaching is allowing students to reattempt problems without penalty, but the process of providing feedback on assignments and regrading subsequent submissions is often prohibitively labor intensive. To balance fostering productive struggle with our own time constraints, we have created a Do and Review homework system in which students self-assess their assignments by identifying their mistakes and reflecting on what they learned from the mistakes. They earn full credit if their self-assessment is thoughtful and detailed. We conducted a study on the impacts of the Do and Review homework system on student learning in Calculus 1. Early results indicate that many students found that the Do and Review homework was beneficial to their learning and helped them understand the value of making mistakes. Moreover, grading these assignments is not time intensive. In this talk we provide further details on the Do and Review homework system and on the results of the study.

Authors:
Kristen Mazur, *Elon University*
Carolyn Yarnall, *California State University Dominguez Hills*

Would You Like a Cold Beverage with Your Inquiry?

5:00 p.m. - 5:15 p.m.

I designed a task about packaging soda in 6-packs for an interview about place value with a young student. The student came to the interview grumpy about a related idea from school, and the combination of my task and his mathematical concern unlocked a mathematical phenomenon that has been extremely generative in my teaching since that interview. In this session, we'll discuss the task, the student's concern, the multiple pathways for inquiry opened by their interaction, and how I leverage them in various classes.

Author:
Brian (BK) Katz, *California State University - Long Beach*

Internships for Math Majors

Saturday, August 5, 10:40 a.m. -11:15 a.m., Room 117

Mathematics has a marketing problem. One way to entice students into mathematics is to provide and advertise career exploration opportunities such as internships. This session is for sharing scholarly work on types of internships, strategies on finding internship opportunities, curriculum design, internship documentation/assessment tools, research on the impact of internships for mathematics majors, or other internship experiences.

Organizers:
Jacci White, *Saint Leo University*
Monika Kiss, *Saint Leo University*

Documentation for Mathematics Internships
10:40 a.m. - 10:55 a.m.
With the growth of data science, robotics, artificial intelligence, and other highly technical fields, the need for logical thinking and problem solving is growing. We need to market our mathematics majors and give them the opportunity to apply their skills in new job markets. This session will begin by sharing documentation and contracts used for Internships in the School of Computer Science, Artificial Intelligence, Robotics, and Data Science as well as a summary of these experiences and outcomes. Faculty are encouraged to share the internships and work experiences of their students including where to look for internship opportunities, documentation and assignments associated with internships, pitfalls to be aware of, positives to look for, new alternatives to traditional internships, etc. The intent is that all faculty will walk away with ideas to increase the number and value of internships and work-related experiences for their mathematics students.
Authors:
Jacquelyn White, *Saint Leo University*
Monika Kiss, *Saint Leo University*

Internship Opportunities through a Sustained Collaborative Project
11:00 a.m. - 11:15 a.m.
In this session, we will introduce a sustained collaborative project with faculty members from the Business school and the Mathematics department. We formed a team of mixed-major students to work with local companies in recent years. In particular, we will describe the current project with an insurance company using real data provided by the company. These experiential learning projects have been successful in preparing the participating students for internship opportunities in the local industry. We will also discuss some tips and lessons we learned.
Author:
Fei Xue, *University of Hartford*

Analysis and Algebra: Convincing Students They Can Do It

Friday, August 4, 8:00 a.m. - 11:35 a.m., Room 117

Real Analysis and Abstract Algebra are often core required courses for mathematics majors. But added rigor, increasing abstraction, and a higher expected standard for mathematical communication can make these classes intimidating for students—even well-prepared students.

Talks in this session will share innovative approaches for helping students deal with the perceived (and real!) difficulty level of these core courses, activities, projects, and alternative methods of assessment. Reports on student outcomes and effectiveness of the approaches are encouraged.

Organizers:

Tova Brown, *Wisconsin Lutheran College*
Kristi Meyer, *Wisconsin Lutheran College*

Community and the Right Amount of Help: Fostering Success in a Graduate Abstract Algebra Course for Teachers

8:00 a.m. - 8:15 a.m.

While teaching an asynchronous graduate abstract algebra for teachers course this semester, we noticed students doing extremely well in all aspects of the course ranging from proof writing to motivation to complete lengthy computational problems. This was all despite the fact that students expressed terror in taking the course at the beginning of the semester. In the current iteration of this course, there are students who recently completed an undergraduate abstract algebra course, students who have not taken a single course in abstract algebra, and students who have not had a proofs-based course in years. In this talk, we will share the students' perceptions of what is helping them to not only succeed, but to excel in the course. Some of the findings include students feeling a sense of community, attending regular Zoom help sessions, and having questions answered in a manner that guides their thinking without giving away the answer.

Authors:

Angie Hodge-Zickerman, *Northern Arizona University*
Cindy York, *Northern Illinois University*

Seeing What's Going On in Abstract Algebra

8:20 a.m. - 8:35 a.m.

One of the hurdles for students when they begin to study Abstract Algebra is their lack of experience and intuition with algebraic structures other than the ones that they grew up with. One way to address that lack is a focus on visualization of structures through the construction of appropriate diagrams (specifically Hasse diagrams) for subgroups, cosets, normal subgroups, ideals, etc. This presentation will focus on a small set of tools in the LaTeX package TikZ that are easy to share with students so that they can visualize these new structures and identify visual invariants to distinguish between them.

Aurhor:

Jeffrey Clark, *Elon University*

A Friendly Introduction to Abstract Algebra

8:40 a.m. - 8:55 a.m.

We will describe a new approach to laying a foundation for abstract mathematics. When students generalize from a wide range of examples, they are better equipped to derive conjectures, make sense of formalizations, and prove new ideas. Thus, they should be given ample opportunities to explore concepts through illuminating examples *before* formal definitions and theorems are introduced. Rather than merely consuming mathematical knowledge, students should learn mathematics by actively creating mathematics. Abstract algebra often acts as "gatekeeper" to completing a mathematics major. To students, algebra can seem impenetrable due to its (seemingly) theoretic nature. In this talk, we will discuss how to take a more concrete approach to the subject and allow students to develop their own understanding, with the aim of making abstract algebra more accessible to more students.

Author:
Ryota Matsuura, *St. Olaf College*

Play in the Abstract Algebra Classroom
9:00 a.m. - 9:15 a.m.
In his speech and subsequent book "Mathematics for Human Flourishing," Frances Su talked about the importance of mathematical play. But in abstract algebra classrooms, this sense of mathematical play often disappears in favor of the strict rigor of definitions and theorems and proofs. In this talk, I'll discuss how I create and cultivate a sense of mathematical play with my abstract algebra students while also retaining a level of rigor appropriate for an upper-level mathematics class.
Author:
Kristi Meyer, *Wisconsin Lutheran College*

Activities and Alternative Assessment in Abstract Algebra
9:20 a.m. - 9:35 a.m.
Abstract Algebra is often a challenging class to teach. While students are familiar with properties of numerical sets, the abstraction to other structures can seem abrupt and intimidating. Implementing activities and alternative assessment right from the start can help students deal with the difficulty level throughout the course. In this talk, I will outline the activities that I use to introduce groups of matrices, discover the dihedral group, and connect the 15 puzzle to permutation groups. I have found these activities provide students with concrete examples to reference as we develop group theory. I will also discuss how I use writing portfolio assignments to build proof writing skills in an accessible way.
Author:
Marie Meyer, *Lewis University*

Abstract Algebra Becomes Pointless
9:40 a.m. - 9:55 a.m.
Some characteristics of established alternative grading techniques include de-emphasizing "points", refraining from averaging grades over time, creating a robust instructor-student feedback loop, and allowing for revisions without penalty -- all while maintaining high standards for student success. In this talk, I will share my rationale behind incorporating these changes in a recent Abstract Algebra course, describe the final grading scheme, and share my overall experience in a "pointless" class.
Author:
Stuart Boersma, *Central Washington University*

Analysis v. Algebra: What Is Abstract?
10:00 a.m. - 10:15 a.m.
In this talk we will look at ideas for both algebra and analysis. It is interesting and perhaps enlightening to compare and contrast. Whereas both are classes where students are challenged to write extensive proofs, the content is strikingly different in many ways, largely rooted in the meaning of abstraction. Abstraction in algebra is applying fundamental properties in diverse settings and is strengthened by viewing examples in different contexts. Abstraction in analysis is found in technical conditions, but not in diverse contexts. Both build off familiar territory, but with with algebra the familiar territory is much more basic, whereas in analysis the familiar territory is the more recent but typically less deeply understood material in calculus. We will share thoughts on ways to leverage and build on the background for each.
Author:
Jeff Johannes, *SUNY Geneseo*

Reading the Masters: A Primary Source Project Approach to Learning Analysis and Abstract Algebra
10:20 a.m. - 10:35 a.m.
19th-century mathematicians witnessed major changes in the practice of their craft. Notable among these were a sharp rise in rigor, a substantial shift in standards for communicating one's ideas, and increased abstraction–exactly the aspects of today's analysis and abstract algebra courses that most challenge students. I describe a set of projects that draw on 19th-century mathematical works as a means to help students overcome these challenges, and report on my own classroom experience and site testing elsewhere that occurred through NSF grants that have supported development of this approach. Intended to teach today's mathematics (not its history), this approach weaves carefully designed student tasks with excerpts from works by Cauchy, Cayley, Dedekind and others who helped reshape analysis and abstract algebra into their current form. By engaging with that mathematics via its historical context, students not only see how and why others did it but gain confidence that they can too.
Author:
Janet Heine Barnett, *Colorado State University Pueblo*

Encouraging Productive Failure in Analysis
10:40 a.m. - 10:55 a.m.
Students often come into real analysis scared of problems that take several attempts to solve, and thus one aim of an analysis course should be to give students a model for how to explore possible solutions without that fear. In my most recent analysis course, I attempted to address this both via assessment techniques and via a historical framework for motivating the content. I assessed students using specifications grading, group tests, oral exams, and a proof portfolio, all of which were designed to present their efforts in a progressive light. In each assignment or exam, students begin with a first attempt or draft before refining their work into something stronger. I used the story of real analysis to emphasize the iterative nature of mathematical discovery—beginning with Newton's first attempt at defining a limit and ending with the construction of the reals and the rigorization of analysis.
Author:
Anne Duffee, *Sewanee: The University of the South*

Explicit Encouragement of Productive Failure and Fruitful Struggle
11:00 a.m. - 11:15 a.m.
In my Analysis courses, I like to be very transparent about the fact that increasing rigor is difficult and uncomfortable at first, but that this experience is shared by virtually all mathematicians-in-training. I include in the course structure several small reading and writing assignments involving some mixture of metacognition on the student's own learning process and enculturation into the mathematics community via readings of others' perspectives. In this talk, I will share some of the resources I have gathered for this purpose, assignment prompts I have built, and anecdotal student responses to my approach.
Author:
Tova Brown, *Wisconsin Lutheran College*

Teaching Analysis with Functions First
11:20 a.m. - 11:35 a.m.
We will discuss an approach to teaching real analysis based on the following principles not used in most standard textbooks. First, discuss limits of functions before limits of sequences, and prove the principal results for limits in the context of functions. Second, postpone the main discussion of sequences and series until the theorems on continuity, derivatives, and integrals of functions have been proven. (This creates a course whose theorems mostly appear in the same order as in calculus.) Third, minimize the number of new ideas to those necessary to prove the theorems of calculus. We have used this approach successfully ten times in a real analysis course at Cal State San Marcos for students who mostly will not

be going to graduate programs in mathematics. Many are future high school teachers. For them, an approach to analysis which is parallel to calculus in its logical order is effective in illustrating the original point of basic real analysis.

Author:
Marshall Whittlesey, *California State University San Marcos*

Research on Undergraduate Mathematics Education

Part A: *Thursday, August 3, 8:00 a.m. - 10:55 a.m., Room 121*
Part B: *Friday, August 4, 1:00 p.m. - 5:35 p.m., Room 121*

The goals of this session are to promote quality research in undergraduate mathematics education, to disseminate educational studies to the greater mathematics community, and to facilitate the impact of research findings on mathematics pedagogy. Presentations may be based on research in any undergraduate mathematical area. Examples include studies about students' reasoning, teaching practices, curriculum design, and professional development.

Organizers:
Brian Katz, *California State University - Long Beach*
Nicole Infante, *University of Nebraska Omaha*

Sponsor:
SIGMAA on Research in Undergraduate Mathematics Education (SIGMAA RUME)

Part A: *Thursday, August 3, 8:00 a.m. - 10:55 a.m., Room 121*

Logical Inconsistency (LinC) in Mathematical Thinking and Its Implication for Teaching Proof-oriented Courses
8:00 a.m. - 8:15 a.m.
Cognitive psychologists suggest that people tend to behave to avoid cognitive inconsistencies. But Roh and Lee's (2018) study indicates that students may not recognize logical inconsistencies in their reasoning even with mathematical content knowledge. This presentation expands on Roh and Lee's research by examining the frequency and prevalent types of logical inconsistencies displayed by undergraduate students when reading and validating arguments related to mathematical assertions. We found that the logical complexity of mathematical statements did not significantly affect the frequency of logical inconsistencies in students' reasoning. However, the type of argument frames had a significant impact, with students exhibiting more logical inconsistencies on assertions with arguments framed using proof by contradiction compared to direct proofs. These findings have important implications for teaching proof-oriented mathematics courses, which will also be discussed in the presentation.
Authors:
Kyeong Hah Roh, *Arizona State University*
Yong Hah Lee, *Ewha Womans University*

Students' Perspectives about the Use of Technology in Calculus Courses
8:20 a.m. - 8:35 a.m.
The purpose of this study is to understand students' perspectives about incorporating technological resources for learning calculus. In this presentation, we used mixed methods to analyze survey questions and individual interviews. Participants were 230 undergraduate students enrolled in calculus courses at a

midwestern research institution, four of whom participated in follow-up interviews. The findings of this study have implications for using technology and augmented reality for teaching calculus, which will develop innovative pedagogies that promote deeper understanding and visualization of several calculus concepts.

Authors:
Alcibiades Bustillo, *University of Puerto Rico - Mayaguez*
Kevin Palencia, *Northern Illinois University*
Ricelia Feliciano, *Northern Illinois University*

You Take the High Road and I'll Take the Low Road: Student Perspectives on the Effective and Ethical Use of Online Resources to Study Mathematics

8:40 a.m. - 8:55 a.m.

College students in mathematics courses make extensive use of online resources to support their learning, but how do they distinguish between positive and negative uses of the internet? How do students draw the line between productive use of online tools, on the one hand, and practices that could lead to overdependence and cheating on the other. Our research team draws on nationwide survey and interview data collected through an NSF grant (DUE-2944960) to document student-centered conceptions of what positive engagement with online resources looks like as well as the dangers, as they describe them, of misusing online resources. We expand on common themes and identify areas of disagreement. This presentation will provide mathematics educators with insight into how and why their students are making use of online resources. We will also describe how this research informs our development of a more general theory that describes how students use online resources to study mathematics.

Authors:
Ander Erickson, *University of Washington Tacoma*
Yoshihiro Yagi, *University of Washington Tacoma*

Technology Use in Undergraduate Mathematics Classrooms

9:00 a.m. - 9:15 a.m.

Technology use in undergraduate mathematics education has accelerated due to the COVID-19 pandemic moving education online for a long period of time. Educators were forced to incorporate technology into their teaching during this period. However, many universities have returned to in-person teaching. It is unknown what the influence of a period of forced technology use had on educational practices. This presentation will report results from a survey sent to all United States mathematics educators at the college level to determine technological products and the extent of their use in college-level mathematics classrooms. This knowledge will be vital to identifying and proliferating the use of high-impact technological products.

Authors:
Darryl Chamberlain, *Embry-Riddle Aeronautical University -- Worldwide*
James Quinlan, *University of Southern Maine*

Investigating the Affordances of Online Homework on Undergraduates' Problem Solving of Related Rates of Change Problems

9:20 a.m. - 9:35 a.m.

We report on preliminary findings of undergraduate students' demonstrated use of mathematical problem-solving (MPS) strategies when solving related rates of change problems (RRCPs) and the affordances of online homework in supporting MPS when solving RRCPs. This study takes place at a large urban university in the Southwestern US with an undergraduate enrollment exceeding 27,000 students. We examined student data on online RRCPs and student work (N=317) on free response midterm examination RRCPs. We conducted individual (N=15), hour-long, task-based interviews using RRCPs in an online format and in a paper-pencil format. Preliminary findings reveal online homework use similar to

that seen by Dorko's (2021) examination of students' use of the "see similar example" feature in online homework, but in the context of RRCPs the online problem features may undermine development of MPS (see Álvarez, et al. 2019, Schoenfeld, 2016) and other RRCP-specific strategies (e.g., Engelke, 2007).

Authors:
James Alvarez, *The University of Texas at Arlington*
Tyson Bailey, *The University of Texas at Arlington*

From Examples to Student Responses in an Interactive Linear Algebra Textbook: Conceptions of Spanning Sets

9:40 a.m. - 9:55 a.m.

Reading questions are an interactive feature added to textbooks to inform instructors of their students' understanding of the materials based on their reading of a section before a lesson. Using Balacheff's (2009) model of conceptions, we analyzed three examples on spanning sets in a linear algebra textbook (Beezer, 2021) and compared with the conceptions emerged from students' responses to two reading questions in the section. Our analysis revealed additional control structures illustrating further conceptions beyond those proposed by the textbook. Evaluating the correctness of using each control structure we uncover potential issues related to their applicability. Future work include analysis of conceptions across different sections to track how students' conceptions evolve over time and how its development impact the correctness in application.

Authors:
Eric Khiu, *University of Michigan, Ann Arbor*
Vilma Mesa, *University of Michigan, Ann Arbor*
Saba Gerami, *University of Michigan, Ann Arbor*
Thomas Judson, *Stephen F. Austin State University*

How Do Postsecondary Linear Algebra Instructors Implementing Inquiry-Oriented Approaches Address Goals of Instruction in an Online Work Group?

10:00 a.m. - 10:15 a.m.

Postsecondary instructors interested in inquiry-oriented instruction of Linear Algebra participated in a sequence of eight one-hour online work group meetings with other experienced inquiry-oriented linear algebra facilitators and teachers. Recordings from three meetings were analyzed for how two participants referenced goals of instruction in preparation for teaching a new instructional unit on subspaces. We identified four goals of instruction of teaching subspaces. We discuss the intersections of several goals of instruction and possible implications for those who want to transition to inquiry-oriented instructional approaches.

Authors:
Minah Kim, *Florida State University*
Shelby McCrackin, *Florida State University*

Native vs. Non-Native English Speakers in Learning Proof-Writing

10:20 a.m. - 10:35 a.m.

This is a research study about whether an individual is a native English speaker is correlated with their learning of mathematical proof-writing. To explore this, students of a first-year proof course were surveyed about their language background, and that information is analyzed with their performance in the course. While this study is still on-going, some preliminary results will be shared in this talk.

Author:
Caelan Wang, *University of Manitoba*

Examining Student Positioning During Groupwork in Linguistically Diverse Undergraduate Mathematics Classrooms
10:40 a.m. - 10:55 a.m.
College math classrooms are adopting more active learning practices like groupwork. These practices are often talk-intensive and require interpersonal interactions. As undergraduate math classrooms continue to serve more students from diverse language backgrounds, more needs to be learned about how multilingual students experience groupwork. In this talk, I present findings from interviews with 28 multilingual undergraduate students enrolled in introductory college math courses. Using positioning theory, I share how students described their positioning while working in groups with peers. While some students had good experiences with groupwork, the majority described being positioned by others in deficit ways that impacted their participation. I end this talk with a discussion about the classroom norms that seemed to shape how positioning unfolded in the classroom and I provide suggestions for making groupwork more equitable in linguistically diverse spaces.
Author:
Jocelyn Rios, *Colorado State University*

Part B: *Friday, August 4, 1:00 p.m. - 5:35 p.m., Room 121*

Researching Mathematics TACTivities
1:00 p.m. - 1:15 p.m.
Our research team has developed several styles of tactile learning activities (TACTivities) that can be used both remotely and in face-to-face mathematics classrooms. These are designed to be collaborative, engaging, and content rich. We are engaged in research to investigate student outcomes, engagement, collaboration, and efficacy as well as instructor perceptions of TACTivities. We would like to recruit anyone interested in being an instructor participant using TACTivities in their classroom and/or to join the research team in this evidence-based scholarship. Currently in Phase 1, the Classroom Engagement Inventory (CEI) and the Learning Object Evaluation for Students and Teachers (LOES-S and LOES-T) are used in modified format to examine student and teacher perceptions of how much was learned, the design of the TACTivity, and how engaged they were while using the TACTivity.
Authors:
Cindy York, *Northern Illinois University*
Angie Hodge-Zickerman, *Northern Arizona University*

Framing of and Use of Representations in Instructional Tasks for Introducing Derivatives Symbolically with Inquiry
1:20 p.m. - 1:35 p.m.
In this study, I present how eight U.S. college calculus instructors with different patterns of inquiry practices framed instructional tasks and used mathematical representations for introducing derivatives symbolically to students. During 1-2-hour long interviews, the instructors proposed two tasks for introducing derivatives symbolically, at a point and as a function. My definition of task framing is twofold: framing as interaction with the content (the types of mathematical problems students are expected to work on; Herbst et al., 2020) and framing for social interaction (lecturing, group work; Doyle, 1984, 2013). The analyses reveal that, although the tasks may look similar on the surface, there is more nuance in the framing and use of mathematical representations, which ultimately shape the mathematical work that the instructors expect of their students. This study showcases the complexity of calculus instructors' task design for teaching derivatives with inquiry.
Author:
Saba Gerami, *University of Michigan*

Debating Infinitesimals: Transgressing Mathematical Boundaries Through a Classroom Activity Utilizing Primary Historical Sources
1:40 p.m. - 1:55 p.m.
We conducted a study in a history of calculus course, taught using primary source material. In this presentation, we share results from a debate activity in which students developed arguments to represent the conceptions of infinitesimals held by Newton, Leibniz, and Berkeley. We present the case of Renae's experience with the debate activity. Our analysis, informed by the theory of mathematical transgressions in which transgressive actions propel students beyond a barrier to outcomes of new upper levels of mathematical understanding revealed several notable outcomes. We focus on one outcome of participating in the debate activity: access to practitioner practice, grounded in Lave and Wenger's situated theory of learning. Access to the practice provided Renae insight that mathematics develops via critique and argumentation. As a result of our investigation, we conjectured that transgressing via the debate activity may foster rich connections from the historical to modern perspective.
Authors:
Kathleen Clark, *Florida State University*
Mark Watford, *Florida State University*

A Theoretical Framework for Contextualizing the Relationship between Students' Meanings for Mathematical Topics and Their Symbolization
2:00 p.m. - 2:15 p.m.
Students' ability to adopt and employ appropriate mathematical representations is crucial for their success in secondary and collegiate-level mathematics courses. Yet, instructors rarely provide opportunities for students to create personalized representations. In this presentation, I report a theoretical framework that emerged from my study of personal algebraic expressions that individual students constructed while reasoning about infinite series convergence. Specifically, I report (1) the intuitive meanings students possessed for series convergence, (2) the traditional and novel inscriptions students utilized to symbolize their meanings, and (3) my categorization of the various meaning-symbol relationships into an explanatory framework for students' symbolizing activity. This framework can help researchers better describe student symbolization, and instructors anticipate better how students might interpret (and employ) the representations they present during their instruction.
Author:
Derek Eckman, *Arizona State University*

Investigating Students' Worldviews of Complex Multiplication and Derivatives
2:20 p.m. - 2:35 p.m.
While there has been extensive research on introductory and proof-based undergraduate courses, complex analysis needs to be explored more. Most research on complex variables has focused on specific interventions to teach particular concepts in complex arithmetic and derivatives or mathematicians' reasoning about complex variables. This case study aimed to investigate how students in a flipped complex analysis course think about multiplication and its relationship to the complex derivative. Overall, participants could describe multiplication from a proceptual and embodied perspective but struggled to conceptualize the complex derivative from an embodied perspective.
Authors:
Mehmet Celik, *Texas A&M University-Commerce*
Rebecca Dibbs, *Texas A&M University-Commerce*

STEM vs. Non-STEM: the Emergence of Instructors Dichotomously Classifying Their Students
2:40 p.m. - 2:55 p.m.
My research group has been qualitatively investigating instructors that fall between the traditional boundary lines of 'high school teacher' and 'college professor.' As part of our exploratory study, we

asked instructors to reflect on what role they believe their math course plays in the rest of a student's education. This particular question was motivated by the potential use of Backward Design in course planning (Wiggins & McTighe 2005). Once instructors decide what knowledge students should gain from the course, they can elect the topics and assignments which will promote their achievement. A theme emerged about the role differing depending on if a student is a STEM major or not. We wonder if instructors know their students' majors or if they independently categorize them accordingly, considering how this was the dichotomous classification upon which they based differential learning objectives. We reflect on the evidence found in our study about this unique classroom phenomenon.

Authors:
Charlotte Beckford, *University of Tennessee, Knoxville*
Anne Ho, *University of Tennessee, Knoxville*

What Makes "College-Level" Math? Dual Enrollment Instructors' Perspectives on "College Level" Math Courses
3:00 p.m. - 3:15 p.m.
Our team collected data on perceptions of math teaching from instructors with experience in both high school and college math teaching and from dual enrollment instructors exclusively. Responses from dual enrollment instructors included phrases like students' maturity, study habits, pacing, independence, responsibility, and rigor. These phrases and the context in which they are used speak to a perception of personal skills necessary for "college-level" math. Our dual enrollment instructors note that their course content is the same compared to their college counterparts. When our instructors who teach both high school and college math speak of their college courses, skills like critical thinking and problem solving appear frequently, but not so much the skills highlighted by the dual enrollment instructors. In this talk, I will explore the perspective of dual enrollment instructors in light of what skills they might perceive to make a math course "college-level".

Authors:
Jessica Kingsley, *University of Tennessee, Knoxville*
Anne Ho, *University of Tennessee, Knoxville*

Identifying and Developing Pre-Service Teacher Noticing in the Mathematics Education Classroom
3:20 p.m. - 3:35 p.m.
A considerable amount of research on teacher noticing has shown watching videos of student and teacher interaction, and then discussing them, improves pre-service teachers' abilities to notice (Sherin & Han, 2004; Star & Strickland, 2008; van Es & Sherin, 2002). Teacher noticing, defined as a teacher's ability to actively notice students' ideas and engagement in a classroom (Erickson, 2011) is the focus of this study. Noticing is a skill needed to be effective as a mathematics teacher, making it important to teach to preservice teachers before they enter their own classrooms. This study examined teacher noticing in a mathematics course for pre-service early and middle childhood teachers. Data were collected from reflection prompts given to pre-service teachers twice during the semester, after watching videos of elementary kids working on mathematics in classrooms. Results will be shared during the presentation.

Author:
Carla Gerberry, *Xavier University*

The Use of Students' Gestures in Navigating the Cognitive Load of Mathematical Proofs
3:40 p.m. - 3:55 p.m.
Activities related to proving mathematical conjectures (e.g., reading, presenting, and constructing proofs) are known for posing significant cognitive challenges to undergraduate students. Some of these challenges can be attributed to the necessity to operate on a substantial amount of information, which may lead to cognitive overload and impede one's progress on the task. In this presentation, I discuss how

students can use their hands to successfully navigate the cognitive load associated with mathematical proofs.

Author:
Vladislav Kokushkin, *Virginia Tech*

A Hypothetical Learning Trajectory to Reinvent Unique Factorization Domains with Connections to Teaching

4:00 p.m. - 4:15 p.m.

We conducted a teaching experiment on graduate students' learning of Unique Factorization Domain (UFD) and building its connection to secondary mathematics teaching. Unique factorization of polynomials provides a mathematical foundation for solving polynomial equations in secondary mathematics. Inspired by the local instructional theory of Realistic Mathematics Education, we designed a task sequence to support graduate students to reinvent the definition of UFD and apply their mathematical knowledge to hypothetical pedagogical situations. Participants were guided to use algebra tiles to model factorization of integers and polynomials as they reinvent the definition of UFD. Pedagogical tasks engaged them in experientially real situations such as evaluating students' mathematical work and responding to students' ideas. In this presentation, we will share the task design and the participants' progression in the knowledge construction and application to teaching.

Authors:
Younggon Bae, *The University of Texas Rio Grande Valley*
Kaitlyn Serbin, *The University of Texas Rio Grande Valley*
Sthefania Espinosa, *The University of Texas Rio Grande Valley*

Rehumanizing Mathematics through Embodied-Focused Noticing

4:20 p.m. - 4:35 p.m.

While noticing frameworks exist, the field lacks an embodiment-focused tool to guide our attending, interpreting, and deciding. We argue intentional and explicit noticing of embodiment can contribute to rehumanizing mathematics and that embodiment pedagogy is an essential component of mathematical knowledge for teaching. We viewed instructional videos with an embodiment-focused lens. We used our noticings of both exemplary embodiment pedagogy as well as missed opportunities to develop prompts, an exemplar, and a rubric for embodied-focused noticing. We have collected and begun analyzing preservice teachers' embodied-focused noticings and will share our preliminary findings.

Authors:
Liza Bondurant, *Mississippi State University*
Jonathan Troup, *California State University, Bakersfield*
Hortensia Soto, *Colorado State University*

Diversity, Equity and Inclusion (DEI) in College Algebra Classrooms: Community College Student's Viewpoint

4:40 p.m. - 4:55 p.m.

In this pilot study we tested various ways to collect data from community college students about their experiences with equity, diversity, and inclusion in the community college mathematics classroom. In the process we identified strategies to best collect the data and several themes about students' understanding of equity. We are in the process of augmenting data from students and plan to update the findings.

Authors:
Nur Wani Hazirah, *University of Michigan*
Vilma Mesa, *University of Michigan*
Claire Boeck, *University of Michigan*
Mary Beisiegel, *Oregon State University*
Bismark Akoto, *University of Minnesota*

Do Growth Mindsets Matter in Collegiate Mathematics? A Discussion of a Systematic Review and Meta-analysis of the Literature.
5:00 p.m. - 5:15 p.m.
Carol Dweck is the pioneer in the study of growth mindset – the belief that a person's intelligence in a subject is malleable and can change with effort and guidance. She was the first to perform experiments to determine that growth mindsets could be enhanced through interventions. Decades later, the literature is now replete with interventions designed to test the connection between growth mindset and academic achievement. The circumstances and effectiveness of these interventions vary greatly. A few research syntheses have been performed to summarize these intervention results. However, no prior research synthesis has focused on mindset interventions in collegiate mathematics classrooms. This presentation will focus on new research in this area: a systematic review of existing literature conducted using random-effects meta-analytic processes. The results will be discussed, along with how this research informs teaching and adds to the discussion of this important topic.
Author:
Sean Murphy, *Eckerd College*

Development and Refinement of a Mathematics-Specific Psychoeducational Survey Instrument
5:20 p.m. - 5:35 p.m.
In our longitudinal cohort research, we have identified several domain-general psychoeducational facets of college students' academic profiles which contribute to a robust explanatory framework for collegiate academic success. However, we have determined that such facets are not specific enough to adequately describe learning and developmental experiences in mathematics. Therefore, a new survey instrument was developed and administered in pursuit of measuring psychoeducational characteristics specific to mathematics. The results suggest the existence of a unique facet related to beliefs that limit students in their engagement with mathematics. In this presentation, the development and refinement of this instrument is detailed, and the results of analyses conducted on its responses and related academic measures are given within the larger context of improving collegiate outcomes in mathematics. Directions for future research are also given.
Authors:
Brian Darrow, Jr., *Southern Connecticut State University*
Michael Ben-Avie, *Quinnipiac University*

Incorporating Alternative Forms of Assessment into Undergraduate Mathematics Classes

Part A: *Thursday, August 3, 8:00 a.m. - 10:55 a.m., Room 105*
Part B: *Saturday, August 5, 1:00 p.m. - 5:35 p.m., Room 121*

We seek presentations on alternative forms of assessment that have been successfully incorporated into an undergraduate mathematics course where all students are required to participate. Topics could include effective projects, portfolios, or presentations. We are particularly looking for presenters who are willing to share tested resources that demonstrate practical ways of adding these products to a course.

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

Part A: *Thursday, August 3, 8:00 a.m. - 10:55 a.m., Room 105*

Teaching Beyond the Learning Objectives: Ideas to Add Enrichment to Your Course
8:00 a.m. - 8:15 a.m.
There is more to your course than just the learning objectives. Introducing enrichment assignments to your course can add elements of fun, accountability, study skills support and motivate learning while boosting grades for engaged students. This talk give ideas for 'participation points' assignments, worth 3% of the course grade, that have been assigned in my courses, some of which were successful and some less so.
Author:
Rachel Frankel, *University of Cincinnati*

Mini Projects for Quantitative Reasoning
8:20 a.m. - 8:35 a.m.
Numerous studies have shown that active learning improves students' learning and retention. In addition, active learning can bring a sense of community to the classroom, improve students' attitudes, and reduce math anxiety. One strategy for incorporating active learning is through the use of small groupwork projects (mini projects) that can be completed in one class period. In this presentation, mini projects and strategies for implementing them in a Quantitative Reasoning course will be discussed and shared.
Author:
Karen Smith, *University of Cincinnati*

Team Writing Projects in a Modeling Class
8:40 a.m. - 8:55 a.m.
Our Computational Modeling course is used to develop modeling, computer programming, and written communication skills to math and engineering majors. A major part of the class involves students working in teams of 2 to 3, to complete two written projects involving dynamical systems or stochastic models. We have implemented a model that requires each student to act as "lead writer" for a major portion of each paper. During this process, students also work together to form a cohesive final product. There are multiple rounds of reviewing and editing which are done within groups, between groups, and by the instructor. The course also satisfies a "writing within the discipline" core curriculum requirement at our University. The talk will therefore also focus on how a mathematics course can be designed to satisfy a writing requirement.
Author:
Sheldon Lee, *Viterbo University*

A Geometric Project for a Linear Algebra course
9:00 a.m. - 9:15 a.m.
In this talk we will discuss a take-home project for a linear algebra course. Within this project students apply concepts from linear algebra, primarily eigenvalues, eigenvectors, and diagonalization, to a three-dimensional geometric problem through a series of scaffolded questions. While the project is framed around a geometric result, no background knowledge in geometry is necessary. One can easily adjust the difficulty of this project by adding or removing different prompts and guiding questions. This provides flexibility in how one assigns this project. It can replace a traditional test (as it did when it was first assigned during the pandemic altered Spring 2020 semester), be a separate assignment to complement other traditional assessments or potentially be an undergraduate research project.
Author:
Bernadette Boyle, *Sacred Heart University*

Convince Me: A Writing Assignment Linking Academic Journal Articles and Abstract Algebra Course Objectives
9:20 a.m. - 9:35 a.m.
We present a cumulative assignment in which abstract algebra students make connections between an article from an academic journal and the algebra they have learned in the classroom, exploring how their class work has contributed to their understanding of the article and vice versa and communicating this information in the form of a memo to the instructor. This memo should point out course learning objectives linked with the article's content and convince the instructor to incorporate the article when addressing these objectives in their next abstract algebra class. We will discuss the format of the assignment, using the Transparency in Learning and Teaching (TILT) design framework, analyze sample submissions, and review the assessment rubric. This memo allows students to practice professional mathematical writing while strengthening their understanding of course content and exploring exciting applications of modern algebra at the same time.
Author:
Vicky Klima, *Appalachian State University*

Student Video Presentations: College Geometry
9:40 a.m. - 9:55 a.m.
College Geometry is a course that is predominantly secondary math education majors, yet all students who have taken (or are taking) Calculus 3 can enroll. A total of three recorded video presentations are assigned throughout the semester. The first presentation is during the first two weeks, where the topic is chosen by the student from a list of sections in the text. The second presentation is over an instructor chosen section. The last presentation is the final exam discussing 6 important questions covered throughout the semester. In this talk we will discuss the progression of assignments, student feedback and my future goals.
Author:
Erin Williams, *University of Central Oklahoma*

Assessment through Solutions
10:00 a.m. - 10:15 a.m.
Assessing student learning through problem solving is not an alternative nor innovative concept; however, if we change what is meant by "solving", deeper insights into a student's understanding can be obtained. Rather than having students solve a problem by simply listing their mathematical computations, we have developed assignments which ask students to provide a detailed solution for given problems. Here students must explain, using complete sentences, all of the steps required to solve the problem. In this talk we will describe what these assignments are, how they have been implemented, the benefits of assessing in this way, and share some student feedback.
Author:
Scott Williams, *University of Central Oklahoma*

Moving Away from Points and In-Class Assessment
10:20 a.m. - 10:35 a.m.
Initially motivated by COVID and teaching online, I have moved all of my classes away from less frequent, high-stakes, in-class, points-based assessments to frequent, low-stakes, out-of-class, binary-scaled assessments. I'll share this approach specifically for graded homework assignments and weekly "checkpoints" (like quizzes), how grading and revision/reassessment works, and how students have reacted to this approach. In addition, we'll discuss the evidence I see for why this scheme is better for all students and promotes their success in learning and understanding key ideas in each course.
Author:
Matt Boelkins, *Grand Valley State University*

Interviewing Students: An Alternative Form of Assessment
10:20 a.m. - 10:35 a.m.
In this session, I will share how I use individual interviews to assess students' understanding of mathematics. I teach mathematics content courses for undergraduate students pursuing a degree and certification in elementary education. In these courses, students engage in high-level tasks and activities (Stein, Grover, & Henningsen, 1996) that develop and deepen their specialized content knowledge (Ball et al., 2005; Hill, Schilling, & Ball, 2004).
One goal of these courses is to help students develop their ability to clearly explain their thinking in written as well as verbal formats. One way in which I assess these skills is by conducting (required) one-on-one interviews with each student. In these interviews, students have opportunities to showcase their thinking in ways that go beyond traditional written explanations. Sample interview questions, student responses, and suggestions for how to adapt this assessment tool to other settings will be shared.
Author:
Amy Hillen, *Kennesaw State University*

Implementing Specifications Grading into College Mathematics Courses using a Points-Based System
10:40 a.m. - 10:55 a.m.
In this talk I will describe a framework of specifications-based grading (SBG) that uses a points-based system of tracking mastery of individual problems and is suitable for use in a variety of mathematics courses. This work has been completed while at Florida Southern College, a small liberal arts college with class sizes ranging from 8 to 25. I will detail my experience adapting SBG to courses that range from Calculus I for non-math majors to Differential Equations and Calculus III. I will also describe how I handle reassessment opportunities, maintain grades, and use technology to help keep students up to date on their current points and overall progress.
Author:
Jason Elsinger, *Florida Southern College*

Part B: *Saturday, August 5, 1:00 p.m. - 5:35 p.m., Room 121*

Stretching Aptitude Through Immediate Feedback
1:00 p.m. - 1:15 p.m.
Traditional test taking is stagnant in the way of how a student's test grade is often reflected by partial credit and not on the student's true mastery of the course objectives. In lieu of a traditional final exam, students taking engineering mathematics were given an alternative assessment that gives the students the ability to demonstrate their understanding and exercise their potential aptitude against gradually difficult questions. The biggest take away from this approach is to encourage students to improve previous calculus math performance by reducing test anxiety.
In this talk, we will highlight how we approach, create, structure, and execute our alternative assessment. In particular how it allows us to provide instant feedback all the while lessen time spent on grading.
Authors:
Mai Tran, *United States Military Academy at West Point*
Shane Smith, *United States Military Academy at West Point*

Beyond Traditional Assessments: Incorporating Diverse Methods in Undergraduate Mathematical Modeling Courses for Holistic Learning and Skill Development
1:20 p.m. - 1:35 p.m.
We present a successful implementation of alternative forms of assessment in an undergraduate Mathematical Modeling of Natural Resources course. Our assessment methods include classwork, learning practice, homework, and group projects. Classwork assignments allow students to practice the

concepts discussed in class while learning practice assignments require them to apply these concepts to solve problems. Homework assignments demand higher learning outcomes based on Bloom's Taxonomy, where students use multiple methods. The course culminates in a research project where students write their research papers in three drafts and receive feedback. We provide support on LaTeX and MATLAB, as well as best practices for teaching scientific writing and presentation skills in undergrad math courses. Our methods are practical and easily implemented by other instructors, with a belief that alternative assessments improve learning and career skills.

Author:
Suleyman Tek, *University of the Incarnate Word*

A Partial Mastery Grading Approach for Calculus

1:40 p.m. - 1:55 p.m.

In this talk we will explore a partial mastery-based grading approach that I have used in Calculus and Precalculus involving a set of Core Learning Targets that students can attempt to master on weekly quizzes, exams, or outside of class if needed.

Author:
Benjamin Wilson, *Stevenson University*

The Reverse Flip Method for teaching Calculus. A combination of POGIL, the Flipped Classroom, and Mastery Grading

2:00 p.m. - 2:15 p.m.

Unlike a standard flip system, students are first introduced to a topic through a discovery based POGIL problem. After the intended goal of the lesson is summarized in class, the students are then required to watch a video that formally introduces the topic on their own time and attempt the homework bringing their questions to the next class meeting. “Ungrading” is then used to evaluate homework. Students receive the solutions to homework problems, make corrections then answer a survey about their understanding. Mastery grading is then used to evaluate assessments. Students have until the end of the term to earn full marks on twenty-five calculus standards. They can repeatedly attempt questions until they earn the credit. My collected data shows that this method of teaching reduced student stress in learning mathematics, increased understanding of difficult concepts and elevated student performance. Student feedback and course averages show how well the method was received.

Author:
Sybil Prince Nelson, *Washington and Lee University*

Making Room for Creativity in Calculus Assessment

2:20 p.m. - 2:35 p.m.

In this talk, I will describe an alternative to exams that gives students ownership of course material, makes room for student creativity, and encourages academic integrity by addressing motivation for academic dishonesty and making it more difficult to find answers online. I will share my experience replacing Calculus tests with a more open-ended, student-constructed review project: students are asked to review the main topics, write and answer their own “exam” questions, and reflect on their learning. This project gives deep insight into students’ knowledge and reasoning. The format of the project reduces student anxiety, increases student feelings of agency, and gives students multiple ways to engage with the material. Many students report enjoying this project and feeling that they have learned more than they would have with a traditional exam. I have found this type of project to be successful in both remote and in-person settings.

Author:
Erin Griesenauer, *Eckerd College*

Utilizing AI chatbots in the Calculus Sequence
2:40 p.m. - 2:55 p.m.
This talk will present an innovative approach to utilizing AI chatbots in the calculus sequence. Chatbots can serve a number of purposes, including providing instant feedback for student questions, facilitating "oral quizzes" using the Feynman technique, and assisting in drafting quizzes for use in mastery-based grading systems. This talk will include a description of the implementation of a chatbot in a Calculus 1 course, the results of the pilot study, and potential benefits and limitations of utilizing chatbots in math education. Overall, the talk will demonstrate the potential of AI chatbots as a versatile tool for improving student learning outcomes in the calculus sequence and beyond, and the opportunities for integration of technology in innovative teaching practices.
Author:
Grant Kopitzke, *University of Wisconsin Stevens Point*

Calculus 1 Assessments – A Project-Based Approach
3:00 p.m. - 3:15 p.m.
Due to the pandemic and professional development opportunities, I, along with many other educators, re-evaluated teaching styles and assessments. This talk will explore the move from traditional Calculus 1 exams to alternative assessments. In particular, attention will be paid to project-based assessments in which students had to demonstrate a more conceptual understanding of the material. In order to do that, projects relied on creativity and critical thinking skills. In addition to projects, exam-like components and grading schemes will also be discussed.
Author:
Liz Lane-Harvard, *University of Central Oklahoma*

Simple applied projects for Business Calculus
3:20 p.m. - 3:35 p.m.
It is generally acknowledged that students in an applied calculus course need more exposure to the real-world uses of the mathematics they are learning. However, implementing such content usually requires significant development time and effort from instructors. Most of this effort surrounds the desire to make these activities relevant, while within the mathematical ability of the students - an admittedly small intersection. We discuss a pair of project assignments which we have implemented into our Business Calculus class in place of more traditional assessments. Due to these assignments being forced into development during the pandemic, many of the concerns of relevance and ability were offloaded onto the students themselves. While results were far from perfect, students generally proved capable of exploring some small new areas without large amounts of instructor support. We share both positive and negative lessons learned, and ideas for further refinement.
Author:
Bradley Paynter, *University of Central Oklahoma*

Inspiring the Uninspired: How alternative assessments can be used to teach mathematics to the Business Student
3:40 p.m. - 3:55 p.m.
In this presentation, we will discuss how alternative assessments were used in a 100-level business math class to inspire freshmen and sophomore students. We will showcase examples of student projects and presentations in which they demonstrate their mathematical skill and how they see mathematics applying to their future career goals. In addition, we will discuss how these assignments were developed using equitable teaching practices, lessons learned from their development, and how these assignments can be generalized to other classes.
Author:
Whitney George, *University of Wisconsin - La Crosse*

An Unlikely Duo: Injecting Art Projects in the Mathematics Classroom
4:00 p.m. - 4:15 p.m.
Too often society has sterilized mathematics to the point that many students view it as drab and deplete of aesthetic intrigue. In this talk, we aim to share how we've altered this perspective via the introduction of art projects in the standard mathematics classroom. We will discuss our implementation, highlight our successes, and speak candidly about the overall experience. All of our rubrics, materials, samples, and more, will be made freely available as well. This talk is based on a joint implementation with Christina Durón at Pepperdine University.
Authors:
Douglas Pfeffer, *University of Tampa*
Christina Durón, *Pepperdine University*

Using Assessments to Promote Growth Mindset in College Algebra
4:20 p.m. - 4:35 p.m.
Scientific evidence highlights the positive impact of a growth mindset on student achievement. Much has been written about promoting growth mindset through lectures and attitudes, however, assessments can also be an important avenue for encouraging a growth mindset in students. In this paper, we describe how we used assessments to promote growth mindset in a college algebra class. In the sections that follow, we discuss the need for these assessments and the principles that underly their development. We then describe the assessments we created, how they were implemented, and student response to them. This is a novel approach to assessment that promotes growth mindset. This reframed how we looked at summative assessments and allowed us to introduce formative assessment elements, like reworks and group feedback, into many aspects of the summative assessments.
Authors:
Hannah Lewis, *Utah State University*
Katy Schneiter, *Utah State University*
D. Lane Tait, *Carbon High School/ Utah State University*

Feedback Forms: Helping Students Engage with Homework
4:40 p.m. - 4:55 p.m.
Students often do homework for the sake of doing homework. They fail to see the broader picture of why homework is important. And they rarely use homework as a way to assess their work and change their habits and mindset for the future. In this talk we will discuss how the authors used graded feedback forms to help students engage about their learning process while completing homework.
Authors:
Jennifer Gorman, *Lake Superior State University*
Joni Lindsey, *Lake Superior State University*

Math homework videos on Flip
5:00 p.m. - 5:15 p.m.
Flip is a simple, free, and accessible video discussion experience for educators and their learners. The presenter will describe the use of Flip for presentation of homework problems in a capstone-like course for preservice teachers called Topics in Secondary Mathematics from an Advanced Viewpoint and a mathematics for elementary teachers' course. Homework is assigned regularly and each student in the class chooses a homework problem that they will present by making a Flip video. They do this a total of three or four times over the course of the semester. This determines their homework grade. Flip allows for video and text comments so other students can view the homework videos and make a comment or ask a question. This experience, including an example and the rubric used for evaluation, will be shared and discussed.

Author:
Cathy Liebars, *The College of New Jersey*

Ethnomathematics: Culture Meets Mathematics in the Classroom

Friday, August 4, 8:00 a.m. - 9:15 a.m., Room 121

This session features talks that present research in Ethnomathematics with a focus on incorporating Ethnomathematics in teaching. Ethnomathematics presents opportunities for increased emphasis on inclusion and diversity at colleges and universities. Ideas and innovations in Ethnomathematics for its use in teaching are welcome.

Organizers:
Ximena Catepillan, *Millersville University of Pennsylvania*
Cynthia Huffman, *Pittsburg State University*
Amy Shell-Gellasch, *Eastern Michigan University*

Sponsor:
SIGMAA on the History of Mathematics (SIGMAA HOM)

Ancient Greek Recognition of Universal Levels of Assessment such as Mastery of Division
8:00 a.m. - 8:15 a.m.
I am working within the "philosophy and cultural nature of mathematics" category explained in the Wikipedia "Ethnomathematics" webpage, which includes the Ethnomathematics distinction between Plato and Aristotle. For Plato, I study Gorgias, for Aristotle, Rhetoric. In studying these texts, I acknowledge the cautions of philosopher Ivor Grattan-Guinness that we can only learn what ideas a text may inspire in the context of our own time. I argue that in Plato's Gorgias, Socrates and Gorgias agree that students in ancient Athens must learn the numerical system of odd and even numbers, or the topic of arithmetic parity. Also, calculation of the speed and movements of the stars is assessed. Thus, the ability to do symbolic equations solved by division calculation, such as knowledge of calculating the formula for speed, is assessed as necessary for student advancement in their respective schools.
Author:
Ann von Mehren, *Shelby County Schools, Memphis, TN (M-SCS)*

Merging Cultural Components in My Math Teaching by Project-Based Learning Method
8:20 a.m. - 8:35 a.m.
Students are living in a multi-cultural society at school and workforce. Culture values have played a profound impact on students' growth including personality, behavior, idea, belief, norm, social practice, relationship, and life. To help students thrive in a society with culture diversity, as teacher, I am responsible to help student reveal cultural identity, cultural awareness, and appreciation. Integrating cultural components into my teaching projects as culturally responsive pedagogy, I will share the experience of 3 classroom-tested projects. First project is about the creation of digital images of cultural symbols on the use of calculus graphing equations and Maple technology. Second project is about cultural patterns with math symmetry. Third project of "Tree Diagram of Culture Impact on Personal Growth" is an exercise to student as self-reflection of culture influence in personal growth in statistics class. Project outcomes and students' feedback will be provided.
Author:
Lina Wu, *Borough of Manhattan Community College-The City University of New York*

Kolams in Graph Theory: A Student Research Project in Southern Indian Ritual Art
8:40 a.m. - 8:55 a.m.
Kolams are a ritual art form found in India, most commonly in the southern state of Tamil Nadu. Comprised of different interlocking knots, these women-drawn designs are placed on the entrances to people's home to showcase the household's emotional state and ask the earth goddess Bhudevi for forgiveness. More aesthetically pleasing kolams are considered latshanam, where the design permeates beauty; monolinearity is one such aspect that implements latshanam. In this talk we will discuss a student research project that examined the monolinearity of labyrinthine kolams through the lens of graph theory, including how such a project was developed and how one could develop a similar student project.
Authors:
Elizabeth Donovan, *Murray State University*
Nathan Hartmann, *Murray State University*

Symmetry in the Artwork of Early Indigenous North American Cultures
9:00 a.m. - 9:15 a.m.
The concept of symmetry appears in the curriculum of many courses including Mathematics for Elementary Education, Geometry, and Abstract Algebra courses. Symmetry also appears in the artwork of many cultures, making it ideal as an opportunity to incorporate Ethnomathematics in the classroom. In this presentation, we will look, in particular, at symmetry appearing in artwork of the Mississippian and Poverty Point cultures.
Author:
Cynthia Huffman, *Pittsburg State University*

Mathematics and Sports
Saturday, August 5, 8:00 a.m. - 10:15 a.m., Room 118/119

The expanding availability of play-by-play statistics, video-based spatial data, and other sports data have led to innovative sports analytics research with impacts on strategy and player evaluation. Other areas of research include ranking methods, predictive models, physics-based analysis, etc. Research presentations, expository talks, and pedagogical contributions are all welcome in this session. Projects accessible to or involving undergraduate students are particularly encouraged for submission.

Organizers:
Rick Cleary, *Babson College*
Hope McIlwain, *Mercer University*

Sponsor:
SIGMAA on Mathematics and Sports (SIGMAA SPORTS)

Statistical Modeling of Length of Seven- Game Series
8:00 a.m. - 8:15 a.m.
In this presentation we will discuss a statistical model for predicting the number of games played in a "best of seven "series and the ultimate winner of the series. Seven-game series are used to determine the champions in NBA, World series of baseball and hockey. We will determine probability of length of a series as a function of p, where p is probability of the better team winning a single game. We will look at

the benefits and shortcomings of previous methods in estimating p and introduce our own approach in determining the value of p. We will then use the goodness-of-fit test to examine how well our model fits the actual results. An accurate estimate of p not only is useful in determining the expected number of games but also can be used to answer the long-standing question of how many games are needed to have a reasonable level of confidence for the better team to win. Our hope in conducting this work is to demonstrate use of basic knowledge of probability and statistics in modeling current events, specifically sports. This project was conducted as part of NSF-funded grant # 1905246 titled "Mathematical and Statistical Modeling across the Curriculum."

Authors:
Reza Abbasian, *Texas Lutheran University*
John Sieben, *Texas Lutheran University*

A Linear Regression Model for Predicting Whiff Percentage in Major League Baseball
8:20 a.m. - 8:35 a.m.
This paper examines data related to the whiff percentage of five different Major League Baseball (MLB) pitches. A linear regression model is used to predict whiff percentage. Our results show that the models for each pitch, except the curveball, have statistical significance. The results of the cutter model are especially significant and give an indication of which pitchers in the MLB should throw their cutter more. The results found herein not only add a piece to the story but, also, lead to future areas of research in pitch modeling.

Authors:
Ryan Savitz, *Neumann University*
Christopher Greve, *Neumann University/Philadelphia Phillies*

The Implementation and Application of Statistics in Shotokan Karate
8:40 a.m. - 8:55 a.m.
This paper introduces a model that addresses the way competitors in Shotokan karate martial arts competitions are evaluated. This new model is a combination of multiple variables that determine the winner of a sparring competition in Shotokan karate. The model we constructed predicts the winner of Shotokan karate matches with a near 100% success rate. The model was constructed using the forward LR variety of logistic regression. Due to some issues of multicollinearity, this model was then refined using the author's knowledge of karate. Finally, a single statistic was developed to capture the ability level of a karate participant.

Authors:
Oliver DiDonato, *Neumann University*
Ryan Savitz, *Neumann University*
Cindy Casey, *Gwynedd Mercy University*

Tip-off in Basketball: Does It Matter Which Team Gets to Start the Game?
9:00 a.m. - 9:15 a.m.
What is the significance of the opening tipoff in National Basketball Association (NBA) games? Does it matter which team wins the opening tipoff and does it have any impact on the game outcome? In this study, we investigate whether the opening tipoff influences the game outcome by analyzing the play-by-play data of all NBA games (n=27,536) dating back to the 1999-20 season up to the 2021-22 season. In addition to the opening tipoff, we consider the importance of any jumpball event, the overtime tipoff, and the likelihood of scoring after securing a jumpball.

Authors:
Eren Bilen, *Dickinson College*
Andrew Scheiner, *Dickinson College*
Barry Tesman, *Dickinson College*

Analysis of a Serve Reception Metric in Women's NCAA D-1 Volleyball
9:20 a.m. - 9:35 a.m.
In this talk, the speaker will present current results of a serve receive metric analyzed statistically from matches played in the Atlantic Coast Conference (NCAA Division I Women's Volleyball). The evolution of the metric used will be discussed as well how is data gathered and analyzed. Examined is the quality of the reception based upon location of the server, location of the receiver, and location of the point of contact of the reception. Additionally presented is how the data was implemented for match preparation and the effectiveness of the metric during matches. The analyses presented can be used by teams to enhance training and match preparation.
Author:
Caleb Adams, *Radford University*

Determining the Winning Formula for an NFL Football Team
9:40 a.m. - 9:55 a.m.
Sports analytics provides students with an exciting and motivating way to teach machine learning and statistics. In this talk I will present the various ways I used machine learning and statistical techniques to predict the winning percentages for NFL football teams. This was incorporated into the classroom as assignments and mini projects. Furthermore, undergraduate research for predicting the winning percentages for NFL football was also accomplished. I will show how I incorporated Bill James' Pythagorean formula, logistic regression, and Artificial Neural Network (ANN) to predict winning percentages using total points scored and total points give up for NFL football. Furthermore, I will present how I incorporated forward and backwards step wise logistic regression, and ANN to predict the winning percentages using various defensive and offensive stats for NFL football.
Author:
Barry Husowitz, *Wentworth Institute of Technology*

How Steep Is Your League? David's Score and Dominance Hierarchies
10:00 a.m. - 10:15 a.m.
Is it possible that your favorite team is stuck in a league perennially dominated by a few other powerful teams, but you don't want to complain without a solid reason? Behavioral biology and mathematics to the rescue! In the 1980's the statistician H. A. David developed a method for ranking the members of a social group in a dominance hierarchy. This method, called David's score, is used to model the social structure of animal colonies and to study the steepness of the dominance hierarchy in those colonies. The steepness of the hierarchy indicates whether the social structure is more egalitarian or more oligarchical. This talk will apply this method to study the competitive structure of various sports leagues, demonstrating how to calculate David's score and the steepness of the dominance hierarchy. Perhaps you will also gain a more elegant way of expressing your athletic frustration.
Author:
Thomas Polaski, *Winthrop University*

My Favorite Statistics / Data Science Activity
Friday, August 4, 2:00 p.m. - 5:55 p.m., Room 117

We all have that one statistics or data science activity that students respond positively to and we really enjoy teaching. We would like you to share that activity with us! This session invites papers from across the curriculum that critically engage students in statistics and data science material.

Organizer:
Grant Innerst, *Shippensburg University*

Sponsor:
SIGMAA on Statistics and Data Science Education (SIGMAA SDS-ED)

Flipping a Penny
2:00 p.m. - 2:15 p.m.
This activity introduces or reviews the key concepts of population, sample, variable, data, distribution, and histogram. Each student simulates flipping a penny ten times exclusively with their mind, records the result as a case, and repeats the process three more times. Next each student flips an actual penny ten times, records the result as a case, and repeats the process three more times. Finally, a computer simulates flipping a penny ten times, records the result as a case, and repeats the process many times. Each student now determines for each of their cases the number of heads and the length of the longest consecutive run, and we do the same with the computer-generated cases. As a class, we create histograms for the data from each variable for the human simulated, actual, and computer simulated cases. Finally, the histograms are compared. We have always found that simulating randomness accurately is difficult for humans but seemingly easy for deterministic computers.
Author:
David Housman, *Goshen College*

Transformations of Random Variables
2:20 p.m. - 2:35 p.m.
In my course, Statistics, an Introduction, I often have many math-phobic students who quickly become disconnected from the material when distributions of random variables are explored through computational tools. I find that these students do much better and feel more confident when they can explore distributions with good ol' pencil and paper. This is why my favorite statistics activity is my worksheet titled "Population Transformations." In this activity, students discover the effect that linear transformations, including standardization, have on the parameters and shape of a discrete random variable. Then, based on the patterns they discover, they make conjectures about what the same transformations will do to a continuous random variable. In this talk, I will present this activity, as well as discuss my recently published workbook that contains all of my note-taking guides and activities for the course.
Author:
Lindsey Fox, *Eckerd College*

Reading & Critiquing Applications of Statistics in an Introductory Course
2:40 p.m. - 2:55 p.m.
In an introductory statistics course, students engaged in regular reading and discussion assignments structured around statistics-focused articles. The readings typically described a study or a statistical approach to a subject and focused on topics such as medical research and policy, political engagement, repetition in music, grades during COVID, and baseball. These readings served as examples to students of how statistics can be used in areas of interest to them while also giving students an opportunity to critique statistical work or writing. I will describe the types of assignments, student response, finding appropriate readings, and what I plan to change in the future.
Author:
Jessie Oehrlein, *Fitchburg State University*

An Analysis of the Use of Paraview in the Classroom
3:00 p.m. - 3:15 p.m.
The use of data visualization tools in the classroom is growing rapidly, and this paper discusses implementing these tools in order to conduct research and experiments. Data visualization plays a crucial role in understanding data since the majority of available data is raw. It would be beneficial if data visualization projects were incorporated across the curriculum using data visualization tools such as Paraview to enhance students' computational abilities. The purpose of this paper is to examine how data visualization tools are applied in the classroom. The Paraview tool is an open-source tool designed to learn data visualization techniques, such as fluid dynamics. It is anticipated that the teacher and student will gain a greater understanding of science concepts by analyzing the data presented by this tool.
Authors:
Devender Rapolu, *Southern University and A&M College*
Mohammad Salam, *Southern University and A&M College*
Shizhong Yang, *Southern University and A&M College*
Albertha Lawson, *Southern University and A&M College*
Luria Yong, *Southern University and A&M College*

Data Visualization Activities to Illuminate Cognitive Pitfalls and Help Students Become Better Communicators of Data
3:20 p.m. - 3:35 p.m.
Data visualization is an engaging entry point to get students thinking critically about data and how it intersects their everyday lives. It is one of the most ubiquitous mediums through which we consume information, yet there are known cognitive pitfalls and difficulties in statistical reasoning that are often not taken into account when visualizing data. In this talk, I demonstrate a series of classroom activities that expose students to best practices established from data visualization and cognitive science research. During these activities, participants (1) are confronted with their own cognitive limits in gleaning insight from certain visualizations; (2) experience the cognitive ease that simple design changes can engender; (3) practice constructing multiple visualizations of the same data to highlight different stories; and (4) engage in an “I like, I wish” constructive feedback session that allows them to collectively arrive at more effective data communication.
Author:
Kaitlyn Fitzgerald, *Azusa Pacific University*

Introducing the Law of Large Numbers to Statistics Courses Through an Interactive Programming Activity
3:40 p.m. - 3:55 p.m.
When students are first introduced to theoretical and empirical probability, they tend to have trouble linking the two concepts together. The Law of Large Numbers is the link between the concepts. The Law acts as the foundations for the understanding of sampling distributions, and thus enables the ability to make statistical inferences. My favorite statistics activity involves having students visualize the Law of Large Numbers through computer simulations of coin flips, die rolls, etc. What happens to the long-running probability of an outcome as the number of trials increases? Students will explore the consequences of long-running empirical probabilities to make a conjecture of what happens to the empirical probability of an outcome as the number of trials keeps getting larger. In this way, students are engaged and having active participation from the beginning of the process in discerning the fundamental differences between empirical and theoretical probability.
Author:
Patrick Stewart, *Millersville University*

Using R Projects to Explore Regression
4:00 p.m. - 4:15 p.m.
We share our favorite pair of activities from an introductory statistics class: an in-class project that explores linear regression, and an out-of-class project that explores multiple regression. Both activities use R in a fundamental way, and students are actively pushed to better familiarize themselves with the statistical concepts and the technology simultaneously. We will discuss the effectiveness of these projects while providing context in how students engage with R projects in this class.
Author:
John Ross, *Southwestern University*

Statistics and Data Activities with R
4:20 p.m. - 4:35 p.m.
In this presentation, I would like to explore several Statistics and Data activities using R which students found helpful and were a pleasure for me to teach. These include preliminary descriptive data analysis and visualization as well as application of user defined functions to proportion, chi-squared, means tests, and simulations. I will discuss successful students' class projects.
Author:
Leon Kaganovskiy, *Touro College*

Optimization and Regression Models
4:40 p.m. - 4:55 p.m.
My favorite lesson in data science is introducing linear models for regression and classification. I believe that students intuitively understand regression models as optimization problems. Presenting them as such in a calculus class for liberal arts majors allows continued connections to ideas through the semester from basic applications of the chain rule to numerical methods for optimization problems, partial derivatives and gradients, and constrained optimization and lagrangians.
In this session I discuss how I use these examples throughout my course as a primary application of calculus. We rely on the Python computing language and readily accessible datasets to perform both symbolic and numerical computations to build our regression models. Along with the discussion I will share resources for use in the classroom and examples of student work in summative projects involving regression and calculus.
Author:
Jacob Koehler, The New School

Ethics As Instructon
5:00 p.m. - 5:15 p.m.
I inherited and adapted an assignment involving ethics in a statistics course. As a mathematician transitioning to teaching statistics, I have tried to incorporate recommendations from the statistical education literature, but I did not expect the unintended benefits of the ethical assignment in terms of communicating statistical approaches and practices. This presentation will share the features of the assignment as well as its perceived benefits.
Author:
Jeremy Case, *Taylor University*

Student Driven Data to Illustrate Statistical Concepts across the Curriculum
5:20 p.m. - 5:35 p.m.
Students are often disconnected from the examples provided in the classroom, in the talk we present several easy and inexpensive activities and games for which students generate their own data. Furthermore, we illustrate how the data is used to teach concepts from beginner level to advance level.

Such concepts include: data description, empirical rule, hypothesis testing, confident intervals, distribution testing, estimation and likelihood.

Authors:
Ryad Ghanam, *Virginia Commonwealth University in Qatar*
Edward Boone, *Virginia Commonwealth University*

Political Campaigns as a Motivation for Data Science
5:40 p.m. - 5:55 p.m.
A tricky aspect of Data Science (DS) education is introducing the "soft skills" that employers often find lacking in early-career professionals. To address this with sophomore DS students, I incorporate substantial activities using quantitative methods to contribute to political campaign strategy. Working with sophomore political science students who are embedded in local campaigns, students collaborate to ask and answer questions using election results data and lists of registered voters. Since the questions come from current campaigns, DS students find them more genuine than those of a standard course assignment. In the end, students see the importance of clear communication when collaborating with people who are not data-oriented. They also see that the simplest method that works to answer a question is almost always the best approach, as our political science peers do not care whether the contributed insight came from a simple visualization or a machine-learning algorithm.

Author:
David Gerberry, *Xavier University*

Implementing Corequisite Education

Part A: *Thursday, August 3, 2:00 p.m. - 5:55 p.m., Room 121*
Part B: *Saturday, August 5, 8:00 a.m. - 9:15 a.m., Room 107*

Corequisite courses are growing in popularity throughout the mathematics community. A corequisite course is a prerequisite course that has been strategically redesigned to be taken concurrently with the primary course. There are a variety of implementations being tried, varying in structure and content. This session invites presenters to share their own institution's implementation, including successes or cautionary tales, research, trends, or results that can increase our understanding of best practices for designing the courses, and supporting students who need to take them.

Organizers:
erica J. Whitaker, *University of Kentucky*
Vilma Mesa, *University of Michigan*

Sponsor:
MAA Subcommittee on Curriculum Renewal Across the First Two Years (CRAFTY)

Part A: *Thursday, August 3, 2:00 p.m. - 5:55 p.m., Room 121*

Corequisite Implementation at Missouri Western State University
2:00 p.m. - 2:15 p.m.
Missouri Western State University is an open access regional university in the Midwest. We have been offering a corequisite course with our Contemporary Problem Solving course since the fall of 2015 and later introduced a separate corequisite option for our Introductory Statistics course. In this talk, I will

discuss the push at the state level in Missouri for Math Pathways and corequisite education through my experience as a member of the statewide Corequisite at Scale Taskforce (CAST) created by the MO Department of Higher Education. I will also describe the evolution of the corequisite model at MWSU and discuss some of the successes and failures we've experienced.

Author:
Lori McCune, *Missouri Western State University*

Embedded Corequisite Instruction for All: An Experiment in Calculus I
2:20 p.m. - 2:35 p.m.
In the Fall semester of 2016, the Department of Mathematics and Statistics at the University of Alaska Fairbanks began implementing a proctored ALEKS PPL assessment at the beginning of all first-semester Calculus I courses. This embedded assessment data collected over several years indicated that a large fraction of students who were legitimately placed into Calculus I (via prerequisite course work, placement tests, etc.) nevertheless demonstrated large gaps in their precalculus knowledge base. Since, the population of students with large gaps in precalculus knowledge had pass rates less than half of their better-prepared peers, in Fall 2021, explicit, designed, precalculus instruction was embedded into all Calculus I courses as part of a 2-year, 4-semester experiment. This talk will describe preliminary results based on analysis from the first two semesters of implementation and discuss some of the questions the analysis raises.

Authors:
Jill Faudree, *University of Alaska Fairbanks*
Julie McIntyre, *University of Alaska Fairbanks*
Ryan Bridges, *University of Alaska Fairbanks*

Analyzing the Effectiveness of a Homegrown Calculus Prerequisite Skills Lab
2:40 p.m. - 2:55 p.m.
In Fall of 2019 our department again restructured our first calculus course to address staffing and administrative issues with our previous two track approach. Now instead of offering a two-semester course with just-in-time algebra review for students with weaker prerequisite skills we offer a supplemental in-person skills lab to all calculus students using a series of placement quizzes to determine which skill sessions each student must attend.
The goal of our study is to see how student success in this new version compares to our previous two track approach as well as to the standard previous approach with no prerequisite skill review. We collected and analyzed students' grades and placement test scores to help with this comparison. In this talk, I will give details about our new system, the system it replaced, the impacts of both systems, and where each of these systems might be most appropriate.

Authors:
Hannah Robbins, *Roanoke College*
Quinn Kunath, *Roanoke College*

Skipping College Pre-calculus: A Corequisite Implementation Report
3:00 p.m. - 3:15 p.m.
We report completion rates and retention rates after implementing a corequisite Calculus 1 course that has no pre-calculus prerequisite. In recent years, we have seen an increasing number of students matriculating without having taken pre-calculus. Because we did not offer a pre-calculus class, these students had to complete a pre-calculus course at another institution in order to begin the calculus sequence at Whitman. This represented a substantial barrier to access to STEM majors for these students. To address this, instead of creating a pre-calculus class, we designed an alternative Calculus 1 course, "Introduction to Calculus", which included an extra credit and an extra class hour each week. We provided just-in-time instruction of pre-calculus topics to support the calculus content. In this presentation, we will describe the

structure of the course and report on both the success of the students in the new Calculus 1 course and in their throughput success in Calculus 2.

Authors:
Albert Schueller, *Whitman College*
Barry Balof, *Whitman College*
Doug Hundley, *Whitman College*

An Action Research Project Evaluating the Integration of Prerequisite Materials in a Calculus I Course

3:20 p.m. - 3:35 p.m.

Gagne (2010) acknowledged the importance of recalling prerequisite materials in new learning but questioned whether the prerequisite knowledge is accessible for all the students in the class. The author noted that the adequacy of preparedness influences the efficacy of learning. To determine whether there was a significant difference in final grades, this research utilized an intervention in which students recalled prerequisite topics from algebra and trigonometry in a Calculus I course. The study entailed reviewing prerequisite materials outside of the classroom. A two-sample t-test was used to analyze the data by comparing the final grades of students from the post-intervention Calculus I course to the final grades of students from the pre-intervention Calculus I course. An anonymous survey was administered to students regarding the intervention. The presenter will discuss the background, intervention, research method, data collection, limitations and further research in detail.

Authors:
Sharmila Sivalingam, *Maryville University of St. Louis*
Jason Castles, *Maryville University of St. Louis*

Use Longitudinal Data and Moving Average to Illustrate Effectiveness of Supplemental Instruction

3:40 p.m. - 3:55 p.m.

At Texas A&M University-Commerce, supplemental instruction (SI) has been implemented in Calculus since the fall of 2013. In this paper, we apply the concept of moving average to show that supplemental instruction, along with efforts of faculty who teach Calculus, is effective in improving the percentage of students who earned a grade of A, B, or C (ABC rates) in Calculus-based on the data from fall 2005 to spring 2021. However, by directly displaying the ABC rates, we only see that the ABC rates fluctuate from semester to semester, and we can hardly conclude that the ABC rates are increasing. Our longitudinal data also shows that the ABC rates of major ethnic groups have increased with the SI implementation since the fall of 2013. The moving average, commonly used in the financial stock market, can be an effective tool to demonstrate longitudinal data in education.

Authors:
Tingxiu Wang, *Texas A&M University-Commerce*
Mehmet Celik, *Texas A&M University-Commerce*
Pamela Webster, *Texas A&M University-Commerce*

Corequisite College Algebra at Nebraska

4:00 p.m. - 4:15 p.m.

There is a large literature establishing that co-requisite courses increase student success, both in terms of course grades and progress to subsequent courses. We describe the implementation and preliminary results of a co-requisite course for College Algebra at the University of Nebraska-Lincoln, highlighting a crucial component of the course's success - a partnership with the university's advising community. Now a one-credit-hour course, the co-requisite course is designed to support students who would not be placed into College Algebra but are interested in taking the more advanced course as soon as possible. After a small initial pilot in Fall 2021 as a two-credit-hour supplementary course, the course was redesigned as a

one-credit-hour course. A larger pilot in Fall 2022 was quite successful and we expect to offer this course to all interested students beginning in Fall 2023.

Authors:
Allan Donsig, *University of Nebraska-Lincoln*
Josh Brummer, *University of Nebraska-Lincoln*

Two Decades of Corequisite Education
4:20 p.m. - 4:35 p.m.
Between 2002 and 2004, the Department of Mathematics at UL Lafayette decided to design and implement a corequisite version of their College Algebra course. At the time, the idea was simple, novel, and not called "corequisite support." The idea was that students who are underprepared or fall slightly below the prerequisite threshold for the standard course would benefit from more time in the classroom. Since that time, the structure and implementation of this single corequisite course has gone through many changes. These changes include the number of credit hours, the course numbering system, the course name, the course structure (ie. lecture time vs. lab time), the number of enrolled students, and, finally, modifications due to COVID-19. Our many successes and challenges have allowed us to become a model for other STEM and non-STEM departments at our institution and others in the State of Louisiana.

Author:
James Kimball, *University of Louisiana at Lafayette*

Supporting Student Success Through a College Algebra Corequisite Course
4:40 p.m. - 4:55 p.m.
Consistent with national trends, our institution has seen growing numbers in developmental math enrollment over the past decade, with sharp increases in recent years. In an effort to meet the needs of this growing population and shorten STEM-track pathways for students starting in algebra, we created a corequisite course for our College Algebra course starting in the Fall 2020 semester. This 2-credit course was designed with a "just-in-time" content model and within our institution's coordinated course structure, with worksheet sets and quizzes available to instructors. In Fall 2022, enrollment in the corequisite course grew to 398 students, with nearly 80% earning credit for the course and 66% successfully completing College Algebra. This allowed them to enroll in Precalculus the following semester, streamlining their path through the STEM-track math sequence and eliminating a full semester of math instruction.

Author:
Jessica Babcock, *Temple University*

A Nuanced Look at Math Pathways
5:00 p.m. - 5:15 p.m.
While College Algebra is no longer required for many programs at institutions across the country and offering corequisite support courses to shorten mathematics pathways is now increasingly common, institutional performance gaps persist and success in mathematics is still a significant obstacle for students in achieving their academic goals. Many institutions have structural barriers to scaled implementation like scheduling and registration, but others are also recognizing the nuances that need to be considered to best serve students with these new models. Leaders in this work are moving toward a framework that addresses the structural, pedagogical, curricular, and support components of student success as well as content alignment at multiple levels. We share some observations related to high school connections, default placements and pathways, professional development, pedagogy, the role of other campus offices and departments, and prerequisites specifically in STEM pathways.

Author:
Laura Schueller, *Complete College America*

Names Matter! Incorporating Precalculus into Calculus
5:20 p.m. - 5:35 p.m.
Prior to Fall 2021, many incoming students at Missouri University of Science and Technology were placed into a semester of precalculus prior to Calculus I. Most of these students took a course called calculus in high school and expressed displeasure at being placed below calculus. In response, a new two-semester sequence (Calculus I-A and Calculus I-B) was developed which incorporates precalculus on a just-in-time basis into a slower-paced introduction to calculus. Initial student (and parent) feedback has been stronger than expected, but we have also observed an extreme negative impact on traditional Calculus I enrollment and success rates. Information about the course structure and overall experience will be presented.
Author:
Paul Runnion, *Missouri S&T*

The Impact of a Holistic Math Student Support Program, Based on Compassionate and Loving Kindness Pedagogy and Practices, on Students' Attitudes towards Mathematics, Their Self-concept and Their Self-efficacy
5:40 p.m. - 5:55 p.m.
Many challenges can hinder students' success in introductory math courses from personal challenges, mental health problems, time management, math anxiety, and institutional barriers. A comprehensive student support program based on compassion and loving kindness pedagogy, as well as reinforcing student success strategies, was implemented in a few math introductory courses in order to address those challenges.
Author:
Samara Chamoun, *Michigan State University*

Part B: *Saturday, August 5, 8:00 a.m. - 9:15 a.m., Room 107*

Teaching Within a Corequisite Setting - If Corequisite Students are Already Taking THE Course, What Should the Corequisite Do Differently?
8:00 a.m. - 8:15 a.m.
Assuming that the content of a corequisite course includes prerequisite and target course content, what then do we do in the corequisite? Say it again, but louder? Or if the corequisite is not just a study hall, how else can we engage students in ways that will support their success? This session will offer pedagogical strategies for developing student understanding of mathematics content and student self-regulated learning. The ideas that will be shared can be generalized to any corequisite setting in mathematics and statistics.
Authors:
Katherine Mawhinney, *Appalachian State University*
Tracie Howell, *Appalachian State University*
Eric Marland, *Appalachian State University*
Katrina Palmer, *Appalachian State University*
Gregory Rhoads, *Appalachian State University*

Appalachian State University's Support Course System for STEM Students
8:20 a.m. - 8:35 a.m.
For the last 5 years Appalachian State University's Department of Mathematical Sciences has developed unique placement procedures and support courses (corequisite and fallback) to increase student success in the calculus sequence (specifically precalculus, differential calculus, and integral calculus). This session will provide the timeline of efforts, revisions, and current structure of these supports, along with a

summary of student success data. This session will also include advice regarding administrative concerns and collaborations with advising offices that may be useful for others interested in implementing similar measures at their own institutions.

Authors:
Eric Marland, *Appalachian State University*
Tracie Howell, *Appalachian State University*
Katherine Mawhinney, *Appalachian State University*
Katrina Palmer, *Appalachian State University*
Gregory Rhoads, *Appalachian State University*

Corequisite Support to Improve Student Success in Mathematics and Statistics
8:40 a.m. - 8:55 a.m.
In recent years, colleges and universities have increasingly turned to co-requisite courses in mathematics as a way to provide more support to students who may struggle with these courses. However, simply placing students in a co-requisite course is not always enough to ensure retention, as measured through graduation rates or through completion of math general education requirements. At the Idaho State University (ISU), the majority of students are "non-traditional" college students. It is a challenge to serve these students well, particularly in our attempts to increase the first-year retention rates. The presenter and her colleagues have developed the "P" or "Plus" courses for each math pathway, which provides supplemental instructions in a co-requisite support model. We will discuss successes and challenges of this model, in the context of our student population at ISU.

Author:
Qingqin Qu, *Idaho State University*

Research on Direct Enrollment in the VCCS: An NSF-Funded Study
9:00 a.m. - 9:15 a.m.
Recent years have seen many developmental education programs switch to a corequisite model in which students complete just-in-time remediation connected to a gatekeeper credit-level mathematics course. Many programs have seen gatekeeper mathematics success rates improve, but implementation of corequisite education models varies considerably. Research on the causal impacts of corequisite reforms on student success and longitudinal outcomes, as well as the instructional and curricular choices that impact student success, is still in a nascent stage. This presentation will overview a systematic program of reforms at the Virginia Community College System (VCCS) and share the research design and preliminary results from a National Science Foundation grant. This research is ongoing and participants are encouraged to bring their own questions and share experience to help inform this research.

Author:
Zachary Beamer, *Piedmont Virginia Community College*

Teaching and Learning of Differential Equations

Part A: *Thursday, August 3, 8:00 a.m. - 10:55 a.m., Room 117*
Part B: *Friday, August 4, 1:00 p.m. - 4:35 p.m., Room 106*

This session features talks by ordinary differential equations (ODEs) educators. We invite presentations of successful undergraduate projects using ODEs, demonstrating effective pedagogies and use of technology, and introducing successful, classroom-tested unconventional ways of teaching traditional concepts in ODE classes. Presenters are encouraged to submit articles to CODEE (www.codee.org), an open access journal devoted to the teaching and learning of ODEs.

Organizers:
Maila Hallare, *United State Air Force Academy*
Johannah Crandall, S*pokane Falls Community College*
Viktoria Savatorova, *Central Connecticut State University*

Part A: *Thursday, August 3, 8:00 a.m. - 10:55 a.m., Room 117*

Mathematical Insights on the Spread of Pollutants
8:00 a.m. - 8:15 a.m.
Lakes flowing into the ocean carry a great deal of pollution in many forms. Here, we present an example of a teaching module that demonstrates how differential equations can be used to investigate an environmental problem such as pollution. Consider a linear, circular, or star formation of three or more lakes. Assuming there is a pollutant source at each lake in the cascade, how much pollutant can be found in each lake? Students in a first course in differential equations can tackle this problem using methods they have learned in class.
Author:
Maila Hallare, *United State Air Force Academy*

An ODE classroom Project to Model Carbon Dioxide Concentration
8:20 a.m. - 8:35 a.m.
Exposure to too much carbon dioxide can cause headaches, fatigue, and even more severe symptoms. An elevated carbon dioxide level inside a building can also be an indication of poor ventilation. Thus, it is valuable to understand how carbon dioxide levels can change inside an office or classroom. In this talk, we will discuss a project that asks students to use first-order differential equations to model the concentration of carbon dioxide in an office over time. The situation is potentially analogous to the mixing problems often found in textbooks. In this project, data was collected using an Aranet4 sensor, which allowed students to test their models. Conclusions about the project will also be discussed.
Author:
Brian Hollenbeck, *Emporia State University*

Sustainable Fishing and Maximizing Profit: Are They Compatible?
8:40 a.m. - 8:55 a.m.
We develop differential equations that model population growth including constant effort harvesting. One equation relates to species that exhibit compensation growth, that is, a decreasing per capita growth rate. We develop another for species exhibiting depensation, that is, an increasing then decreasing per capita growth rate. We describe characteristics of each type of species. Analysis of these equations using phase-line analysis leads to finding stable and unstable equilibrium populations in terms of the harvest rate. From this, we generate general principles related to maximizing the sustainable harvest and how this is different for the two types of species. Finally, we introduce a cost function for harvesting and develop additional principles related to maximizing profit and the tragedy of the commons when using open access harvesting. These results lead to a better understanding of the issue of overfishing and why it is difficult to control.
Author:
James Sandefur, *Georgetown University*

Differential Equations Modeling of the Historic Global Human Population
9:00 a.m. - 9:15 a.m.

The historic global human population dataset provides an opportunity for modeling with simple differential equation models for population. Using the per-capita population growth rate (PPGR) predicted by the models and estimated PPGR from the data, we estimate parameters for the exponential model and discover that we cannot estimate parameters for the logistic model. We also create a new differential equation that models this data using ideas from the derivation of the logistic model. This superexponential model goes to infinity in finite time. While the initial superexponential model is good for interpolating the population data, it does not closely match the PPGRs estimated from the data. We switch to a hybrid model that is superexponential for the first portion of the data, and logistic for the rest. This hybrid model greatly reduces the modeling error and can extrapolate from the data.

Author:
Jean Marie Linhart, *Central Washington University*

Using ODEs and Epidemiology to Promote STEM Motivation among First-Generation Students
9:20 a.m. - 9:35 a.m.
"Infectious Disease Modeling" is an interdisciplinary introductory level seminar at Cal State University, Dominguez Hills, where students learn about ODEs as a tool to explore compartmental epidemiological models such as SIR, SIRS, SEIR and SIRV. Most of the students in the course are first-generation students who are not majoring in STEM. The aim of this interdisciplinary seminar is to promote achievement, belonging and motivation in STEM, and to decrease fear and anxiety towards STEM. In this course, students learn how to create a diagram representation of the dynamics of an infectious disease, transform it into ODE systems and understand the significance of the elements in an ODE equation. Students also learn how to solve ODE systems numerically with the use of scientific software (mainly MATLAB), and how to graph and interpret both the vector field and the solution of ODE systems.

Author:
Cynthia Sanchez Tapia, *California State University, Dominguez Hills*

From Calculus to Advanced Mathematics: A Study of COVID-19 Cases on a College Campus
9:40 a.m. - 9:55 a.m.
Does college student behavior mimic that of a damped harmonic oscillator? The question arose when examining self-reported COVID-19 student case data that, when graphed by semester, appeared to be sinusoidal with decreasing amplitude.
We describe a sequence of activities undertaken with a science major who had completed only a single semester of Calculus to explore the data, test the hypothesis, and build a mathematical model. We highlight how the study exemplifies project-based learning of differential equations, linear algebra, and numerical mathematics, and present the final results.

Author:
Cara Brooks, *Florida Gulf Coast University*

Models Described Using Differential Equations: First Steps in the Study of Parameter Sensitivity Analysis
10:00 a.m. - 10:15 a.m.
Differential equations are useful tools for modeling a variety of processes in physics, engineering, life sciences, ecology, economics, etc. Making predictions is the primary use of such models. Input variables or parameters can be perturbed and resulting system behavior will be observed. In this talk we will discuss the effect of changes in a model parameters on relevant model outputs. These are the first steps into the realm of parameter sensitivity analysis, and we mostly deal with one-at-a-time local methods. We introduce the concepts of question of interest and sensitivity index. Technology is used for computations and visualizations. Numerical examples are provided.

Authors:
Viktoria Savatorova, *Central Connecticut State University*
Aleksei Talonov, *University of Nevada Las Vegas*

Resources for Faculty and Students in Differential Equations
10:20 a.m. - 10:35 a.m.
We share some resources for faculty and students through communities of practice and tech supports. We present an overview of modules with teaching supports for a car suspension and for EBOLA that are published in SIMIODE. We also give information on SIMIODE's virtual faculty conference, MAA workshops, and an international virtual student contest. We present an overview of a model for cholera with a bacteria reservoir that is published in CODEE's open-access journal. We also show some classroom resources from IODE. Most of the tech supports we show are free.
Authors:
Therese Shelton, *Southwestern University*
Patrice Tiffany, *Manhattan College*
Rosemary Farley, *Manhattan College*

Modeling Labs for a Course on Differential Equations
10:40 a.m. - 10:55 a.m.
We present aspects of a course in ordinary differential equations that was redesigned to incorporate mathematical modeling. The course direction toward modeling began with the adoption of the SIMIODE text, Differential Equations: A Toolbox for Modeling the World, by Kurt Bryan. We then developed a scaffolded sequence of labs implemented at regular intervals throughout the semester intended to train students in construction and analysis of mathematical models using differential equations. In these labs students learn basic principles of modeling, and MATLAB computing skills, that better prepare them for many of the high-quality modeling projects already available in the text and elsewhere. We discuss the planning, implementation, and results of these team-based activities.
Authors:
Ala' Alnaser, *Florida Polytechnic University*
Justin Hoffmeier, *Florida Polytechnic University*

Part B: *Friday, August 4, 1:00 p.m. - 4:35 p.m., Room 106*

Mathematical Derivation and Analysis on Enzyme Kinetics Reaction Using Ordinary Differential Equations
1:00 p.m. - 1:15 p.m.
In my Mathematical Modeling course, I will assign this project for 4-5 students (a group) at the beginning of the semester and ask them to make the oral presentation and to submit the written paper of their results until the end of semester. The project will be introduced under step-by-step guidelines as follow: 1. Derive the system of ODEs to represent a diagram of a chemical reaction using the knowledge of ODEs. 2. Simplify the system under assumptions. 3. Represent the system as the dimensionless system using the nondimensionalized technique. 4. Approximate the nonlinear system near each equilibrium based on the linearization and discuss the stability near each equilibrium. 5. Simulate the nonlinear system numerically using a mathematics software, Maple. Through steps 4 and 5, students can compare behaviors of solutions and interpret the results. This project is an example of developing project-oriented Mathematical Modeling course between mathematics and chemistry.
Author:
Jeong-Mi Yoon,*University of Houston-Downtown*

A study of DE Knowledge Transfer to Engineering Courses: A SUMMIT-P Initiative
1:20 p.m. - 1:35 p.m.
An interdisciplinary team at VCU consisting of mathematics and engineering faculty has worked to improve the knowledge transfer required for the integration of applications in the Differential Equations curriculum. This work is part of the multi-institutional SUMMIT-P initiative which aims to transform first-and second-year mathematics through collaboration with partner disciplines. The collaborative efforts have uncovered a variety of differently presented but identical constructs in categories ranging from notation up through higher-level interpretation. We provide some specific examples and analyses of these constructs and the implications for knowledge transfer and pedagogical concerns. Conversations around mathematics and disciplinary imperatives served to create a holistic view of the role mathematics and partner discipline professors have in improving learning outcomes.
Authors:
Rebecca Segal, *Virginia Commonwealth University*
Laura Ellwein-Fix, *Virginia Commonwealth University*
Afroditi Filippas, *Virginia Commonwealth University*

Exploring ODE phase portraits in Minetest, an open-source voxel game
1:40 p.m. - 1:55 p.m.
Minetest is a free, open-source sandbox game engine that features gameplay similar to Minecraft, and in this talk I will demonstrate how to generate phase portraits of ODE systems in the game's three-dimensional world using MathPlot, a mod that provides in-game mathematical plotting capabilities. The low resolution of the blocky world presents a practical need to apply scalings to equations, which is a natural prelude to important ideas such as non-dimensionalization. Moreover, one can easily observe a chaotic system's sensitivity to perturbations in initial data and the effect of step size in various numerical methods, which can be leveraged to create beautiful structures. Check this out if you're interested in using mathematics to do large-scale construction in a Minecraft-like voxel game!
Author:
Kyle Claassen, *Rose-Hulman Institute of Technology*

Exploring Differential Equations with Interactive Jupyter Notebooks
2:00 p.m. - 2:15 p.m.
I will highlight interactive OER course materials created using Jupyter notebooks. Differential equations provide a rich universe to explore models and train students as mathematical experimentalists. Interactive Jupyter notebooks create a flexible learning environment to bridge the divide between theory and practice. Jupyter is a free, open-source platform that provides instructors and students an environment to weave together narrative text, executable code, visualizations, and videos all in one document. Course materials are delivered in Google Colaboratory, a free, cloud-based application where instructors and students interact with course materials. The flexibility to design materials for a variety of course formats and seamlessly integrate everything into one environment help foster an engaging and fun environment for both students and instructors. Jupyter notebooks help equip students with computational tools to gain further insight and intuition into differential equations.
Author:
Adam Spiegler, *University of Colorado Denver*

Using Interactive Figures to Teach Differential Equations
2:20 p.m. - 2:35 p.m.
The more things stay the same, the more they change. I know this is backward from normal usage, but I think it is true about teaching differential equations. The methods and ideas that I learned in my first differential equations course almost 40 years ago are still the ones that we teach today. But, now we have new tools to help us to teach, and websites and apps were created to give students (and professors) the

ability to create their own graphs. A new addition is interactive figures: figures embedded in the book that can be manipulated by the student (and professor) to illustrate specific points. This talk will demonstrate several interactive figures that have been recently created to accompany Boyce, DiPrima, and Meade (12e), including their usage for in-class demonstrations, individual exploration by students, and as part of homework problems.

Author:
Douglas Meade, *University of South Carolina – Columbia*

Physical Models and Guided Inquiry for Learning Linear Systems of ODE
2:40 p.m. - 2:55 p.m.
Through collaborative guided inquiry activities, students explore simple physical models, trajectories in the phase planes, and finally the linear systems of differential equations that best represent the physical models. After thoroughly exploring the different representations of the models, students work through a guided development of the algorithmic or computational solution procedure and verify that the solutions produced reflect the prescribed behaviors of the physical models. The process of exploring physical and graphical models first allows students to appreciate the mathematical models and solutions. The students also develop the cognitive and affective process skills needed to acquire, interpret, and apply knowledge.

Author:
Chris Oehrlein, *Oklahoma City Community College*

Historical Developments of the Laplace Transform
3:00 p.m. - 3:15 p.m.
The Laplace Transform had a long and convoluted history before it arrived in the form students see in a standard Ordinary Differential Equations course. Indeed, Deakin in 1981 and 1982 identified over 30 well-known mathematicians that made important contributions to its development. While utilizing history and primary sources has pedagogical benefits, this history is much too complex to be of use in the classroom. Here we present a simplified version that traces the history from Euler and Laplace to the modern version, with the most pedagogically useful other contributors singled out. We explain their contributions along with some historical examples, both of which can be used to supplement an ODE course.

Author:
Adam Parker, *Wittenberg University*

A Deeper Dive into Specs Grading in an Ordinary Differential Equations Course
3:20 p.m. - 3:35 p.m.
For the past four years, we have paired specifications-based grading with an Inquiry-based active learning strategy in our Ordinary Differential Equations course. We will discuss the evolution of both strategies, highlight their successes, and discuss strategies for pairing these two approaches. Additionally, we will discuss the challenges we still face in making these strategies more broadly successful for all our students. While many of our students describe our courses in positive terms, are very engaged in the classroom, and express appreciation of the perceived benefits of Active Learning and Specs-based grading, a significant number of students do not seem to objectively benefit from them. We will take a deep dive into the performance of our students to understand how more students can effectively make use of Active Learning and Specs-based grading to be successful in our course.

Authors:
Mami Wentworth, *Wentworth Institute of Technology*
Mel Henriksen, *Wentworth Institute of Technology*

Adding Gamification Elements to a Mathematics Course
3:40 p.m. - 3:55 p.m.

To motivate students and improve their performance, gamification elements have been added to the Differential Equations course. The elements of gamification that were added focus on trying to improve student habits that directly relate to success in the course. The elements used will be described and the results will be presented. A sample syllabus and Moodle shell will also be presented. The gamification elements are totally voluntary, so students do not need to participate. The habits demonstrated by the students in the Spring 2023 course will be compared with the habits exhibited by the students in the Spring 2021 course. The grades for the students who choose to participate will be compared to the grades of the students who choose not to participate. The gamification structure is being introduced in the 2023 course and the 2021 course used the traditional course structure. Both courses used the same grading methods and textbook.

Author:
Nora Strasser, *Friends University*

Modern Pen Pals in ODEs
4:00 p.m. - 4:15 p.m.
One concern we have as educators is whether our students can effectively communicate their mathematics. The Math Pals project addresses that through written, oral, and interpersonal communication. Our ODE classes at our respective universities created video lessons and supporting materials including homework and quizzes with solutions to send to the other university, "pen pal" style. This made our students the expert at their topic giving them an in-depth look at the material and encouraged them to think deeply about the details they needed to convey to an audience who has never seen this material before.

Author:
Nicole Panza, *Francis Marion University*
Amanda Mangum*, Converse University*

Leveraging Outside Partnerships and Authentic Tasks to Develop Quantitative Literacy and Reasoning

Friday, August 4, 8:00 a.m. - 11:15 a.m., Room 120

The beauty of quantitative literacy and reasoning is that it equips students to tackle meaningful challenges in their personal, work, and civic lives. In this session, we invite educators to share how they intentionally consider students' present and future lives in course design. In particular, presenters should share ways they successfully engage with outside partners or incorporate real-world problems.

Organizers:
Kathryn Appenzeller, *The University of Texas at Austin*
Samuel Luke Tunstall, *Trinity University*
Gizem Karaali, *Pomona College*
Catherine Crockett, *Point Loma Nazarene University*

Sponsor:
SIGMAA on Quantitative Literacy (SIGMAA QL)

QR in the Business School: Boosting Student Return on Investment
8:00 a.m. - 8:15 a.m.
Over the last decade, business has remained the most popular major area for American undergraduate students. Those who choose finance and accounting majors typically have strong quantitative skills, while management and marketing majors often lack, or perceive themselves as lacking, such skills. With data-driven decision making becoming increasingly important for management and marketing professionals, business schools face challenges in preparing math averse students for their mathematically intensive work environments. To address this issue, this paper presents direct-engagement partnerships between mathematics educators and business school administrators and faculty. These partnerships aim to develop interventions that improve the quantitative literacy and reasoning skills of business students. By integrating quantitative reasoning into the business curriculum, we hope to equip future managers and marketers with the necessary skills to succeed in a mathematically intensive career.
Authors:
Kenneth M. Sweet, *St. Edward's University*
Kathryn Appenzeller Knowles, *The University of Texas at Austin*

Dear Accountant: Can you tell a story? Improving Quantitative Fluency of Accounting Students through STAR Method
8:20 a.m. - 8:35 a.m.
Despite their proficiency in quantitative literacy, accounting students often struggle with oral communication, impeding their ability to naturally and effectively convey quantitative information and achieve fluency in this domain. Comprising four essential components - Situation, Task, Action, and Result, the 'STAR' method is widely recognized as a highly effective technique for adeptly addressing behavioral interview questions. This paper highlights the potential of the 'STAR' method as a storytelling tool to enhance students' quantitative fluency in client consulting. We outline specific types of oral communication activities that can be effectively implemented in a classroom setting. Through a pre-test and post-test design with separate control and test groups, this study sheds light on the impact of a teaching intervention on the development of students' quantitative fluency.
Authors:
Beu (Eve) Lee, T*exas A&M University - San Antonio*
Ruby Daniels, T*exas A&M University - San Antonio*

Supply Chain Decisions: Do QR Teaching Interventions Improve Student Performance in an Online Simulation?
8:40 a.m. - 8:55 a.m.
Supply chain disruptions caused by the COVID-19 pandemic, natural disasters, semiconductor shortages, and cyber-attacks have dramatically affected the economy, causing significant product shortages and price inflation. The quantitative complexity of supply chains makes it extremely important for business professionals to think critically when making operational decisions. The current study investigated how business students' quantitative reasoning and critical thinking skills changed as they participated in a multi-week online simulation that required students to make a series of real-world supply chain decisions. A control group of students participated in general class lectures and the simulation, while a test group received the same information but also participated in two QR teaching interventions about purchasing and contracts. Data analysis found use of formative QR teaching interventions significantly improved students' ability to make appropriate supply chain decisions.
Authors:
Chin-Yen (Alice) Liu, T*exas A&M University - San Antonio*
Ruby Daniels, T*exas A&M University - San Antonio*

Identifying the Essential Quantitative Skills and Competencies for Safe Nursing Practice
9:00 a.m. - 9:15 a.m.
In 2021, the High-Quality Mathematics Education for Nurses Task Force published seven recommendations for improving quantitative education practices in nursing. Among them is the charge for faculty and communities of interest to engage in structured conversations to "identify the quantitative skills and competencies necessary for quality and safe nursing practice." Beginning in January 2022, as part of the larger statewide work of aligning programs of study with appropriate math pathways, mathematics and nursing faculty across Arkansas formed a working group to address this recommendation. The results of their collaboration were published by the Charles A. Dana Center in September 2022. More recently, a collaborative group of mathematics and nursing faculty have sought to build upon this work and incorporate feedback from educators across the United States. This session will share important findings and implications of these collaborative efforts.
Authors:
Daniel Ozimek, *Pennsylvania College of Health Sciences*
Victor Piercey, *Ferris State University*
Joan Zoellner, *Charles A. Dana Center*

(Cancelled) ~~**Across Discipline Partnerships to address Health Inequities in Quantitative Literacy**~~
~~9:20 a.m. - 9:35 a.m.~~
~~This talk will discuss a module for Quantitative Literacy developed at Michigan State University with funding of an MSU Creating Inclusive Excellence Grant and collaboration with the mathematics department, Fisheries and Wildlife, Center for Instructional Excellence, and MSU Libraries. This goal of this module was highlight health inequities in different populations due to the COVID-19 pandemic. Students used an interactive disease simulation created by Dr. Jen Owens of MSU's Fisheries and Wildlife to investigate virus spread with different parameters. Student also learned about disease spread and read media that highlighted the disparate impacts of the COVID-19 pandemic on populations in the United States. The talk will highlight the cross-unit collaboration, project creation, challenges, student reflection. Also discussed will be how the curriculum will be updated to continue to bring elements of social justice into the classroom with new and relevant topics.~~
~~**Author:**~~
~~Rachael Lund, *Michigan State University*~~

Data Analysis for Social Justice among Underrepresented Groups
9:40 a.m. - 9:55 a.m.
The Data Analysis Research Experience (DARE) Project is an NSF-funded initiative designed to foster positive attitudes toward data analysis and improve students' quantitative reasoning (QR) skills. QR, the contextualized use of data involved in critical thinking, is an essential competency for college graduates. Our approach towards DARE views QR within a social justice lens and seeks to redress the inequalities that have arisen due to underrepresented students' quantitative disadvantages. This is accomplished by establishing a faculty development program (FDP) and a data analysis program. DARE seeks to strengthen students' QR and data analysis skills, interest, and confidence through projects that create a compelling context for the exploration of socially relevant problems. Assessment data indicate that DARE has been effective in improving the quantitative teaching skills of participating faculty and promoting interest and competency in data analysis skills among CUNY students.
Authors:
Esther Wilder, *Lehman College, The City University of New York*
Eduardo Vianna, *LaGuardia Community College*
Caterina Shost, *The Research Foundation of the City University of New York (CUNY)*

Solving Society's Problems By Solving Science & Math Problems
10:00 a.m. - 10:15 a.m.
We describe a partnership between the Towson University Center for STEM Excellence and our graduate program in mathematics education. We share ways in which we have engaged in-service teachers in scientific experiments and quantitative literacy activities to better understand social justice issues. For secondary teachers, we describe and show student work on an activity that uses gel electrophoresis and probabilities in Punnett squares to explain aspects of health justice. For elementary and middle school teachers, we show how an experiment that models the impact of carbon dioxide in the atmosphere to illustrate climate change and help illustrate environmental justice.
Authors:
Mary K. Stapleton, *Towson University Center for STEM Excellence*
Diana Cheng, *Towson University, Department of Mathematics*
Rachael Miles, *Towson University (graduate student in mathematics education)*

Service Learning in a Data Literacy and Visualization Course
10:20 a.m. - 10:35 a.m.
Data Literacy and Visualization is a general-education quantitative-literacy course that features a strong service-learning component. Students first learn how to work with data, including basic statistics and data visualization software. Then they work in groups with a community partner, typically a local non- profit organization that lacks the in-house expertise to analyze derive value from their data. Projects have included analyzing the effects of COVID on homelessness, identification of food deserts and areas with low access to health care, and a geospatial analysis of vacant lots, city park locations and the local tree canopy in order to recommend locations for mini arboretums.
Authors:
Becky Brusky, *University of Nebraska at Omaha*
Betty Love, *University of Nebraska at Omaha*
Michelle Friend, *University of Nebraska at Omaha*
Julie Dierberger, *University of Nebraska at Omaha*
Mahbubul Majumder, *University of Nebraska at Omaha*

Integrating Financial Numeracy in College-level Mathematics: Evidence from Ontario, Canada
10:40 a.m. - 10:55 a.m.
The article discusses the integration of financial numeracy into mathematics courses offered by a sample of nine colleges in Ontario (CA). Financial numeracy involves formal and informal mathematical knowledge in financial contexts. The findings reveal a disparity between formal mathematics courses and numeracy courses. Out of the 797 total mathematics courses identified, 335 were not related to business programs. 265 were formal mathematics courses, providing students with a foundation in mathematical theory, while 70 were numeracy courses, those that promote applications of mathematical concepts in everyday life and make the subject more accessible to students. The study identified that 7 colleges offer courses that expose students to financial numeracy concepts, and 26 of these courses, both formal and numeracy-based, cover a wide range of applications of financial concepts in personal and professional life.
Authors:
Alexandre Cavalcante, *University of Toronto*
Asia Majeed, *University of Toronto*

Teaching Statistical Literacy Using Authentic Tasks
11:00 a.m. - 11:15 a.m.
Today's students are interested in social issues. These usually involve everyday statistics based on observational studies where confounding is a bigger issue than randomness. In Statistical Literacy (UNM

Math 1300) students learn: (1) Association is not causation, disparity is not discrimination. (2) Statistical educators have no expertise on whether a disparity is caused by systemic discrimination. (3) Statistical educators have expertise in showing how disparities can change after taking something into account. Students are given authentic tasks: they explore current social statistics (as presented in tables, graphs and statements) that are classified by gender, race and class. They learn about conditional probability by using ordinary English. They learn the difference between a total and a partial derivative by standardizing a crude association using weighted averages. Students find this focus on authentic tasks involving everyday statistics to be motivating and satisfying.

Author:
Milo Schield, *University of New Mexico*

Mathematical Experiences and Projects in Business, Industry, and Government

Saturday, August 5, 8:00 a.m. - 10:35 a.m., Room 117

The extraordinary growth of complex open-ended problems facing business, industry, and government, along with the flood of available information and data to address these challenges, may seem overwhelming. It should not! As mathematicians, operations research analysts, and engineers, including those within academia who have addressed these issues, we experience and tackle these problems with experience, knowledge, and technological tools. We solve applied mathematics problems in business, industry, and government, including military applications, almost daily. We seek presenters to share their real world applied examples of this type of problem-solving. These talks may include successful mathematical applications or problems where you have no clue how to proceed and are seeking ideas from our audience. Your talks will serve as inspiration to solve and tackle the real challenges that we may face in the future. You do not have to be a BIG SIGMAA member to attend or present.

Organizers:
Vinodh Chellamuthu, *Utah Tech University*
Caroline Maher-Boulis, *Lee University*
Namyong Lee, *Minnesota State University, Mankato*

Sponsor:
SIGMAA on Business, Industry, and Govermment (SIGMAA BIG)

Optimal Meal Selection Strategies to Fight Local Food Insecurity
8:00 a.m. - 8:15 a.m.
Power Packs Project ("PPP") is a non-profit organization that distributes boxes of food and an associated dinner recipe weekly to needy families in three counties in Central Pennsylvania. We know that food from PPP improves students' mental and physical health, but demand for their services is greater than ever. We used mathematical optimization strategies to help PPP select future recipe rotations and food procurement, reducing costs while maximizing nutrition. We created multiple objective functions to quantify the cost and benefits of each recipe: the retail cost, the actual cost to PPP given its discounted supply networks, and the nutritional value. We then carried out integer programming optimization to identify an optimal recipe schedule, and worked with the PPP team to refine the automated results. This

project provided an opportunity to engage undergraduates in applied mathematics research with a clear social impact, and can be replicated in other local communities.

Authors:
Christina Weaver, *Franklin & Marshall College*
Yiqi Ye, *Franklin & Marshall College*
Zehua Liu, *Franklin & Marshall College*

Long-Term Employee Retention from Short-Term Data
8:20 a.m. - 8:35 a.m.
The goal of this project is to utilize short-term start-of-employment data from the IntelyCare platform to identify nurses with the best potential to succeed, providing crucial insight for the company to double down on marketing, retention efforts, and promotions to persuade nurses "on the-margin". With this information, IntelyCare can more accurately target nurses who would have otherwise found employment elsewhere, convincing them to stay on the app. We explore the use of the best machine learning models selected by our algorithmic pipeline to predict whether a nurse will end up in the top 10-20% of shifts completed. We use various early experience variables, such as nurse qualification, shift acceptance, and completion rates to test and train our models.

Author:
Semere Gebresilasie, *Wentworth Institute of Technology*

Building A Community-Engaged Mathematics Learning Experience
8:40 a.m. - 8:55 a.m.
Service-learning uses classroom coursework to address challenges facing communities. Through direct collaboration with community organizations, students develop a sense of civic responsibility while understanding applications for their mathematical skills. This talk will focus on how to implement a service-learning experience within the mathematics curriculum. In particular, we will use the structure of the iPERCED model and focus on: investigating community needs; preparing for the experience; engaging the community and students with meaningful projects; reflecting and connecting; evaluating course outcomes; and demonstrating and celebrating results. The course design aspects which will be discussed were originally developed for a 2019 course supported by the Preparation for Industrial Careers in Mathematics (PICMath) program. A second iteration of this course, taught in 2023, focused specifically on community-engaged learning.

Author:
Jessica Kelly, *Christopher Newport University*

Interdisciplinary Projects: Bridging the Gap between Classroom Learning and Industry Needs
9:00 a.m. - 9:15 a.m.
Interdisciplinary collaboration provides students with an authentic learning experience by allowing them to solve real-world problems from business, industry, or government agencies. This presentation will highlight some projects from Southern Utah businesses, industries, and government agencies, as well as the solutions provided by Utah Tech University students. The presenter will also share how interdisciplinary collaborative projects help students take ownership of classroom knowledge. Additionally, the presentation will discuss the benefits, successes, and challenges of mentoring student teams on applied and authentic projects.

Author:
Vinodh Chellamuthu, *Utah Tech University*

Math in the Workplace: It's Like Sneaking Pulverized Broccoli Into Your Kid's Pizza Sauce
9:20 a.m. - 9:35 a.m.

It'd be so cool if all business challenges could be solved with a protractor or calculator or even just a basic Proposition >> Proof.
Alas, humans. The worst and most unpredictable variable, what with their independent thinking and… emotions. How could a mathematical concept be successfully applied to a business situation that's awash with humans at every turn?
Here's how: By acknowledging that this unpredictable variable is the most predictable component that exists in all business equations. Connecting mathematical terms & theories to real life situations can ascribe meaning to common 21st Century business practices, thereby jointly grounding individuals to become a part of an effective team.
Consider this amateur mathematician's alternate approach to sustainable Organizational Design.
Takeaways include: Gaining inspiration from theoretical math as a process framework.
Real world applied examples of using math concepts successfully in the workplace.
Author:
Kate Ertmann, Kate Loves Math* - katelovesmath.com

Case Study on Industrial Math Projects Arise from Health Science and Energy Industry
9:40 a.m. - 9:55 a.m.
In this presentation, we report on how we found some suitable industrial mathematics projects (or problems) for our students. These projects were proposed by the local health science community and a local energy company, which gave us an active project-based learning environment. We also share how this project-based learning deepens our students' understanding the real world problem-solving. In addition, we report on how our students get motivated to learn more advanced topics in mathematics through these projects.
Author:
Namyong Lee, *Minnesota State University, Mankato*

Expanding Undergraduate Research in Business, Industry, and Government: Evidence-Based Strategies to Make It More Inclusive
10:00 a.m. - 10:15 a.m.
This talk aims to explore evidence-based strategies for expanding undergraduate research (UR) opportunities in business, industry, and government, with a focus on promoting inclusivity and diversity. The author will discuss the benefits of UR for both students and organizations, as well as the challenges faced in increasing access to these opportunities.
For the last seven years, we have developed an innovative and successful model that provides students from underrepresented groups in STEM with an opportunity to perform data-enabled industrial mathematics research by exposing them to problems outside of academia that are mathematical and data-driven in nature. Our study is based on 60 major projects with multiple different companies, businesses, and government labs involving over 170 undergraduate students from 23 universities. In this talk, we will address the evidence-based strategies we learned from these activities, significant outcomes of research projects.
Author:
Mihhail Berezovski, *Embry-Riddle Aeronautical University*

Applying the Explicit Formula for the Mean Square of Dirichlet L-Functions to Prime Power Moduli to Cryptography
10:20 a.m. - 10:35 a.m.
First, we derive an explicit formula for the second moment in the family of Dirichlet L-functions to a prime power modulus. Motohashi derived explicit formulas for the second and fourth moments of the Riemann zeta function along the critical line, and our formula provides the analogue for the second

moment of Dirichlet L-functions. There are many estimates on the power moments for Dirichlet L-functions, but this work does not include an error term.
Second, we will discuss how the explicit formula could potentially be used in conjunction with known uses of L-functions in cryptography. We will discuss potential uses in analyzing the security of cryptosystems. In addition, questions will be posed for future considerations.
Author:
Frank Romascavage III, *Montgomery County Community College*

Mathematical Modeling with Preservice (and In-Service) Teachers

Thursday, August 3, 4:00 p.m. - 5:55 p.m., Room 120

How and when are preservice teachers learning mathematical modeling and then learning how to teach mathematical modeling? This session invites speakers to share examples of modeling experiences and guidance in teaching modeling to future and current teachers. This modeling instruction may be found in teacher preparation courses, mathematics major courses, extracurricular activities, or teacher in-service workshops.

Organizers:
Amanda Beecher, *Ramapo College*
Kayla Blyman, *St. Martin's University*
Blain Patterson, *Virginia Military Institute*
Catherine Paolucci, *University of Florida*

Sponsors:
Consortium for Mathematics and Its Applications (COMAP)
SIGMAA on Mathematical Knowledge for Teaching (SIGMAA MKT)

You CAN build a Simulation!
4:00 p.m. - 4:15 p.m.
Even YOU can build a simulation! During this session, we will build probabilistic models using random number generators. Then we will build Monte Carlo Simulations to examine long run probabilities. Deterministic models are useful but how to add randomness? This session will utilize Excel to build the simulations. Other software packages and programs are more powerful and elegant, but most users have Excel.
Key ideas: Modeling randomness (flipping a coin or rolling a die); building simulations; and Excel functions (conditional formatting, random numbers, locking a cell, count, count-if, etc.)
OUTLINE:

1- Introduction of me
2- Connection of topic to deterministic models
3- Target audience (future students) for this instruction
4- Simulate flipping a coin.
5- Excel Functions
6- Build Monte Carlo Simulation
7- Extend to rolling a die.
8- Questions

Author:
William Farmer, *Culver Academies*

Pre-Service Math Teachers Are Math Majors: Mathematical Modeling Education For Everyone
4:20 p.m. - 4:35 p.m.
Pre-service math teachers are math majors. One of the things that has brought them to yearn to teach is their love of and joy in mathematics. So, one question could be, how and when are mathematics majors learning mathematical modeling? This talk will focus on how Wartburg College builds mathematical modeling into our major for everyone starting in first semester Calculus, extending that to a full course in Mathematical Modeling, and our plan to extend that for our preservice teachers with coaching the MathWorks Math Modeling Challenge.
The talk will share the example of Wartburg College and how we embed modeling early and often into the curriculum of all of our mathematics majors, but particularly our pre-service students. Examples will be shared from the first-year course, the upper-level course, and a brief example from the contest.
Author:
Mariah Birgen, *Wartburg College*

Using Four Big Ideas to Develop Secondary Preservice Teachers' Knowledge about Mathematical Modeling
4:40 p.m. - 4:55 p.m.
Mathematical modeling situates mathematical problem solving squarely in students' day-to- day experiences, and it can broaden students' understanding of how mathematics has a role to play in everyday decision-making. When students model, they bring multiple facets of their identity and their experiences to understand a problem and inform their solution strategy. Thus, it is likely that the modeling process will unfold in different ways for different problems. To help navigate this complexity, rather than focusing on mathematical modeling as a series of steps in a process to complete, we (Arnold et al., 2021) ground our conceptualization of modeling in four big ideas that each illuminate a fundamental aspect of the process of mathematical modeling. In this talk, I will describe these four big ideas, illustrate ways to facilitate secondary preservice teachers' conceptualization of them, and share how preservice teachers reflected on opportunities to teach mathematical modeling.
Author:
Elizabeth Arnold, *Colorado State University*

Mathematical Modeling Teacher Preparation Based on Multiple Experiences
5:00 p.m. - 5:15 p.m.
Mathematical modeling, as an approach to solve problems, requires developing multiple competencies associated with making assumptions, turning an everyday scenario into a workable math question, validating conclusions, and iterating to improve or generalize the model. Because experience in mathematical modeling requires time and practice, and connects to many mathematics concepts, it is helpful to pre-service teachers to be exposed to modeling multiple times in their preparation. This presentation will focus on stand-alone modules that have been developed to be inserted into existing teacher preparation courses. The modules expose pre-service teachers to the modeling process, its connections to other topics, and use reflections and simulations of practice to develop mathematical knowledge for teaching modeling.
Authors:
Cynthia Anhalt, *University of Arizona*
*R*icardo Cortez*, Tulane University*
Brynja Kohler, *Utah State University*

Coupling Mathematical Modeling Professional Development with Community Connection Events
5:20 p.m. - 5:35 p.m.
Coupling mathematical modeling professional development experiences with community connection events creates strong, motivated learning communities centered on local contexts. This report synthesizes themes from reflections and artifacts from such an event. Local in-service teachers, faculty, and preservice teachers participated in the cultural and professional development activities of the Utah State University STEAM Expo on the Blanding Campus, an annual event highlighting Science, Technology, Engineering, Arts, and Mathematics in the rural communities of Southeastern Utah. Results show that incorporating cultural exchange opportunities with relevant modeling contexts corresponds with a strong sense of belonging and connection to the learning community, and high motivation to incorporate mathematical modeling into classrooms. Additionally, participants displayed an interest and willingness to participate in both future professional development and community connection events.
Authors:
Carrie Bala, *Utah State University*
Cynthia Anhalt, *University of Arizona*
Brynja Kohler, *Utah State University*

Bringing Math To Life With Social Justice: Mathematical Modeling with Teachers
5:40 p.m. - 5:55 p.m.
This presentation describes a graduate course in which in-service teachers solved and developed mathematical modeling problems through the lens of social justice mathematics lessons (SJML's) tailored towards the middle and high school levels. The first author mentored teachers first to practice solving SJML's, then use micro-teaching with their peers to create or extend SJML's to meet the needs of their student populations, and then to reflect upon their implementations to build a sustainable way to continue using SJML's in their instructional practices. The results of a pre- and post- survey indicated favorable shifts in teachers' beliefs about their teaching for the purposes of empowering students to consider social justice. From the lens of a facilitator of the professional learning experience, we discuss the sustainability of this approach to helping mathematics teachers teach SJMLs.
Authors:
Diana Cheng, *Towson University*
John Gonzalez, *US Department of Defense*

Problem Creation and Problem Solving
Saturday, August 5, 8:00 a.m. - 11:55 a.m., Room 120

Problem creation and problem solving are fundamental not only in mathematics research, but also in mathematics education and outreach. This area ranges from journals with problem solving sections to competitions (institutional, regional, national, and international). We invite submissions on creating problems and teaching problem solving in co-curricular and classroom settings, such as leading problem-solving clubs and teaching problem-solving classes. We encourage speakers to discuss successful strategies in creating/solving problems and effective ways to address the challenges.

Organizers:
Mohammad K. Azarian, *University of Evansville*
Jeremiah Bartz, *University of North Dakota*

Steven J. Miller, *Williams College*
Chenyang Sun, *Williams College*

Problem Child: Using Problems as a Springboard to Research
8:00 a.m. - 8:15 a.m.
I will discuss my experience with several aspects of problem creation and solution, from serving as the editor of the Pi Mu Epsilon problem section to teaching classes on problem solving to running a math riddles page which is used in schools across the country. The goal of these endeavors is to try to excite students about mathematics in general and give them skills to attack a variety of challenges.
Author:
Steven Miller, *Williams College*

Strategies and Challenges in Creating Original, Interesting, and Publishable Mathematical Problems
8:20 a.m. - 8:35 a.m.
I have published problem proposals in various mathematics journals, and for more than two decades I have solely composed and graded problems for the Annual University of Evansville Undergraduate Mathematics Competitions. Also, for six years I was responsible for the Indiana College Mathematics Competition, sponsored by the Indiana Section of the Mathematical Association of America. In this presentation, I will discuss my strategies as well as the challenges that I faced in creating problems. I will share the satisfaction of creating new, interesting, and publishable problems, as well as the frustrations and disappointments that I have encountered.
Author:
Mohammad K. Azarian, *University of Evansville*
Collaborative Efforts in Mathematical Problem Creation
8:40 a.m. - 8:55 a.m.
The goal of this talk is to illuminate the connection between collaboration and problem creation. We first consider how undergraduates are encouraged to collaborate in order to help them solve a mathematical problem and how this collaboration persists at professional levels. We will then provide examples of famous theorems that had multiple contributors. The problems that are considered come from all mathematical levels, and the solutions that arise out of collaborations to solve these problems frequently lead to the creation of other problems. We end with specific problems, some from mathematics contests, that have been inspired by collaborative research.
Author:
C.J. Lungstrum, *Virginia Tech*

What's Your Problem? Here Are Some of My Favorites
9:00 a.m. - 9:15 a.m.
Have you ever looked at a math competition problem and wondered about more than just the answer? We'll look at a selection of problems I wrote for MATHCOUNTS, how to solve them, and then look at them in a larger context of where they came from and how they found their way to both a middle school contest and a college classroom. Sometimes a small change in wording converts a problem from a quick calculation to an unsolved research question!
Author:
Edward Early, St. Edward's University

From Problem-Solving to Publication
9:20 a.m. - 9:35 a.m.

This talk aims to demonstrate one case study: how problem-solving leads to publication. Beginning with a proposed Monthly problem, we first analyze and link it to a classical problem. After searching for various solutions to the classical problem, we single out one approach with some additional work which solves the Monthly problem. Meanwhile, we also find the used approach reveals the possibility for extension. Combined with some interesting existing results, we end with an acclaimed published paper.
Author:
Hongwei Chen, *Christopher Newport University*

Problems Are Somewhere
9:40 a.m. - 9:55 a.m.
It could be a challenge to create a new and interesting math problem. However, the idea of an interesting new math problem may hide in a casual chat, in a colleague's educational seminar, or in a social media post. In this presentation, the presenter will share the experience of how a couple of published math problems were created.
Author:
Hong Biao Zeng, *Fort Hays State University*

A Student-Faculty Problem Solving Group at a Multi-Campus Institution
10:00 a.m. - 10:15 a.m.
In this talk we discuss a brief history of a student-faculty problem solving group, the Eagle Problem Solvers. We discuss the challenges and opportunities of working together across multiple campuses at our institution. We highlight some of our favorite problems, including those whose extensions have led to fruitful research opportunities.
Authors:
James Brawner, *Georgia Southern University*
Samuel Aguilar, *Georgia Southern University*

Strategies for Problem Posing
10:20 a.m. - 10:35 a.m.
Posing challenge problems is a creative process. In this talk, several strategies for developing and creating interesting and inviting problems are discussed. Examples are presented to demonstrate the various strategies.
Author:
Jeremiah Bartz, *University of North Dakota*

Calculus Betting Games: Higher Order Thinking Projects
10:40 a.m. - 10:55 a.m.
We describe a calculus project involving evaluation cognitive skills, designed to motivate first year Calculus students into learning and thinking about some of the concepts of this discipline.
Authors:
Katiuscia Teixeira, *University of Central Florida*
Eduardo Teixeira, *University of Central Florida*

Mathematical Modeling Contests and Club for College Students
11:00 a.m. - 11:15 a.m.
From 2013-2019, the UW-Platteville Mathematics Department has had a successfully organized mathematical modeling contest for UW-Platteville students. Students who have participated in the UW-Platteville contest have also participated in regional and international modeling competitions. I will talk about UW-Platteville mathematical modeling contest, how we created our more popular and successful problems for this competition, and how the contest led to organizing the mathematical modeling club.

Moreover, I will discuss how we lead problem solving sessions during the UW-Platteville Mathematical Modeling club meetings, and the future plans for our contest.
Author:
Leonida Ljumanovic, *University of Wisconsin – Platteville*

Fostering Inner Creativity: The Benefits and Challenges of Encouraging Student-led Projects Based on Class Curriculum
11:20 a.m. - 11:35 a.m.
The purpose of the talk is to present the significance of projects that involve students utilizing their own ideas following exposure to the class curriculum. The students' ideas are indicative of their creativity, authenticity, diversity, and the quality of their cognitive processes. This pedagogical approach was applied in various classes throughout the semester, resulting in the development of students' inner creativity. The talk will discuss the benefits, challenges, and rationale behind this approach, as well as its impact on the students' learning process in an authentic learning environment. Additionally, the talk will showcase some exemplary projects that were created by the students as a final group project, emphasizing the need for building a collaborative environment within the classroom.
Author:
Md Sazib Hasan, *Utah Tech University*

Writing Effective International Modeling Contest Problems for MCM/ICM
11:40 a.m. - 11:55 a.m.
The Mathematical Contest in Modeling (MCM) and Interdisciplinary Contest in Modeling (ICM) is an international mathematical modeling challenge sponsored by COMAP that has teams of 3 students select one of 6 open-ended problems to solve and write up their results in a 25-page paper during the 4 days of the contest. The purpose of the contests is to challenge teams of students to clarify, analyze, and propose solutions to open-ended.
Authors:
Amanda Beecher, *Ramapo College of New Jersey*
Kayla Blyman, *Saint Martin's University*

Mathematics and the Life Sciences: Initiatives, Programs, Curricula
Thursday, August 3, 5:00 p.m. - 5:55 p.m., Room 117

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. Presentation 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.

Organizers:
Timothy Comar, *Benedictine University*
Raina Robeva, *Randolph-Macon College*
Carrie Diaz Eaton, *Bates College*

Sponsor:
SIGMAA on Mathematical and Computational Biology (SIGMAA BIO)

Connecting Mathematics with Chemistry: An Interdisciplinary Curricular Initiative Involving Faculty and Students
5:00 p.m. - 5:15 p.m.
With support of an NSF S-STEM grant, we have formed an interdisciplinary group of mathematics and chemistry faculty and students at Saint Michael's College to explore relationships between the two disciplines. As one facet of our work, we have created pedagogical enhancements for our undergraduate mathematics (especially calculus) and chemistry (including general and physical chemistry) courses to illuminate interdisciplinary links. In this talk, we will highlight some of broader initiative components and detail some activities and enrichment that we have been creating for our undergraduate courses.
Authors:
George Ashine, *Saint Michael's College*
Bret Findley, *Saint Michael's College*
Mitchell Andrea, *University of Connecticut School of Dental Medicine*
Dylan Wawruck, *New Chapter Inc.*

Introductory Student Research Projects In Mathematical Biology
5:20 p.m. - 5:35 p.m.
This presentation will discuss some ongoing student research projects in mathematical biology initially designed for students with only introductory experience in mathematics and no prior experience in mathematical biology. The projects are based on the development and analysis simple ecological models or vaccination models. The modeling frameworks included agent-based models and impulsive differential equations. We will discuss how the students begin to explore problems and then progressively learn to ask and investigate further questions.
Author:
Timothy Comar, *Benedictine University*

Fascination with Fluctuation: Luria and Delbrück's Legacy in Mathematics
5:40 p.m. - 5:55 p.m.
When does evolution occur? Jean-Baptiste Lamarck proposed that organisms adapt in response to environmental stimuli, passing the changes on to their offspring. Charles Darwin asserted that changes occur independently of the environment but only organisms with variations that provide competitive advantage survive. Remarkably, the dispute was settled by a mathematical argument in 1943 by biologist Salvador Luria and physicist Max Delbr\"uck and has generated a considerable amount of mathematical literature since. In celebration of the 80th anniversary of their seminal publication, the talk outlines the original Luria-Delbr\"uck work and presents ideas for inclusion in various mathematics courses. The Luria- Delbr\"uck fluctuation test can also be used to initiate student research projects and as a bridge to graduate-level work on topics involving branching processes, infinitely divisible distributions, limit theorems, asymptotic behavior, and stable measures.
Authors:
Raina Robeva, *Randolph-Macon College*
John Jungck, *University of Delaware*

My Biggest Teaching Flop
Friday, August 4, 9:35 a.m. - 10:30 a.m., Room 121

Teaching math is hard. In this session, we will learn from our mistakes and become better teachers by investigating what *hasn't* worked. Each presentation will describe a time that a

pedagogical strategy was employed but did not have the expected results, with a reflection on possible causes for this dissonance. We'll explore the limitations of teaching strategies and which factors influence their success.

Organizers:
Erin Griesenaur, *Eckerd College*
Russ Goodman, *Central College*
Allen Harbaugh-Schattenkirk, *Longwood University*

Inquiry Learning and Change of Variables
9:35 a.m. - 9:50 a.m.
In the Fall semester of 2022, I had prepared a lesson I was very proud of for change of variables in Multivariable Calculus. This took the form of a series of activities in a team based inquiry learning style scaffolded exploration. What was meant to be a quick and intuitive explanation justifying the Jacobian and change of variables turned out to be the opposite, both sowing confusion and taking an inordinate amount of time. In this talk, I explain the activity, the sources of confusion, and give an autopsy of what in my estimation went wrong, and how I avoided it in the Spring semester.
Author:
Tien Chih, *Oxford College of Emory University*

A Spectacular Teaching Failure in an Upper-Level Probability Course
9:55 a.m. - 10:10 a.m.
My most extreme failure as an educator occurred in my Spring 2015 section of a 300-level probability course. The class was an embarrassing parade of basic teaching errors, although those mistakes became clear only in hindsight. I implemented a new (to me) teaching strategy of delivering course content only through assigned readings from a textbook, and class time was dedicated solely to answering student questions over that reading. This strategy failed for a variety of reasons. In this talk I discuss the lessons I learned from this experience, including (but not limited to): don't implement a new teaching method the first time you teach a course, don't bow to institutional-level pressure from administration when selecting a teaching method, and don't be innovative just for the sake of it.
Author:
David McCune, *William Jewell College*

Too Many Great Ideas at Once
10:15 a.m. - 10:30 a.m.
With over 30 years of teaching experience, there have been numerous times when I had what seemed like a great idea, but it took too much time for me to effectively implement. This hit the hardest in fall 2020 when I attempted to use every idea, I had ever heard about teaching in a hybrid setting all at once (going against my own advice to new faculty in Project NExT). It involved implementing a fully flipped setting for all my classes, complete with videos and a plethora of written feedback from me for students. It was more than I could possibly do, and my students struggled from my lack of feedback. I was able to move forward by gathering advice from colleagues both locally and across the country and rethinking my approach. After working through my struggles, I found ways to better structure my classes and to be more efficient with feedback while still providing students with the resources they needed.
Author:
Julie Barnes, *Western Carolina University*

Improving DEI in Departments and Programs: Examples and Case Studies

Thursday, August 3, 8:00 a.m. - 10:35 a.m., Room 120

Given the role of mathematical sciences in educating essentially all students who enter higher education and its status as a significant impediment to retention and college completion, colleges and universities will never fully improve diversity, equity, and inclusion (DEI) unless they are addressed in mathematics and statistics. In this session, presenters will discuss policies and practices that have been successful at building diverse and inclusive environments.

Organizers:
Michael Dorff, Transforming Post-Secondary Education in Mathematicis (*TPSE Math) and Brigham Young University*
Abbe Herzig, Transforming Post-Secondary Education in Mathematicis (*TPSE Math)*

Sponsor:
Transforming Post-Secondary Education in Mathematicis (*TPSE Math)*

Metamorphosis of Education: How Cross-Cultural Communication and Inter-Humanism Close the Achievement Gap
8:00 a.m. - 8:15 a.m.
Description: The U.S. NAEP Data for 2022 showed that there was a decline in math proficiency for students across the nation. Further, millions of students fail to complete school, causing them to drop out of college. Given these findings, educators and leaders must find ways to bridge the achievement gap. Reports from the National Report Card and National Center of Education Statistics have shown that there has been a cultural disconnect, with eighty percent of educators being Caucasian, needing support when serving 70 percent of learners of diverse ethnic descents. There has been a need for engagement in the classroom and a need for teachers to have options for how to bridge the gap. Through providing a pathway for how learners can communicate with their teachers and peers, students will have a greater opportunity to take a risk at learning and contributing in the math classroom.
Author:
India White, *Coauthor- Big Ideas Learning/National Geographic Learning*

What I Learned about Teaching Math from Completing a [not-math] Graduate Degree
8:20 a.m. - 8:35 a.m.
In the past four years, I started and completed an Ed.D. degree modeled after the Carnegie Project on the Educational Doctorate (CPED). Among CPED's goals are equity, ethics, and social justice for our students. I entered the program as a mathematician who teaches at a community college and viewed the program from a mathematician's lens. The competencies I developed were implemented in my teaching. Specific developments include syllabus language and written communications (especially in online courses) and their effects on students' comfort in seeking extra help, formative assessment development that fills gaps in prior mathematics knowledge in such a way that students are encouraged to develop their skills, and program development (particularly co-requisite math courses and undergraduate research courses) that narrow inequity gaps. Parallel findings in research in mathematics education and non-mathematics educational leadership will be highlighted and explored in context.
Author:
Jonathan Weisbrod, *Rowan College at Burlington County*

Modifying Placement Practices and Programming to Promote Access to STEM Coursework
8:40 a.m. - 8:55 a.m.
With students of increasingly diverse mathematics backgrounds entering our institutions, a challenge at many small universities is providing ample course offerings that provide STEM-intending students with an on-ramp to Pre-Calculus and Calculus I. Meeting students where they are–and not just where we want them to be–is an important part of making our mathematics courses more inclusive of students with diverse schooling backgrounds. Over the past three years at Trinity University, we have worked to design a mathematics placement process that ensures all students can start out in the course that they want to (i.e., Pre-Calculus or Calculus I). In this presentation, I will discuss the new course we have created–MATH 1100 (or Math Skills Workshop)–that students can take for free over the summer, including challenges and successes we have had so far. I will also welcome feedback and comments from attendees.
Author:
Luke Tunstall, *Trinity University*

Applying Calculus with Culturally Relevant Pedagogies
9:00 a.m. - 9:15 a.m.
Mathematics departments typically offer numerous sections of an introductory course in Applied Calculus, also called Business Calculus. Students completing this course come from a variety of majors representing differing levels of interest and preparedness to engage with course content. Meeting diverse learning needs of these students is no easy feat. A promising approach to creating inclusive and engaging environments is implementing culturally relevant pedagogies.
Presentation attendees will learn about a curriculum revision project undertaken by a team of six mathematics faculty. To support this work, our team completed professional development on culturally relevant pedagogies, gathered data from students regarding learning approaches and problem-solving contexts relevant to their lives, and used what we learned to create a more culturally relevant curriculum. Attendees will acquire actionable strategies for revising mathematics curricula with culturally relevant pedagogies.
Authors:
Aaron Trocki, *Elon University*
Brittany Riggs, *Elon University*
Larry Cantwell, *Elon University*
Emily Elrod, *Elon University*
Dan Flores, *Elon University*

Students' Perspectives about Learning and Relevance of Calculus
9:20 a.m. - 9:35 a.m.
In this quantitative research, we study students' perspectives about learning mathematics through problem solving and the relevance of mathematics to their professional career. We analyzed data from surveys completed by a group of students enrolled in calculus I, II, or III at a midwestern research university. The demographic data in the surveys allowed us to conduct correlational analysis to visualize patterns in the data when acknowledging specific minoritized and non-minoritized groups in STEM. This study is significant because calculus has a very strong relationship with the retention in STEM programs, which has been disproportional between minority and non-minority groups. Discussions of this presentation have implications for innovating calculus pedagogies acknowledging students' insights about teaching and learning.
Authors:
Kevin Palencia Infante, *Northern Illinois University*
Ricela Feliciano-Semidei, *Northern Illinois University*
Alcibiades Bustillo Zarate, *University of Puerto Rico - Mayagüez Campus*

DEI Initiatives in the Calculus Sequence and School of Science at Monmouth University
9:40 a.m. - 9:55 a.m.
In this talk, we will discuss the initiatives being taken to promote equity and improve retention in the School of Science at Monmouth University. In particular, two instances will be discussed: first, the initiatives taken by the present author (inspired by the work of Bryan Dewsbury and others) to revamping Monmouth's calculus sequence; and second, the initiatives taken by the School of Science DEI Committee (of which the present author is a founding member) to foster school-wide growth amongst the faculty in the areas of diversity, equity, and inclusion.
Author:
Torrey Gallagher, *Monmouth University*

Improving the Mathematics Major by Developing a Community at Critical Transition Points
10:00 a.m. - 10:15 a.m.
The pandemic cut many of the ties between students, making challenging courses even more so. Two courses, Elementary Linear Algebra and Introduction to Abstract Mathematics, have been identified as critical transition points in our mathematics major because there are substantial differences in graduation rate as a mathematics major depending on the grade the student earns in those courses. To help students at this critical point, we are taking a peer-led teaching and learning approach. For the last four semesters, we have offered sessions we call “Prime Time”. Preliminary results from our evaluation of the effectiveness of Prime Time have shown that these sessions are rebuilding a sense of community for mathematics majors that was damaged by the pandemic; that Prime Time attendees are more diverse than our major as a whole; that students who attend Prime Time sessions have found them to be supportive; and that there is weak evidence that course grades are improving.
Authors:
Mike O'Leary, *Towson University*
Alexei Kolesnikov, *Towson University*
Vince Guingona, *Towson University*
Christopher Cornwell, *Towson University*

Common Threads: Cultivating Community through DEIB Work
10:20 a.m. - 10:35 a.m.
This presentation details how a mathematics and computer science department at a small liberal arts college is engaging in collective work on diversity, equity, inclusion and belonging (DEIB). It describes manageable, cost-neutral actions faculty and students can take to initiate or extend efforts at their own institutions. The talk offers a multi-faceted approach to promote DEIB that involves small changes in several quarters. Categories of emphasis include faculty and staff education and actions, centering student voices and their initiatives, making structural and systemic changes, reconfiguring physical space, engaging partners in the local community, and reframing course offerings, syllabi, and content. Positioning DEIB as a site of broad collaboration is helping us reimagine and rebuild a department community that fractured during the pandemic. A notable outcome is how navigating fraught and challenging issues is moving us toward a shared responsibility for effecting change.
Author:
Linda McGuire, *Muhlenberg College*

MathArt: Classic and Novel Intersections of Mathematics and the Arts
Friday, August 4, 2:00 p.m. - 5:55 p.m., Room 120

MathArt is a dynamic and emerging interdisciplinary field whose aim is to amplify the variations in mathematical thinking. This amplification occurs by opening a dual conversation about what makes a mathematical result 'beautiful' and/or what mathematics and creativity have in common. We welcome presentations investigating the intersections of mathematics and the arts and their engagements in any pedagogical setting. Some speakers may share their mathematical research or classroom experiences in more traditional pairings, such as with studio art or the performing arts. Others may present particularly 'beautiful' mathematics, perhaps taking the form of elegant proofs, visualizations created through programming, or new perspectives on existing results.
All interpretations of mathematics and the arts, including the physical and the conceptual, are welcome. We especially encourage undergraduate and graduate students to participate.
This session is sponsored by the Association for Women in Mathematics.

Organizers:
Janet Fierson, *La Salle University*
Shanna Dobson, *California State University, Los Angeles*
Emelie Kenney, *Siena College*
Buna Sambandham, *Utah Tech University*
Jeanette Shakalli, *Panamanian Foundation for the Promotion of Mathematics (FUNDAPROMAT)*

Sponsor:
Association for Women in Mathematics (AWM)

The Mathematics of Dance Notation
2:00 p.m. - 2:15 p.m.
Dance notation is to a dancer as written music is to a musician. Musical notation is well-known and widely understood, whereas dance notation is less so; the key distinction between the two being that one is discrete while the other is continuous. In this talk, we will take a look at a specific dance notation called Labanotation and some of the mathematics behind it. In particular, we will use combinatorics to see the overwhelming number of dances that can be recorded with just a subset of Labanotation positions. We will also discuss the algebraic structure of words formed from Labanotation positions.
Author:
Jessie Hamm, *Winthrop University*

Combining Math, Origami, and Technology to Construct Art Designs
2:20 p.m. - 2:35 p.m.
The project that will be described in this presentation shows how math can be used to combine the ancient Origami art and powerful technology in developing interesting and eye-catching art designs. It will reveal the math which is both hidden behind the amazing Origami folds as well as used in geometric constructions with GeoGebra.
This project has been used in various STEM outreach events with high school students, but can also be used in a variety of undergraduate classes, especially the ones that require use of technology and integration with other disciplines, including liberal-art math classes, classes where conic sections are taught, geometry, etc. The main goal of this project is to demonstrate to students the integration of math, art, and technology in developing some amazing art designs.
Author:
Violeta Vasilevska, *Utah Valley University*

Homotopy in Battle Royale Video Games
2:40 p.m. - 2:55 p.m.
Many modern Battle Royale video games such as Fortnite, PUBG: Battlegrounds, and Apex Legends use straight line homotopies to confine players into late game disk-shaped regions. The author discusses a modification to the standard model by introducing "pinch zones," where a random sector of the disk closes in faster or slower than the others. These sector-pinching homotopies will be presented as visualizations that were programmed in SageMath.
Author:
Jared Bunn, *Florida Polytechnic University*

Sequentially Congruent Partitions
3:00 p.m. - 3:15 p.m.
This talk stems from an undergraduate research project on integer partitions, finite sums of positive integers that make deep connections in algebra, analysis and combinatorics. In our project we discovered an interesting class of partitions, the parts (summands) of which obey a strict congruence condition we refer to as "sequential congruence": the mth part is congruent to the $(m + 1)$th part modulo m, with the smallest part congruent to zero modulo the length of the partition. Sequentially congruent partitions appear in partition theory in two surprising ways. In the initial 2019 paper on the subject, undergraduate M. Schneider and the speaker prove the number of sequentially congruent partitions with largest part equal to n, is equal to the partition function $p(n)$. In a follow-up 2021 paper, Sellers, Wagner and the speaker prove the number of sequentially partitions of size n (sum of parts), is equal to the number of partitions of size n whose parts are perfect squares.
Authors:
Robert Schneider, *Michigan Technological University*
Maxwell Schneider, *University of Georgia*
James Sellers, *University of Minnesota Duluth*
Ian Wagner, *Boston Consulting Group*

Extension of Fundamental Transversals and Euler's Polyhedron Theorem
3:20 p.m. - 3:35 p.m.
In 1752 Euler discovered that the number of vertices minus the number of edges plus the number of faces of a convex polyhedron is always equal to 2. This is known as Euler's Polyhedral Formula, or sometimes Euler's Polyhedron Formula. Polyhedra plays an important aspect in many fields of Mathematics, especially in Geometry. During the birth of group theory, symmetry manufactured most of the development of symmetry groups, permutation groups, and automorphism groups of Polyhedra. The concept of an orbit of an element of a polyhedron further developed into the creation of what is called a fundamental transversal. A fundamental transversal of a polyhedron intersects each element and induces a connected sub graph of the polyhedron. Meaning that each element that is intersected is a representative of the orbit that they belong to. We are interested in investigating the number of orbits that a fundamental transversal has on a given polyhedron. In this talk we will present a new extension of Euler's polyhedron formula to provide different classifications of Polyhedra according to their Euler orbit characteristics. An Euler Orbit Characteristic (EOC) is the number of orbits of vertices (#Vg) minus the number of orbits of edges (#Eg) plus the number of orbits of faces (#Fg) of a polyhedron. We will provide three different cases of an EOC to show its usefulness in cataloging various types of Polyhedra.
Author:
Joy D'Andrea, *University of South Florida Sarasota – Manatee*

The Art-Math of Cubic Polynomials and Polynomiography
3:40 p.m. - 3:55 p.m.

Significant mathematical discoveries have resulted from the study of cubic polynomials the most famous of which is Cardano's formula and complex numbers.
However, there is more to cubic polynomials than meets the eye. On the one hand, classic and novel iterative algorithms can approximate the roots of cubic equations in a more efficient manner than using Cardano's formula. On the other hand, visualization of these algorithms, called polynomiography, leads to images that lie in the realm of art and design, some of which resemble natural patterns. Geometric problems related to cubic polynomials too can result in other artistic expressions. In summary, the study of cubic polynomials provides a convenient two-way bridge between art and math. On the one hand, it leads to tools in art and design. On the other hand, it provides a format for learning and teaching sophisticated mathematics and algorithms. Numerous related interdisciplinary art-math projects can be developed.
Author:
Bahman Kalantari, *Rutgers University*

The Algebra of Tuning Theory
4:00 p.m. - 4:15 p.m.
Musical tuning theory and analysis of various scales will be discussed using concepts from abstract algebra. In particular, we discuss N-tone equal temperament, Pythagorean and higher-limit just-intonation scales, commas and tempering, and perception of harmonic consonance and the relationship of these topics to mathematical ideas including equivalence classes, rational versus irrational frequency relationships, group theory, lattices, and the geometry/topology of musical pitch space.
Author:
Shaun Ault,*Valdosta State University*

Geometry for the Artist: A General Education Course
4:20 p.m. - 4:35 p.m.
Geometry and art have been inseparable everywhere in the world throughout history and there is no reason to teach them separately. The mathematics course Geometry for the Artist at Maharishi International University is a general education course that teaches geometry and its applications in art. Topics in the course include symmetry, perspective, fractals, Euclidean and non-Euclidean geometries, and topology—all with applications in the arts. This paper describes the course and gives examples of applications and student activities.
Author:
Catherine Gorini, *Maharishi International University*

A Recycling Educational Class Project, Flavored with Arts and Mathematics
4:40 p.m. - 4:55 p.m.
A framed graph is a planar graph whose outer face is a rectangle, where a connected planar subgraph is attached inside the rectangle. An equivalence relation is defined on a certain class of face colored framed graphs. The class project is to create an art work (2 or three dimensional) by colorful recycled plastics, and also to design a framed planar triangulation (one may replace a triangulation by a grid or by any other polygonal configuration) that is equivalent to the original art work. The plane triangulation presents a colorful geometric figure that somehow represents the coloring beauty of the original art work. This project has been assigned in a class, taken by life science and humanity students, as a plastic recycling educational assignment that is a dilemma here in Puerto Rico, as it is in the most countries. We first highlight a few plastic recycling facts in the Island and then present some experimental results of our class project.
Author:
M. Reza Emamy-K., *University of Puerto Rico Rio Piedras*

Straightening the Ability to Visualize in Undergraduate Matheratics Courses using Drawing-to-Learn Framework
5:00 p.m. - 5:15 p.m.
Spatial ability has been identified as a crucial factor in development of experience in STEM fields. In this presentation we will propose a framework for incorporating drawing-to-learn strategies in undergraduate mathematics and argue that drawing can serve as a valuable tool for model-based reasoning, complementing formal analytic approaches and providing means to predict and guide formal arguments. We provide examples of how drawing activities can be integrated into some undergraduate mathematics courses, and we draw on existing research to support the effectiveness of drawing-to-learn methods. Our aim is to encourage educators to consider drawing in mathematics education and to provide practical guidance for integrating drawing into some undergraduate courses. By promoting the use of drawing as a means of visualizing mathematical concepts, we hope to help students develop their spatial ability and formal reasoning skills necessary to succeed in STEM fields.
Author:
Mile Krajcevski, *University of South Florida*

The Intersection of Arts and Mathematics Cognition
5:20 p.m. - 5:35 p.m.
This work examines the potential of using the Pirie-Kieren (P-K) framework to explore the development of mathematics understanding and art appreciation when engaging in an action-based embodied cognition task involving the Fibonacci spiral and the wood-block print, The Great Wave of Kanagawa. Task-based interviews were conducted with four pairs of pre-calculus students. Qualitative inductive analysis revealed how the P-K framework is useful in unpacking the math and visual-rich aspects of cognition. The implications of this work include designing mathematical learning experiences that integrate artwork storytelling, and action-based embodied cognition tasks to support students' entering mathematical formalizing when abstracting mathematical concepts. Future work may investigate the electrical brain waves when engaging in such mathematics learning experiences to develop new interventions and instructional strategies to support the potential integration of arts and mathematics.
Author:
Tuto Lopez Gonzalez, *San Francisco State University*

Creativity in Writing Calculus Exams
5:40 p.m. - 5:55 p.m.
I will describe the different ways I incorporate creativity and art in the calculus exams I write, with specific examples. I incorporate creativity not only visually in the aesthetics of the exam and layout, but in the problems and theme of the exam.
Author:
Felicia Tabing, *University of Southern California*

My Favorite Adapted Math Circle Topic
Saturday, August 5, 8:00 a.m. - 10:55 p.m., Room 121

Math circle leaders are always on the hunt for new session topics. In this session, presenters will share math circle topics that they have adapted from other contexts. Examples may include adapting a journal article into a session, or running a session based on contest problems. Presenters will share the key details of their session topics as well as their process for adapting the materials to be appropriate for a math circle.

Organizers:
Tom Clark, *Dordt University*
Gabriella Pinter, *University of Wisconsin Milwaukee*

Sponsor:
SIGMAA on Math Circles for Students and Teachers (SIGMAA MCST)

Math Photo Album: Math Experiments and Math Posters
8:00 a.m. - 8:15 a.m.
You will see many examples of mathematics experiments, mathematics photos, and mathematics posters. This is a publisher accepted math book "Math Photo Album: Math Experiments and Math Posters" project. Mathematics concepts will cover K5- K12. Check out my TED x Talk for a beginner level introduction.
Author:
Havva Malone, *Rolla High School*

A Fox and a Sock Introduce Group Theory
8:20 a.m. - 8:35 a.m.
Introductory group theory provides an excellent source of material for younger students to explore abstract mathematical thinking and can be a great starting place for a Math Circle Session. In this talk I'll discuss how I used a stuffed fox and a sock to introduce some introductory groups theory concepts while helping with the Eugene Math Circle and some of the motivating ideas I tried to capture when crafting this activity. I'll also share some of the ways these concrete tools helped students gain faster access to deeper mathematical ideas and created a student-centered language for students to explore their own group theory related questions.
Author:
Jeffrey Musyt, *Slippery Rock University*

Lights Out! - Dimensions
8:40 a.m. - 8:55 a.m.
In Lights Out, you start with a graph with lights at the vertices that are either on or off connected by wires which are the edges. When you "press" a vertex, the light itself does not change, but every light connected to it by wires changes its state - if it was on before, it is now off, and vice versa. Your goal is to either turn every light off or determine that it is impossible to turn all of them off.
Schwinghamer, Peters, and Cathain found that given an arrangement of lights, the game of Lights Out can be won on that arrangement from any starting number of lights on or off if and only if the adjacency matrix of the arrangement has an inverse over Z_2. In our Math Circle activity, we look at this from a discovery point of view. We begin by playing on simple cycle graphs, then continue on to the graph of the cube to determine that every problem in this arrangement has a solution. We then extend to the graph of the hypercube to determine when a solution exists to our game.
Authors:
John Weeks, *Texas A&M University*
Philip Yasskin, *Texas A&M University*
Kyle Murphy, *Texas A&M University*

Exploring Continued Fractions
9:00 a.m. - 9:15 a.m.

From my earliest days as an instructor and admirer of math contests like the Nevada Prize Exam put on by the late Dr. Don Pfaff annually for Nevada's High School students for over 50 consecutive years, I remember appreciating the beauty of problems which in essence ask an algebra student (with no calculus background or knowledge of limits) to actually compute a limit by converting an infinite continued fraction into a simple quadratic equation. Later I learned how amazing finite continued fractions can be in approximating famous irrational numbers with relatively small denominators. There is so much mystery and beauty there: The geometry inspired by the Euclidean algorithm, The Fibonacci numbers for capturing complexity, and if you have ever wondered about the infinite decimal expansion of π, then think, admire, and ponder all over again about π's infinite continued fraction!

Author:
Edward C Keppelmann, *University of Nevada – Reno*

The Stick Figures Mystery
9:20 a.m. - 9:35 a.m.
As mathematicians, we see math as a living and breathing subject, involving the upper levels of the Bloom's Taxonomy: create, evaluate, analyze, apply, and understand. However, to most people, mathematics just means crunching numbers, remembering methods and following rules – the lowermost levels of Bloom's taxonomy. This is perhaps why even though learning mathematics is not as difficult as learning music or playing a sport, math does not invoke a similar enthusiasm and zeal. Math circles provide an opportunity for us to share our joy of mathematics by discussing interdisciplinary topics that expose the beauty, elegance and value of mathematics within and beyond the classroom. In this presentation we will share some problems from classical mathematics, including a Sherlock Holmes mystery story that can be used in math circles.

Author:
Manmohan Kaur, *Benedictine University*

Functions Come to Life
9:40 a.m. - 9:55 a.m.
Imagine a world where functions are not confined to a blackboard, but come to life as magical beings! Such a world is described in the book Funville Adventures by Fradkin and Bishop - there, each inhabitant has a special power to transform objects.
We adapted the stories from Funville Adventures into a math circle session that introduces students to the concept of functions and related topics such as domain, commutativity, and invertibility, in an intuitive and engaging way.
The circle session is centered around activities based in the world of Funville, where children are introduced to various function characters and solve "who-done-it" style puzzles. Can we figure out the order in which functions were applied to an object? If so, the function is commutative. Can we reverse what we just did to an object? If our actions can be undone, the function has invertibility. Finally, students are guided through some hands-on problem-solving scenarios to help solidify this kind of reasoning.

Authors:
Sasha Fradkin, *Main Line Classical Academy*
Tatiana Ter-Saakov, *Main Line Classical Academy*

A Recipe to Infinity
10:00 a.m. - 10:15 a.m.
This topic was adapted not from a journal article or a contest problem, but from a dinner recipe! Dividing the recipe led to a "need" to measure 1/3 of a teaspoon, but all my measuring spoons were powers of 1/2 (from 1/2 to 1/64!), so I asked my children what we should do. Out came the graph paper, and soon we were summing infinite geometric series. Besides switching from a savory side dish to a sweet snack recipe, adapting the activity for a math circle has involved designing a sequential structure, and eventually

creating 2-D manipulatives for hands-on exploration. Over the last decade, it has been modified for middle school, upper elementary and lower elementary math circles. All will be described in detail.
Author:
Skona Brittain, *Santa Barbara Math Ellipse*

Hyperbolic Soccerballs
10:20 a.m. - 10:35 a.m.
The activity Hyperbolic Soccerballs was originally developed while teaching non-Euclidean geometry to future secondary teachers, providing a tactile activity to experience features of the hyperbolic plane. Students build a charismatic model of the hyperbolic plane, and then investigate lines, parallel lines, and triangles on it. This turned out to also be a popular activity for a math circle, and I have used it successfully over two dozen times with audiences from middle school to college, including several different courses.
Author:
Frank Sottile, *Texas A&M University*

Crossing the Desert with Mathematics
10:40 a.m. - 10:55 a.m.
Crossing a desert in a jeep is difficult work, but planning the locations of supply caches along the route leads to an interesting mathematical problem that doesn't require a trip to the Sahara. This setting is perfect for a math circle because there are multiple ways to investigate the problem and many ways to generalize as well depending on the level of the participants. We will share some of the original papers that inspired this topic of investigation as well as necessary adaptations to increase accessibility and put inquiry at the center.
Author:
Thomas Clark, *Dordt University*

Recreational Mathematics: Puzzles, Card Tricks, Games, and Gambling
Saturday, August 5, 3:00 p.m. - 5:55 p.m., Room 120

Puzzles, card tricks, board games, game shows, and gambling 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.

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

Sponsor:
SIGMAA on Recreational Mathematics (SIGMAA REC)

The Art of Asking Questions
3:00 p.m. - 3:15 p.m.

Here's a puzzle: Leon and Larry always lie, but Tim always tells the truth. You meet the three of them, but you do not know who is who. What one question could you ask of one of the brothers to determine whether or not he is Larry? This is an example of a question puzzle, that is, a puzzle in which you must craft a question whose response is informative even without knowing whether or not the respondent is truthful. Question puzzles are an important subgenre of logic puzzles generally. We will consider several examples and discuss general considerations applicable to all such puzzles.

Author:
Jason Rosenhouse, *James Madison University*

Squarely: A New Puzzle of Arithmetic, Sets, and Logic

3:20 p.m. - 3:35 p.m.

For most people, the primary appeal of Sudoku is the simplicity of its rules and the challenge of its logic. Fill a 9x9 grid consisting of nine 3x3 cages so that each row, column, and cage contains all the digits 1 through 9. Squarely is a new type of number puzzle that blends these aspects of Sudoku with the basic addition and multiplication aspects of Kakuro puzzles. In its most basic form, solving a Squarely puzzle consists of filling the 25 cells in a 5x5 grid with three occurrences of the digits 2 through 9 and a single occurrence of the digit 1 in such a way that each row, column, and the two long diagonals contain no repeated digits. As with Sudoku, the Squarely puzzles range in difficulty based on how much information is provided. In this talk, I will present several mathematical questions that arise in creating and solving these puzzles.

Author:
John Wilson, *Centre College*

Surprising Sudoku Connections

3:40 p.m. - 3:55 p.m.

Sudoku variations include additional restrictions that impact the strategies we use to play the game. Our choice of strategies can highlight properties of the game that lead to interesting connections to other areas of discrete mathematics. In turn, these connections inform and facilitate our research. In this talk, we explore connections resulting from three REU projects on the Mathematics of Sudoku.

Author:
Shelly Smith, *Grand Valley State University*

Using Graph Theory to Solve Puzzles and Brain Teasers

4:00 p.m. - 4:15 p.m.

Using Graph Theory to solve puzzles and brain teasers is not new. A well-known example of this is the elegant graph theoretic solution to the Instant Insanity puzzle (Parker Brothers). In this talk we consider several other puzzles and discuss their solutions. In each case, graph theory aids the solver not only in attaining a solution, but in better understanding the nature of the puzzle.

Author:
Robert Molina, *Alma College*

A Van der Waerden Game on the Naturals

4:20 p.m. - 4:35 p.m.

We introduced and studied a van der Waerden-style Maker-Breaker game on the natural numbers. The players alternate picking natural numbers, and no number can be selected more than once. The first player (Maker) is trying to create a "copy" of S of the form aS+b where a is a natural number and b is an integer. The second player (Breaker) is trying to stop them. We proved that when the size of S is 3, Maker can always win in 3 moves. When the size of S is 4, Maker wins in at most 5 moves, and we've characterized when Maker can win in 4. When $|S|=n>4$, then Maker can never win in exactly n moves.

Authors:
Gabriel Weiner, *Auburn University*
Yee Ern Tan, *Auburn University*
Liam Barham, *Auburn University*

PG (2,7) Now Available at a Game Store Near You: Spot It! in the Classroom
4:40 p.m. - 4:55 p.m.
One of the challenges of introducing students to projective geometry lies in the fact that students have a difficult time visualizing planes and spaces that are not affine (i.e., settings in which parallelisms do not exit). One standard approach has been to introduce the notion of perspectivity in art. Even so, some students find that they still lack a "real world setting" in which projective axioms seem reasonable. The card came Spot It! provides such a setting.
The game Spot It! can be viewed as a Desarguesian projective plane from which two lines have been removed. In this note, we will explore ways that Spot It! can be used as an effective teaching aid for introducing students to concepts in projective geometry, such as Desargues' Theorem, Pappus' Theorem, and projective arithmetic. Perhaps even more importantly, Spot It! serves as an example of how projective geometry can provide hours of fun for the whole family!
Author:
Mark Miller, *Marietta College*

Gerrymandering is Not A Game--Except When It is
5:00 p.m. - 5:15 p.m.
Distrix is a game about political redistricting played on a 6 x 6 board: 17 squares with power ratings from 1-9 controlled by the red party, 17 by blue, and 2 neutral. During play, the board is progressively tiled with 9 non-overlapping tetrominoes (5 shapes,19 orientations in total). With two players, whoever controls the most districts wins. The game can also be played in solitaire mode. Here the goal is to gerrymander the board to favor one party or the other, or to create a redistricting plan that is as fair as possible.
We developed a program to produce each of the 178,939 tetromino tilings of a 6 x 6 Distrix board. While somewhat infeasible to generate these "on the fly", the templates are saved in a file and can be recalled to evaluate every possible districting plan for a given board. In real world redistricting, it is not possible to examine all plans, and heuristic methods are used. Thus, we are also developing techniques to produce heuristic solutions.
Authors:
Ventsi Gotov, *University of Rhode Island*
Madhukara Kekulandara, *University of Rhode Island*
Edmund Lamagna, *University of Rhode Island*

A Mathematician Wanders Into A Sportsbook
5:20 p.m. - 5:35 p.m.
After the Professional and Amateur Sports Protection Act of 1992 was overturned by the United States Supreme Court in May 2018, online sportsbooks began to proliferate across several U.S. states. Mathematics informs the ways that bets are offered, and we can use mathematics to study the question of guaranteed payouts from free bets that are offered. This talk will use ideas from precalculus, and a bit of calculus, to explore interesting problems that emerge when a mathematician wanders into a sportsbook.
Author:
Edward Aboufadel, *Grand Valley State University*

A Precise Probability Related to Simpson's Paradox
5:40 p.m. - 5:55 p.m.

Suppose two friends, Robbie and Julia, participate in a two-day contest in which they repeatedly attempt a task with a clear success/failure outcome, like flipping a coin hoping for heads or shooting free throws on a basketball court. If Robbie has a higher success rate on Day 1, and a higher success rate on Day 2, does he necessarily have a higher success rate for the two-day period?
Initiated readers may know that the answer, in general, is NO, the simplest case of a statistical reversal phenomenon known as Simpson's Paradox. But is this sort of reversal common, or is it merely a pathological fringe scenario?
Here we investigate the likelihood of occurrence of Simpson's paradox in this two-day, two-player framework, with no assumed prior knowledge. In other words, the players' success rates each day, and the proportion of each player's attempts taken on the first day, are all chosen uniformly at random between 0 and 1.
Author:
Alex Rice, *Millsaps College*

Linear Algebra: Modern Applications and Computation

Friday, August 4, 1:00 p.m. - 3:55 p.m., Ballroom A

This session invites examples of modern applications of linear algebra and computation successfully incorporated in undergraduate linear algebra courses with evidence of that success in terms of student learning, student engagement, student persistence in STEM, etc. and/or recent research in linear algebra accessible to undergraduates, for example topics for undergraduate research projects, course projects, or illustrative examples for a course.

Organizers:
Suzanne Dorée, *Augsburg University*
Christine Andrews-Larson, *Florida State University*
David Austin, *Grand Valley State University*
Monika Kiss, *St. Leo's University*

Linear Algebra Activities to Develop Conceptual Understanding and Computational Proficiency
1:00 p.m. - 1:15 p.m.
The math department at Grand Valley State recently developed a two-course linear algebra sequence that is required of all math majors but does not have calculus as a prerequisite. The main goals for these courses include developing students' conceptual understanding and their ability to apply this understanding to solve meaningful problems using a computer. This talk will describe a series of collaborative activities in which students explore applications, such as the JPEG image compression algorithm, linear regression, and principal component analysis, using computational tools to facilitate their investigations. Students report that these applications and computation lead to a deeper understanding and appreciation of linear algebra and, indeed, the role of mathematics in their studies.
Author:
David Austin, *Grand Valley State University*

Digital Image Processing in a College Linear Algebra Course
1:20 p.m. - 1:35 p.m.

We provide multiple example of computational projects designed to illustrate concepts and techniques of college-level linear algebra. In the process, we explore connections between linear algebra and other fields, such as Fourier Analysis and Wavelet Analysis.

Author:
Yevgeniy Galperin, *East Stroudsburg University of Pennsylvania*

A Linear Algebra Story: How We Reconstructed a Matrix from its Eigenvalues
1:40 p.m. - 1:55 p.m.
A linear algebra course introduces completely new rules of thinking about algebraic operations. For students to become proficient in new techniques, from time to time they need to solve tedious problems. However, it is crucial to keep students engaged. This is the challenge we want to address.
One of the proactive approaches we propose is "to tell a story", help students to finish a puzzle by giving them problems that are connected to each other throughout the semester.
The role of instructor in this story is to provide the narrative and support, while students discover the plot. We show how to incorporate the classical research problem into the instructional design and use newly discovered connections for motivation of studying this topic.

Authors:
Anastasiia Minenkova, *University of Hartford*
Alex Holley, *University of Connecticut*

If Eigendoit, then So Can You!
2:00 p.m. - 2:15 p.m.
In this talk I present some fun applications of linear algebra coming from my 10 year experience of teaching this course. For example, did you know that you can use the game Bomberman to explain determinants? Or diagonalization to predict the outcome of a Pokémon battle? In addition, I will present my YouTube channel Dr Peyam, which currently has over 150,000 subscribers and more than 100 linear algebra related videos, ranging from Gaussian elimination all the way to dual spaces and functional analysis, which students found particularly useful.

Author:
Peyam Tabrizian, *Brown University*

What Do Probability, Calculus, and Differential Equations Have in Common? Linear Algebra!
2:20 p.m. - 2:35 p.m.
As Linear Algebra is different than their previous math classes which are mostly calculus, students often wonder why they are even taking this class. In this talk, I will discuss short out-of-class projects that I have assigned to my linear algebra students so that they can see how linear algebra is used in other branches of mathematics such calculus, differential equations, and probability. These projects not only show that linear algebra is an important tool in other branches of math, but that there are relevant real-world applications of linear algebra.

Author:
Jason Molitierno, *Sacred Heart University*

Flag Mean Lab for Intermediate Linear Algebra
2:40 p.m. - 2:55 p.m.
Applications of geometric data analysis often involve producing collections of subspaces, such as illumination spaces for digital imagery. For a given collection of subspaces, a natural task is to find the average of the collection. A robust suite of algorithms has been developed to generate measures of center for a collection of subspaces, one of which is the Flag Mean. In this talk, we present a Flag Mean Lab designed for an undergraduate intermediate linear algebra course which introduces students to the concepts of data subspaces, principal angles, and subspace averaging via the Flag Mean. Computations

are conducted in Matlab, with application to a toy problem as well as data subspaces formed from collections of digital photos of human faces. This lab has been run across two semesters, with expressed student appreciation for the clear window it provides into the active research field of geometric data analysis.

Author:
Justin Marks, *Biola University*

Linear Algebra over Bicomplex Scalars
3:00 p.m. - 3:15 p.m.
Bicomplex numbers form a four-dimensional generalization of complex numbers. This presentation shows how linear algebra taken over bicomplex scalars has results that generalize corresponding theorems for linear algebra over the complex field. Several examples, some emanating from student-faculty collaborative research, are displayed, and several fruitful ideas for accessible undergraduate research projects are given.

Authors:
William Johnston, *Butler University*
Rebecca Wahl, *Butler University*

Application of Matrix Diagonalization in Number Theory
3:20 p.m. - 3:35 p.m.
The calculation of eigenvalues and eigenvectors of a square matrix, or matrix diagonalization, is part of a standard undergraduate Linear Algebra curriculum. Typical applications of matrix diagonalization include stochastic matrices and applications to difference equations. The purpose of this presentation is to give a novel application of matrix diagonalization in number theory. We begin with an old number theory theorem, which describes all integer Pythagorean triples using matrix multiplication. Then we present an application of matrix diagonalization, which results in a complete characterization of every integral "almost" isosceles right triangle, namely an integral right triangle where the lengths of its two legs differ by only one unit. This can be a source of undergraduate research project. With some scaffolding, this can also lead to a course project in a Linear Algebra course.

Author:
Byungchul Cha, *Muhlenberg College*

Encoding Data in Vectors and Linear Combinations
3:40 p.m. - 3:55 p.m.
With broadly ranging applications and the increasing popularity of data science and computing, demand for access to linear algebra content grows. Further, there are now free and widely available AI platforms such as ChatGPT that students are likely to use in a range of ways that might support or inhibit their learning. In this session, we will provide an example of a sequence of contextualized problems in which students encode data into vectors and use linear combinations of vectors to structure that information in helpful ways. In later tasks, some of these linear combinations come to be reinterpreted as elements of null spaces in ways that illustrate the usefulness of null spaces for describing infinite solution sets to both homogeneous and non-homogeneous linear systems. We will include some practical commentary about strategies of using instructional technologies (discussion boards, vlogs) to address the complexities created by the wide availability of AI resources.

Authors:
Christine Andrews-Larson, *Florida State University*
Minah Kim, *Florida State University*

Posters

MAA Contributed Poster Session

Thursday, August 3, 10:45 a.m. - 12:00 p.m., West Hall (Exhibit Hall)

Given previous years' success with the MAA Contributed Poster Session (CPS), the MAA is pleased to continue with this session at MathFest 2023 in Tampa. The MAA will provide corkboards for the posters – you just need to bring your poster.

Please consult this year's Call for Contributed Posters for more information, and what to expect for submitting and preparing presentations.

Organizers:
Timothy Flowers, *Indiana University of Pennsylvania*
Holley Friedlander, *Dickinson University*
Steve Butler, *Iowa State University*

Bouncing Around with Fibonacci
We consider the following generalization of the Fibonacci sequence: $x_n=(x_(n-2)+x_(n-1))^p,$ where $0<p<1.$ This sequence converges independent of the chosen initial conditions x_0 and $x_1.$ We examine how the initial values affect the behavior of the convergence. We show that for any given $x_0,$ there is a unique value of x_1 for which the resulting sequence oscillates. We provide a construction for $x_1.$ Any other value for x_1 leads to eventual monotonic behavior of the sequence. We conclude with some open questions suitable for further study.
Authors:
Justin Hoffmeier, *Florida Polytechnic University*
Michael Brilleslyper, *Florida Polytechnic University*
Jawad Sadek, *Northwest Missouri State University*

Alternative Forms of Assessment in Proof-writing Courses
This poster illustrates various methods used to engage and assess students in proof-writing courses that are not your typical quizzes and exams. One of the primary goals of the methods discussed is for students to understand the value of learning from their mistakes and how the revision process is intrinsic to proof-writing. These activities, in turn, not only help students learn how to be successful in advanced mathematics courses, they also help to create an encouraging environment where students are less afraid to speak up, ask questions, and present their work.
Author:
Britney Hopkins, *University of Central Oklahoma*

Dynamics of a Delayed Nonlinear Mathieu Equation
We investigate the dynamics of a delayed multiparameter nonlinear Mathieu equation in the neighborhood of $\delta=1/4$.
The equation involves a distributed delay, cubic nonlinearity, and 2:1 parametric resonance. Using the averaging method, we obtain a slow flow that is analyzed for stability and bifurcations, and the resulting predictions are compared against actual system responses. We identify regimes where the slow flow exhibits Amplitude Death, periodic solutions, or quasiperiodic system responses. These behaviors would

be difficult to isolate otherwise without intensive numerical searching of the multiparameter space. However, there are also parameter regimes where discrepancies arise between the slow flow predictions and the actual system response, particularly for large amplitude or bounded aperiodic behavior. We carefully consider the reasons for these discrepancies.

Authors:
Ranses Alfonso Rodriguez, *Florida Polytechnic University*
S. Roy Choudhury, *University of Central Florida*

Elizebeth Smith Friedman and the First American Break into Enigma

In January 1940, the U.S. Coast Guard intercepted numerous messages that were encrypted on a commercial Enigma D machine using the same key. By solving these messages in depth and examining the resulting cipher alphabets for each position of the rotors, the Cryptanalytic Unit, headed by Elizebeth Smith Friedman, was able to recover the wiring of two of the rotors. This poster explains Friedman's methods in detail and uses them to determine the wiring of two rotors from an Enigma M3 machine.

Author:
Stuart Boersma, *Central Washington University*

The Teaching of Matrices from the Perspective of a Linear Algebra Lecturer. Relationships between Content Knowledge and Pedagogical Content Knowledge

This work focuses on understanding the knowledge of a Linear Algebra lecturer when teaching the content of matrices to students of the basic year prior to university entrance. The information collected through videos and semi-structured interviews was analyzed with the Mathematics Teacher's Specialised Knowledge model (MTSK, Carrillo et al., 2018). In the teacher's practice was possible to determine how he uses examples (Knowledge of mathematics teaching), mistakes and difficulties of students (Knowledge of features of learning mathematics) to impart the subject (Knowledge of topics). Relationships were established to understand the teacher's practice. Our results can serve to think and guide professional development processes focused on Algebra and Linear Algebra, where teaching situations inspired by previous research on teacher knowledge are used, and also the connections found serve to validate the use of the MTSK model in the study of the teacher's knowledge.

Authors:
Diana Lucia Vasco Mora, *Universidad Técnica Estatal de Quevedo*
Nuria Climent Rodriguez, *Universidad de Huelva*

Advantages of a Research-and-Practice Cycle in a Capstone Course for an Online Master's in Mathematics Program for Inservice Teachers

UTK's Master of Math is an online program for high school teachers interested in college teaching. These educators may be interested in a lecturer position, an adjunct role, or qualifications to teach dual enrollment. They are full-time professionals and part-time students in evening classes. They have pedagogical knowledge, but their formal education was for secondary teaching. Also, many of these students are women with major family care responsibilities on top of their jobs, so the traditional pathway to acquire initial college teaching experience with a GTA is not feasible. As part of a project studying educators between institutional boundaries, an instructor and research team collaborated to add content about college teaching into a capstone course. We will present details on the research-and-practice cycle, examples of classroom tasks, analysis of student work, and future plans. Ideas from this project can be implemented in similar degree or professional development programs.

Authors:
Karin M. Pringle, *University of Tennessee*
Anne M. Ho, *University of Tennessee*

Modeling Train Track Dynamics

How can we use mathematics to describe the dynamical nature of a train's movement along a given track? For instance, given a track configuration and a train with a designated orientation, what tracks are traversed? Will the train get "stuck" in one portion of the configuration? It is easy to see that as train track configurations get larger and more complicated, the choices that a train makes at a "fork" impact the future options. This poster presentation will attempt to address these questions.

Authors:
Tracey McGrail, *Marist College*
Elizabeth Reid, *Marist College*

Wavelet Based Hybrid Stock Forecast Using Machine Learning Algorithm

One of the most sought-after goals in the financial world is a reliable method by which investors can predict a stock price movement consistently. Advancements in stock prediction via the use of machine learning have improved the accuracy of such predictions and yielded better ideas about value investments in the stock market. However, with the addition of an M-band wavelet transform as a preprocessing step, we can denoise our data set (prior stock prices) and refine it to make the forecast even more accurate. This approach leverages the benefits of both M- band wavelet decomposition to capture different trends and patterns in the data, and multiple neural networks to develop a powerful nonparametric hybrid forecasting model. To demonstrate the power of our algorithm, we perform a stock forecast using a discrete 4-band wavelet transform-based hybrid machine learning algorithm. This algorithm will be further supported with an MSE to measure the error of forecasting.

Author:
Peter Bigica, *Western Connecticut State University*

Providing a Transformative Learning Experience for Math Education Majors

The mission of a metropolitan university in Oklahoma focuses on providing students with transformative learning experiences that empower them to become engaged citizens and leaders. We discuss a transformative learning experience that is beyond the classroom for math education majors. Student engagement in the tenets of transformative learning will be described, as well as the connection between the project, its results, and various mathematics communities.

Author:
Kristi Karber, *University of Central Oklahoma*

Building an Infectious Disease Modeling Lab at a Small Liberal Arts College

In this poster, I will address how I recruit and select students, prepare students for research, construct an interesting yet approachable research question, support students throughout their project, and support my own professional productivity. In particular, I will share my experience working with first-year students. My previous and current projects with undergraduate students include estimating the number of quarantine beds Eckerd College would need during the first full semester of the COVID-19 pandemic, investigating the role of healthcare workers in the transmission of C. difficile in a hospital ward, modeling the effect of resistance to disinfectants on the transmission of hospital-acquired infections, and optimal harvesting in an ornamental fishery suffering an outbreak of koi herpesvirus.

Author:
Lindsey Fox, *Eckerd College*

Teaching Pre-Service Elementary and Early Childhood Students about Four Operations Using Base 5 Number System

Students in a required mathematics course for elementary and early childhood perspective teachers use a Base 5 number system to gain an understanding of how young children will learn of the 4 main operations. Using story problems, numbers in a base 5 system, and virtual manipulatives the students in these classes experience frustration, learn perseverance, and gain a better sense of what their students will

face when learning about +, -, x, ÷ of whole numbers. Also, learning about the general types of story problems: join, separate, part-part-whole and compare, in conjunction with the mathematics can facilitate a deeper understanding of why those types of problems are mentioned in the state standards and their utility.

Author:
Kevin LoPresto, *Francis Marion University*

Use of a Online Dialogic Video to Reason Quantitatively with Algebraic Expressions

Mathematics education has been experienced rapid changes since the COVID-19 pandemic, which has increased the proliferation of the use of instructional video. The shift to digital (Engerman & Otto, 2021) has pushed educators to explore the affordances and limitations of video in classrooms. One technology that has shown promise for STEM instruction is the use of dialogic videos, which are videos that feature more than one individual engaging in dialogue (Alrø & Skovsmose, 2004). One such group of videos are part of the Project MathTalk (www.mathtalk.org), whose purpose is to show students quantitatively reasoning about algebraic expressions. I use the construct of instrumental orchestration to conceptualize the intentional and systematic organization and use of online dialogic videos as part of a classroom teaching experiment with middle school students. Preliminary findings provide an initial use model for dialogic videos in mathematics classrooms.

Author:
Isabel White, *Ph.D. Student*

Transforming a General Education Math Course Using POGIL

We highlight some of the POGIL activities written for a general education math course that focuses on developing problem-solving and critical thinking skills through studying concepts in geometry, set theory, logic, probability, and statistics. We have developed twenty-nine activities that have been used regularly over the last ten years, including by other faculty at FGCU and elsewhere. The response from students has been positive and the success rate in the class has improved dramatically. Student feedback will also be shared.

Authors:
Katie Johnson, *Florida Gulf Coast University*
Brian Johnson, *Florida Gulf Coast University*

Reducing Math Anxiety and Increasing Math Self-efficacy

Math anxiety is the feeling of nervousness or fear that can create difficulty in learning or doing mathematics. Studies have shown that there is a correlation between math anxiety and math achievement. In an 8-week online course, students studied topics including math anxiety, mindset, and memory formation. These students completed a video presentation describing a real-world application of mathematics. Hence, they examined root causes of their math anxiety, strategies for dealing with these negative feelings, and explored mathematics applications. A comparison of pre- and post-course MSEAQ results showed an increase in reported self-efficacy regarding mathematics.

Authors:
Shanda Hood, *University of Arkansas*
Joshua Girshner, *University of Arkansas*

Teaching Basic Computer Programming with Mathematical Applications in the Age of Continuously Changing Technology

In this poster we present a course that teaches basic programming and mathematical applications, such as modeling, to mathematics majors. We have been teaching this course for years but gave it a makeover for the 2022-2023 academic year. It is now taught in Python and its many packages, with a total cost for materials to students under thirty dollars. A data science section was added, and the projects shifted to a

focus on the use of mathematics in emerging technologies such as quantum computing. In this poster, we provide the course layout, materials, project ideas, and impressions.
Author:
Leslie Jones, *The University of Tampa*

Preparing Graduate Students to Teach Mathematics
This poster presentation intends to present, discuss and show ways to prepare graduate students better to teach in two-year and four-year institutions post-Covid (2020). Trends show that there are and will continue to be gaps in conceptual understanding of the mathematics concepts of our enrolling students in post-secondary institutions. This session will present varying teaching methods and professional development for mathematics graduate students intending to teach at two-year and four-year institutions. Topics will also include adapting teaching in various mediums (face-to-face, Hybrid, synchronous, and asynchronous online) to address student needs, institutional needs, and expectations. This session aims to provide other graduate faculty mentors/coordinators with additional ideas, support, and aid in supporting the growth of their graduate students to become well-prepared mathematics educators.
Author:
John Sevier, *Appalachian State University*

Counting and Calculating in Medieval Europe
This work will give an overview of the first known introduction of the Hindu numeration system into Christian Europe and its subsequent (limited) use from the late 10th to the early 13th century. Several surviving manuscripts give evidence of how the new numbers were written and conceptualized in the existing framework of Roman and Greek number systems, and document changes in the forms of the number symbols. Some also give examples that provide interesting insights into the evolution of methods for doing calculations. Despite the surviving manuscripts, there are still significant gaps in our knowledge of the adoption and transmission of Hindu number symbols prior to the first edition of the Liber Abaci in 1202, and we will highlight these as potential areas for further study.
Author:
Chuck Lindsey, *Florida Gulf Coast University*

Counting Pushups Using Partitions
In college football games, it is common for students to rush the field and do pushups equal to the new total score each time their team scores. We wondered, given the total number of pushups completed, what was the sequence of scores? An investigation of this problem led to surprising connections with counting the partitions of an integer into a fixed number of distinct parts. We highlight some of these connections and demonstrate some of the combinatorics inherent in this problem.
Authors:
Beth Schaubroeck, *U.S. Air Force Academy*
Michael Brilleslyper, *U.S. Air Force Academy*

Distribution of Minority Voters across Districts of the Oklahoma State Legislature, 2001–2030
Representative Democracy requires that citizens have the ability to be represented in government. The most common way of achieving this is by dividing citizens into geographic districts where they can vote for a representative. Unfortunately, the process of drawing these districts is itself a political process, calling into question the quality of representation. The most fraught debate surrounding this is the assignment of minority voters to districts: is the uneven distribution of racial and ethnic minorities to voting districts simply a result of the uneven geographical distribution of those same minorities? In an attempt to shed some light on this question, we share our analysis of the 2001–2030 voting districts of the Oklahoma State Legislature using the computational tools developed by the Metric Geometry and Gerrymandering Group.

Authors:
Bradley Paynter, *University of Central Oklahoma*
Britney Hopkins, *University of Central Oklahoma*
Liz Lane-Harvard, *University of Central Oklahoma*
Thomas Milligan, *University of Central Oklahoma*
John Wood, *University of Central Oklahoma*

Calculus: From Practice to Theory, a Differential Approach
In 2000 Grattan-Guiness observed that Calculus textbooks "give a prime place to limits without explaining why . . . this very difficult concept is desirable . . . or what . . . less rigorous approaches are being superseded." We present an OER text: "Differential Calculus: From Practice to Theory," which addresses this issue.
In part 1 we begin, as Leibniz did, by basing the differentiation rules explicitly on the notion of a differential. We examine how these rules can be used to solve substantial problems from the history of mathematics and science, e.g., the Catenary, the Witch of Agnesi, Galileo's investigation of falling bodies, the Brachistochrone Problem, etc.
In part 2 we address the logical difficulties inherent in the notion differentials. The question of rigor is thus presented as a problem to be solved, rather than an abstraction imposed, from the student's point of view, for no apparent reason.
Authors:
Eugene Boman, *Penn State, Harrisburg*
Robert Rogers, *SUNY, Fredonia*

Symmetry Reduction of a Gas Dynamic System of PDEs with a Special State Function
I will present new results on the symmetry reduction of gas dynamic systems of PDEs following the general framework presented by Lev Ovsyannikov in his article The "podmodeli" program. Gas dynamics https://www.sciencedirect.com/science/article/pii/0021892894901376 The gas dynamics systems of equations, with special state equation, has a 12-dimensional Lie algebra of symmetries which generates a group of space translations, time translation, rotations, Galilean translations, uniform dilations, and pressure translation. I will present a classification of subalgebras of this 12-dimensional Lie algebra up to similarity and will demonstrate how using the process of symmetry reduction one can transform a gas dynamic system of this type into the systems with one or two independent variables, which can be solved exactly leading to new particular solutions of the original system. A description of the motion of particles for these particular solutions will be also presented.
Author:
Dilara Siraeva, *North Carolina State University*

Supplemental Skills for Calculus Course
UW-Platteville's Mathematics Department created a new course titled Supplemental Skills for Calculus, and we started implementing it in the Fall of 2022. This is an eight week, credit/no-credit course, that was designed for students who were failing Calculus I. It includes a review of some of the fundamental topics from algebra and trigonometry, as well as the development of study skills and the mindset required for success in Calculus. I will present about this course, and especially my experience in teaching it during the last two semesters.
Author:
Leonida Ljumanovic, *University of Wisconsin – Platteville*

Mathematics Photo Album and Posters
You will see many examples of mathematics experiments, mathematics photos, and mathematics posters. This is a publisher accepted "Math Book Photo Album and Posters" project. I am open to collaborators

who have similar vision —teaching math through experiments, photos and posters. Math concepts will cover K5-K12. Check out my TEDx talk for a beginner level introduction.
Author:
Havva Malone, *Rolla High School*

Numerical Solutions for Systems of Caputo Fractional Differential Equations with Initial Conditions Using Laplace Transform Method
In our previous work, we obtained numerical solutions for sequential Caputo fractional differential equations of order 2q with a linear nonhomogeneous term, utilizing the Laplace transform method. In this current study, we extend our work to develop numerical solutions for systems of Caputo fractional differential equations with order q, where $0 < q < 1$, using the Laplace transform method. The method yields the integer results as a special case.
Authors:
Buna Sambandham, *Utah Tech University*
Aghalaya Vatsala, *University of Louisiana at Lafayette*

Video Feedback in Online Math Classes
Providing feedback to student submissions in online classes can be a time-consuming process especially at smaller institutions where assistants and/or graders are not available. In this Poster Session, I will review the benefits of incorporating video feedback to enhance teacher-student communication. With a focus on best practices and avoiding roadblocks, I will share a review of the literature and demonstrate how to effectively create and deliver video feedback. This poster is ideal for math instructors/professors looking to improve their feedback techniques and will cover techniques for both small and large class sizes at a variety of course levels. Visitors will also gain a solid understanding of the different apps and tools, free or low-cost, available for creating and sharing video feedback in their Learning Management System, YouTube, and/or Google Drive. An interactive element will be available in order to view videos and assess the ease of the various apps.
Author:
Grace Cook, *Bloomfield College of Montclair State University*

Community College Student Voices on Equity in Mathematics Classrooms
Research on diversity, equity, and inclusion (DEI) often overlook students' perception of equitable or inclusive practices. This poster will focus on the preliminary results of a study investigating College Algebra students' perceptions and experiences of DEI in their community college mathematics classrooms.
Authors:
Bismark Akoto, *University of Minnesota*
Dexter Lim, *University of Minnesota*
Irene Duranczyk, *University of Minnesota*

An Activity on Divisibility Rules for Undergraduates
Most students are familiar with rules for determining if a positive integer is divisible by 2, 3, 4, 5, 6, 8, 9, 10, and perhaps a few other numbers. An activity will be presented that uses this basic knowledge of students to lead them to explore divisibility rules for other numbers. This activity can be used to teach undergraduates about the process of mathematical discovery.
Author:
Frederic Latour, *Central Connecticut State University*

Peak Performance: Setting up Incoming Freshmen for Success via Summer Math Bridge Program

Peak Performance is a summer math bridge program at Northern Arizona University. Our main goal is to help incoming freshmen/transfer students who are 1-2 math courses behind their major requirements to improve their math placement. Students that participate in this free and online program are matched with an undergraduate tutor, known as a math coach, with whom they work on strengthening their math and study skills. Additionally, our math coaches connect these incoming students to academic and social resources both at NAU and around Flagstaff to help their students feel connected to NAU as they arrive for their first semester. This poster includes data from the most recent iterations of the program related to student participation in the program and their success in their first year math courses.

Author:
JoseAngel Gonzalez, *Northern Arizona University*

Complex Variable Methods Applied to the Hamiltonain Problem and a Possible Approach Showing that "Modified Hamiltonian Problem" is NP

Complex Variable techniques are demonstrated that provide an exponential solution to the Hamiltonian Problem and a tie in to prime numbers. Approach can easily be extended to the "The Traveling Salesman Problem" and " Expense Account Problem". Also provided is an approach to the Modified Hamiltonian Problem (i.e.Are there an even or odd # of Hamiltonian Circuits without repeating vertices except the first?) that may show that it is NP.

Author:
Samuel Kohn, *Retired – NYIT*

Analysis Properties of The Continuous Function in Banach Space

Purpose of this paper is explained about characteristics of continuous functions in the Banach space. Discussion begins with the norm space. Norm space is complete if each Cauchy sequence in the space is convergent. There are 5 characteristics of continuity in Banach space: 1) T function in Banach space continuous if and only if T is bounded, 2) Function in Banach space continuous at p if and only if lim f(x) = f(p); 3) Suppose X, Y and Z Banach space, E ⊂ X, f(E) ⊂ &→(Y), f:E→Y, g:f(E)→Z, if f continuous in p∈E and g continuous in f(p)∈f(E), then g∘f continuous in p; 4) Suppose X, Y are Banach space, f: X → Y, function f is continuous on X if and only if f(W) is close in X, for each closed set W in Y; 5) A linear operator T on Banach space is continue if T continuous at a point.

Author:
Prihantini Prihantini, *Bandung Institute of Technology*

MYMathApps Calculus

MY Math Apps Calculus is an online text for a 3 semester calculus course for STEM students. You can see a sample of about half the chapters at https://mymathapps.com/mymacalc-sample/. I will show the structure of the text with emphasis on the interactivity and graphics, both 2D and 3D, static and animated, visual and manipulatable. Course surveys show the students actually read the book, find the interactivity engaging and like having solutions to many exercises. Nearly all theorems have proofs which are either in the text or accessible for interested students by clicking a button. The order of material is slightly modified to enhance the learning process.

Author:
Philip Yasskin, *Texas A&M University*

Algebraic K-functors for Γ- rings

This is an attempt to extend to algebraic K-theory our approach to group actions in homological algebra that could be called an introduction to Γ-algebraic K-theory. The originality of our approach to the study of homological properties of groups and rings consists of the definition of a new and natural, unexpected action of a discrete group Γ on the classical chain complexes defining classical homology of a group G and of a ring R respectively, particularly induced by its given action on the group G and on the ring R

respectively, called Γ-group and Γ-ring. For Γ-rings, the Milnor algebraic K-theory and Swan's algebraic K- functors are introduced and investigated. Particularly, the Matsumoto conjecture related to the symbol group, and the Milnor conjectures related to Witt algebras and Chow groups for Γ-rings are extended.
Author:
Khvedri Inasaridze, *Razmadze Mathematical Institute*

On Step-Stress Plan Model Under Type-II Censored Weibull Data
The accelerated life testing (ALT) is frequently used in examining the component reliability and acceptance testing. The ALT is carried out by exposing the unit to higher stress levels in order to observe data faster than those are producing under the normal conditions. The simple step-stress model based on type-II censoring Weibull lifetimes is studied here. In this paper, Bayesian approaches are developed for estimating the model parameters and predicting times to failure of future censored of the simple step-stress model from Weibull distribution. Monte Carlo simulation is performed to check the efficiency of the developed procedures and analyze a real data set for illustrative purposes.
Authors:
Mohammad Raqab, *Kuwait University*
Mohammad Alamleh, *Kuwait University*

A New Method for Solving Differential Equations
We present a novel algorithm for approximating solutions of two-point boundary value problems (TPBVPs) that applies identically in both linear and nonlinear cases. Our method applies Picard iteration to generate solutions, but we have observed that many quadratures encountered in this process cannot be performed in closed form. To overcome this, we introduce auxiliary variables that enable us to perform the necessary quadratures. We demonstrate the effectiveness of our method by comparing its performance against several benchmark problems, and our results indicate that it outperforms existing methods in terms of accuracy and convergence rate. Our method has the potential to impact a broad range of applications, from physics to engineering, and we believe that it represents a significant contribution to the field of numerical methods for solving TPBVPs.
Author:
Hamid Semiyari, *American University*

An Invitation to Mathematical Physics and Its History
Much of early mathematics, say before 1600 BCE, involved the love of art and music. Our psychological senses of color and pitch are determined by the frequencies (i.e., wavelengths) of light and sound. The Chinese and later the Pythagoreans are well known for their early contributions to music theory. Learning languages is an advanced social skill. Math is different due to the rigor of the grammar (rules of the language) as well as the way it is taught (i.e., not as a language). A third difference between math and language is that math evolved to explain physics, having important technical applications. Context can be critical, and the most important context for mathematics is physics. Without a physical problem to solve, there can be no engineering mathematics. This book begins with elementary number theory and ends on Maxwell's equations. Complex algebra and complex analytic functions are developed in detail, always motivated by physical examples. The basic theory of mathematical physics it defined via postulates. Several important relations are established that may not be well known, using examples from Maxwell's equations. Many homework problems are presented, many with the solutions. An instructor's manual with all the solutions to all the problems is available. The author is open to the development of an open-source version of the LaTeX manuscript to allow for future expansion of the basic themes.
Author:
Jont Allen, *University of Illinois*

PosterFest 2023: Scholarship by Early Career Mathematicians

Friday, August 4, 3:15 p.m. - 4:45 p.m., West Hall (Exhibit Hall)

This poster session and networking event provides an informal opportunity for early career mathematicians to present and discuss their scholarly activities (such as: expository work, preliminary reports, scholarship of teaching and learning, and research reports). Nontenured faculty and graduate students are encouraged to apply. Undergraduate submissions will not be accepted. Questions regarding this session should be sent to the organizers.

Organizers:
Holly Attenborough, *University of Wisconsin-Platteville*
Lisa Driskell, *Colorado Mesa University*

Sponsor:
MAA Committee on Early Career Mathematicians

Uncover the Hidden Activity Patterns and Differentiate Fake Personas of the Russian Troll Networks via a Machine Learning Model

The information operation networks of Trolls manipulate public arguments and exacerbate social drift by misusing social media platforms. Given the increased frequency of this type of threat, understanding those operations is paramount to combat their influence. Building on existing scholarship on the inner functions within those influence networks on social media, we suggest a new probabilistic approach to map those types of operations. Using Twitter content identified as part of the Russian influence network, we classify accounts type and analyze their activities within the network. We trained a predictive model to map the activities and identify similar behavior patterns across the network. Our model attains 88% prediction accuracy for the test set. We validate our predicted results by comparing the similarities with the 3 Million Russian troll tweets and Russian-language tweets datasets, and the results indicate a 90.7% and 90.5% similarity between the two datasets, respectively.

Authors:
Sachith Dassanayaka, *Wittenberg University*
Ori Swed, *Texas Tech University*
Dimitri Volchenkov, *Texas Tech University*

A survey on r-hued colorings

A proper r-hued coloring of a simple graph is a proper vertex coloring of the graph such that the neighbors of each vertex will be assigned at least r different colors if the degree of the vertex is greater than r; otherwise, every neighbor will receive a different color. In this poster, the recent developments in the studies related to this r-hued coloring will be surveyed. Moreover, open problems on r-hued colorings will be presented.

Authors:
Murong Xu, *The University of Scranton*
Ye Chen, *Northern Arizona University*
Suohai Fan, *Jinan University*
Hong-Jian Lai, *West Virginia University*

Learning Trajectories in Building Scholarship of Teaching and Learning for Early Career Mathematicians

The Scholarship of Teaching and Learning (SoTL) provides a pathway for early career mathematicians to grow their excellence in teaching and learning mathematics. As mathematics faculty build their expertise in teaching, they learn from their practice by experimenting and refining their practice. SoTL provides a scholarly orientation and outlet for faculty to disseminate their knowledge and experience gained from their own practice to other faculty and researchers. Engaging in SoTL helps mathematicians build and benefit from support networks for their practice. We present learning trajectories towards developing scholarship of teaching and learning mathematics for early career mathematicians. These trajectories provide an orientation, and support for scholarly mathematics teaching as a part of their professional growth highlighting knowledge, dispositions, and community support dimensions as a SoTL scholar progresses from beginning to expert with SoTL community engagement and support.

Authors:
Celil Ekici, *Texas A&M University - Corpus Christi*
Fei Xue, *University of Hartford*
Larissa Schroeder, *University of Omaha*
Cigdem Alagoz, *Texas Education Agency*

A Mathematical Model for Optimizing Cancer Radiotherapy with Immunotherapy

A successful combination of radiotherapy with immunotherapy is essential in some tumor control and treatment improvement, which encourages in-depth investigation of the radiation scheduling and its resulting synergistic effect. We proposed a mathematical model to explain and predict the tumor development considering the key factors of the radioimmunotherapy using in vivo data. Our model successfully described the experiment results in multiple scenarios and supported the major biological hypotheses. We further incorporated randomness into the simulated data based on the proposed model in order to resolve the data limitation issue in the clinical studies. Accordingly, we were able to create adaptive treatment plans for individual subjects using the simulation results. Our work does not only predict the treatment effects of radiation in the presence of immunotherapy but also potentially enable personalized regimes.

Authors:
Yixun Xing, *University of North Texas*
Casey Timmerman, *UT Southwestern*
MaryLena Bleile, *UT Southwestern*
Benjamin Chen, *UT Southwestern*
Steve Jiang, *UT Southwestern*

Quaternionic Triangle Groups and Topographs

John Conway developed a tool called the topograph which simplifies the study of binary quadratic forms (BQFs). In general, Conway's topograph is a geometric arrangement of numbers, which connects the symmetry group of a tiling of the hyperbolic plane to the arithmetic of BQFs and integer bases of $\mathbb{Z}\times\mathbb{Z}$ as a $\mathbb{Z}$-module. A connection between a coxeter group and an arithmetic group is what gives rise to this topograph.

Inspired by Conway, a natural question arises: Is there an arithmetic interpretation of other Coxeter groups giving rise to new "topographs"? This certainly is the case with arithmetic triangle groups. Remarkably, one connection is within the realm of quaternion algebras!

My PhD Thesis is aimed at building new topographs for each spherical and hyperbolic arithmetic triangle group. These new topographs will (1) connect the geometry of a triangular tiling to the arithmetic of quaternions, and (2) be applicable to classical number theory, e.g., variations on quadratic forms.

Author:
Amethyst Price, *PhD Student, UC Santa Cruz*

An Overview of the Study of Infinite-Dimensional Integrable Systems

When it comes to nonlinear partial differential equations, one can almost never find an exact solution by hand in terms of elementary functions. However, there does exist an important class of nonlinear PDE for which this is possible. Such equations - referred to as integrable - typically model wave propagation and possess many more interesting properties aside from their solvability. This poster will give an overview accessible to a general audience of the study of integrable systems, which has been an active research area since the late 1960's. We will discuss how such systems can be found, their physical and mathematical significance, the methods used to solve them, and recent developments in the field.

Author:
Nicholas Ossi, *Florida State University*

Classifying Ideals Based on Multiplicative Structures in Homology

Ideals in the algebra of power series in three variables can be classified based on the multiplicative structure on their Tor algebras. The classification is incomplete in that it remains open which structures actually occur; this realizability question was formally raised by Avramov in 2012. An answer to this question would give insight into possible generating functions for the Betti numbers of ideals in local rings, an important homological invariant. In this work, we survey which classes have been realized in the literature and detail the presenter's contributions towards an answer to the realizability question.

Author:
Alexis Hardesty, *Texas Woman's University*

Pre-Service Teachers' Mathematical Identities in Reflective Writing

In mathematics education courses, it is necessary for pre-service teachers to reflect on what it is to learn and teach mathematics. Using reflective writing, pre-service teachers have the opportunity to introspect the roles they play as a student and a teacher.

Author:
Joni Lindsey, *Lake Superior State University*

Graduate coursework on mathematics teaching and learning in higher education.

This poster will highlight findings from a pilot of a course on mathematics teaching and learning in higher education designed specifically for graduate students in the mathematical sciences. It provided students a strategic set of opportunities to explore and practice applying prominent learning theories, evidence-based strategies for instruction and assessment, and the teaching and learning of proof. Furthermore, students were able to create one-page summaries for potential grant proposals for research on teaching and learning and construct teaching statements for use in their future job searches. We will share a general outline of the course as well as findings from a survey given to the students at completion of the course to explore what worked well and what could be refined in the future. Finally, we will highlight the potential for departments to adapt this course in order to better equip their graduate students for their current and future teaching assignments.

Authors:
Sam Vancini, *University of Florida*
Catherine Paolucci, W*estEd*
Mike Jury, *University of Florida*

Sequentially Congruent Partitions

This talk stems from an undergraduate research project on integer partitions, finite sums of positive integers that make deep connections in algebra, analysis and combinatorics. In our project we discovered an interesting class of partitions, the parts (summands) of which obey a strict congruence condition we refer to as "sequential congruence": the mth part is congruent to the $(m + 1)$th part modulo m, with the smallest part congruent to zero modulo the length of the partition. Sequentially congruent partitions appear in partition theory in two surprising ways. In the initial 2019 paper on the subject, undergraduate

M. Schneider and the speaker prove the number of sequentially congruent partitions with largest part equal to n, is equal to the partition function $p(n)$. In a follow-up 2021 paper, Sellers, Wagner and the speaker prove the number of sequentially partitions of size n (sum of parts), is equal to the number of partitions of size n whose parts are perfect squares.

Authors:
Robert Schneider, *Michigan Technological University*
Maxwell Schneider, *University of Georgia*
James Sellers, *University of Minnesota*
Duluth Ian Wagner, *Boston Consulting Group*

Numerical Solutions for Systems of Caputo Fractional Differential Equations with Initial Conditions using Laplace Transform Method

In our previous work, we obtained numerical solutions for sequential Caputo fractional differential equations of order 2q with a linear nonhomogeneous term, utilizing the Laplace transform method. In this current study, we extend our work to develop numerical solutions for systems of Caputo fractional differential equations with order q, where $0 < q < 1$, using the Laplace transform method. The method yields the integer results as a special case.

Authors:
Buna Sambandham, *Utah Tech University*
Aghalaya Vatsala, *University of Louisiana at Lafayette*

Navigating the Landscape of Fear

The term "Landscape of Fear" broadly refers to the impact of predators (real or perceived) on the spatial distribution of and resource utilization by foraging prey animals. However, many classical optimal foraging models have primarily considered simple, discrete environments that do not capture the richness of this spatial structure. In this project, started as part of a summer REU program and continued in collaboration with a team of undergraduate students, we extend those techniques to a continuous, two-dimensional spatial domain. We also seek to capture the impact of predation, imperfect planning, and the depletion of food on the optimal behavior of the planner. We represent the resulting system as a piecewise-deterministic Markov process over a finite time horizon with value functions governed by a system of coupled Hamilton-Jacobi-Bellman PDEs. Using the resulting optimal policies, we construct optimal trajectories and examine predicted usage patterns across various environments.

Authors:
Marissa Gee, *Cornell University*
Nicolas Gonzalez-Granda, *Virginia Tech*
Sunay Joshi, *Princeton University*
Nagaprasad Rudrapatna, *Duke University*
Anne Somalwar, *Rutgers University*
Alexander Vladimirsky, *Cornell University*

Expectation of Chromatic Number for Graph Sequences with a Randomly Added Edge

Consider a sequence of graphs, G1, G2, … , GT of a fixed order = n, constructed by increasing the size of the graph by 1 edge at each step in the sequence, such that E(G1)={0}, E(G2)={vi1vj1}, E(G3)= {vi1vj1, vi2vj2}, where edges may be incident, and so on up to GT, where E(GT) = {vi1vj1, vi2vj2, vi3vj3, …, viTvjT} such that the size of GT, |E(GT)|=T. Then, taking the chromatic number of the graph GT, χ(GT), as a random variable, we can construct the expectation of χ(GT), given by E[χ(GT)] = 1/(Product from k=0 to T of ((nC2)-k)[Sum from i=0 to ω(G)-3 (Product from k=|K3+i| to T ((nC2)-k)(nC3+i)(3+i) + 2[(Product from k=0 to T ((nC2)-k) – Sum from i=0 to ω(G)-3 (Product from k=|K3+i| to T ((nC2)-k)(nC3+i)]], where nCk is given by n!/k!(n-k)! and is read as "n choose k", ω(G) is the cardinality of the

maximum clique in G, and K3 is a 3-clique, K3+1 is a 4-clique, and K3+i is a (3+i)-clique. This can be visualized for sequences of graphs of order 4 or 5.

Author:
Chris Krol, *Rutgers University*

Poster Session for Projects Supported by the NSF Division of Undergraduate Education

Thursday, August 3, 9:00 a.m. - 10:30 a.m., West Hall (Exhibit Hall)

NSF's Division of Undergraduate Education (DUE) grant projects are designed to improve curricula, instruction, laboratories, infrastructure, assessment, diversity, and collaborations at two- and four-year colleges and universities. This session will highlight the progress of these projects and create space for the project personnel to exchange ideas with other faculty and researchers working to strengthen STEM education.

Organizers:
Jana Talley, *Jackson State University*
Audrey Malagon, *Virginia Wesleyan University*
Erin Moss, *Millersville University*

Sponsor:
MAA Math Values NSF DUE Point Blog

The S-STEM program for mathematics majors at the University of Texas at Arlington

The S-STEM program for undergraduate mathematics majors at the University of Texas at Arlington has been running since 2008 with the funding provided by the NSF Division of Undergraduate Education. The experience gained, the improvements made, and the lessons learned are shared as a result of running the program over the years. Various aspects of the program are discussed, including the recruitment, arranging cohort activities, mentoring, monitoring scholars' progress, reporting, and dissemination. Some relevant data are presented, and the impact of the program on the undergraduate and graduate mathematics education at the University of Texas at Arlington is described.

Authors:
Tuncay Aktosun, *University of Texas at Arlington*
Yolanda Parker, *Tarrant County College*
Jianzhong Su, *University of Texas at Arlington*

Undergraduate Service Learning Experiences with Data: Mathematics in the Community

STAT 1100: Data Literacy and Visualization is designed to satisfy the University of Nebraska at Omaha general education quantitative literacy requirement. Data is ubiquitous in all types of organizations today, and individuals who have knowledge and skill in working with data, coupled with discipline-specific expertise, are increasingly valuable assets. In this learn basic statistics, data organization and manipulation skills as well as appropriate visualization techniques and software. In the service-learning component of the course, students apply their knowledge and skills to the real-world data and problems of local non-profit organizations.

Authors:

Becky Brusky, *University of Nebraska at Omaha*
Betty Love, *University of Nebraska at Omaha*
Michelle Friend, *University of Nebraska at Omaha*
Mahbubul Majumder, *University of Nebraska at Omaha*
Andrew Swift, *University of Nebraska at Omaha*
Julie Dierberger, *University of Nebraska at Omaha*

Revised Calculus Concept Inventory: Challenges in Creating a Fair Instrument Across Subgroups

Understanding the foundations of calculus is essential to students' future learning; understanding what students know after completing their first course in calculus is essential to teachers and researchers who seek to further advance student knowledge. A student assessment instrument which accurately measures students' knowledge and understanding of the concepts taught across first calculus courses is needed. The current research team has designed the Revised Calculus Concept Inventory (RCCI) to build on prior efforts. The proposed poster session will review the process that has been used to develop the RCCI and the 23 questions that comprise this inventory. Based on the results of using Mantel-Haenszel, Lord, and Raju methods, two questions showed gender-related DIF, five questions showed race-related DIF, and one item showed ethnicity-related DIF. The proposed poster will highlight these questions and outline current efforts of revision in response to these findings.

Authors:
Barb Moskal, *Texas Tech University*
Jerry Dwyer, *Texas Tech University*
Brock Williams, *Texas Tech University*
Jaehoon Lee, *Texas Tech University*
Isabell Server, *Texas Tech University*
Laura Juarez, *Texas Tech University*

Noyce Scholars: Shedding Light on Impactful Approaches

Texas Tech University received funding from the National Science Foundation in 2019 to implement the "Leveraging Learning Assistantships, Mentoring, and Scholarships to Develop Self-Determined Mathematics Teachers for West Texas" (NSF 1852944). After four years of implementation, many lessons have been learned with respect to recruitment, training, certification, content delivery, retention and placement. This poster will review both effective and ineffective methods that have been tested through this project's implementation. By analyzing the impact of current strategies, the next generation of Noyce programs can be designed to maximize potential benefits to participating scholars.

Authors:
Jerry Dwyer, *Texas Tech University*
Brock Williams, *Texas Tech University*
Barb Moskal, *Texas Tech University*
Isabell Server, *Texas Tech University*
Laura Juarez, *Texas Tech University*

Developing research-informed instructional materials for undergraduate transition-to-proof courses

This poster aims to showcase our research on how students abstract logical relationships and our development of curricular materials for transition-to-proof courses. We highlight on how our research on students' abstraction of logic and task design for transition to proof courses were intertwined with each other, through two related projects: "Extending a Theoretical Model for Undergraduate Students' Reflection and Abstraction of Proof Structures in Transition to Proofs Courses" (DUE-1954613 & DUE-1954768) and "Generating a Research-Informed Transition to a Mathematical Proof Curriculum" (DUE-2141925). We present key findings, including how students abstract logical relationships and use their

understandings in further reading and comprehending proof-texts. We also present how we collaborated with research mathematicians to develop rich proof-texts to help undergraduate students help humanize mathematics and thus develop a sense of belonging in proof-based mathematics.

Authors:
Kyeong Hah Roh, *Arizona State University*
Paul Dawkins, *Texas State University*
Kristen Lew, *Texas State University*
Kathleen Melhuish, *Texas State University*

Augmented Reality and Artificial Intelligence for Learning Spatial Transformations

We present a novel piece of mathematics education technology that aims to improve student's understanding of spatial transforms through the use of augmented reality and artificial intelligence. Specifically, we use artificial intelligence to generate an augmented reality overlay for physical manipulatives which allows students to view the associated rotation and translation matrices in real time. Students can then use this real time overlay to develop an intuition on how to answer mathematical questions related to spatial transformations.

This material is based upon work supported by the National Science Foundation under Grant No. 2119549.

Authors:
Preston Tranbarger, *Texas A&M University*
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Samantha Aguilar, *Texas A&M University*
Heather Burte, *Texas A&M University*
Yingtao Jiang, *Texas A&M University*
Jeffrey Liew, *Texas A&M University*
Uttamasha Monjoree, *Texas A&M University*
Chengyuan Qian, *Texas A&M University*
Francis Quek, *Texas A&M University*
Coby Scrudder, *Texas A&M University*
Zohreh Shaghaghian, *Texas A&M University*
Leo Solitare-Renaldo, *Homeschooled Highschool*
Dezhen Song, *Texas A&M University*
Carl Van Huyck, *Independent Contractor*
Wei Yan, *Texas A&M University*
Shu-Hao Yeh, *Texas A&M University*

Building Interdisciplinary Partnerships to Create Application-Focused Mathematics Content, A SUMMIT-P Project: NSF#1625557

At Virginia Commonwealth University (VCU) the Mathematics Department has partnered with Engineering faculty under NSF award 1625557, to create activities that allow Differential Equation students to interact with mathematical content in an application focused format. VCU is part of SUMMIT-P: A National Consortium for Synergistic Undergraduate Mathematics via Multi-institutional Interdisciplinary Teaching Partnerships that is an extension of work begun in the Curriculum Renewal Across the First Two Years (CRAFTY) project. We present how faculty conversations between departments can enrich the mathematics curriculum and lead to stronger student engagement. VCU has documented a consistent increase in student attitudes relative to the relevance of the content in differential equations regarding further course and for their careers after college.

Author:
Rebecca Segal, *Virginia Commonwealth University*

Creating and Sustaining a SoTL Community Network in Mathematics
In this session we will discuss our experience of creating a sustained community of scholarship of teaching and learning (SoTL) practitioners that provides mentoring and support to each other in their SoTL projects with online and hybrid collaboration tools. In particular, we will describe the summer workshops and different research projects developed in the network. This project "Supporting and Sustaining Scholarly Mathematical Teaching" is supported by an NSF DUE grant (#1725952).
Authors:
Fei Xue, *University of Hartford*
Mako Haruta, *University of Hartford*
Celil Ekici, T*exas A&M University-Corpus Christi*
Larissa Schroeder, *University of Nebraska at Omaha*

Meaningful Mathematics for Students' Success (M2S2)
With a grant support from the NSF's Improving Undergraduate STEM Education: Hispanic-Serving Institutions, the project aims to enhance students' college preparedness by developing a contextualized College Algebra/College Readiness Skills (CACRS) hybrid course designed by a professional learning community, comprised of secondary and postsecondary math faculty.
Authors:
Ganga Acharya, *CNM, Albuquerque*

Algebra Instruction at Community Colleges: Mathematical Knowledge for Teaching Community College Algebra
One component of the Algebra Instruction at Community Colleges: Validating Measures of Quality Instruction (VMQI), a National Science Foundation-funded project (ECR awards 20006021, 20006021, 20005273, 20005664), is developing an instrument to measure mathematical knowledge for teaching community college algebra (MKT-CCA). We hypothesize that teacher knowledge needed to teach mathematics is multidimensional. We present initial psychometric results of the large-scale field test of the MKT-CAA with respect to our hypothesized model which has six dimensions, two tasks of teaching (choosing problems and understanding students work) and three content areas (linear, exponential, and rational functions). The poster gives an overview of our project highlighting the blueprint and the various stages of our process. We will outline some challenges we encountered and limitations in our work to design and to validate the instrument.
Authors:
Bismark Akoto, *University of Minnesota*
Dexter Lim, *University of Minnesota*
Irene Duranczyk, *University of Minnesota*
VMQI Team, *AI@CC Research Group*

Making STEM Matter: Teacher Leadership, Justice-Centered Pedagogy and Makerspace Technology
This NSF-DUE Robert Noyce Teacher Scholarship Program - Track 3 project (Award #2243461) will serve a national need of developing teacher leaders of science, technology, engineering, & mathematics (STEM) to sustainably improve STEM education in middle & secondary grades.Our project beginning July 1, 2023 establishes a professional learning community with 15 Master Teacher Fellows (MTFs) in a Maryland urban school district.The learning community will support MTFs' in transforming their instruction by: (1) integrating equity- & justice-centered STEM pedagogies & (2) leveraging makerspaces to introduce new opportunities for community-oriented STEM learning.We present results of pilot work conducted in 2022-23, including (1) survey analysis related to the partnering district's teachers' self-

efficacy, agency, values & leadership, & (2) examples of justice-centered STEM lessons used with in-service teachers enrolled in the Towson University Master of Science Mathematics Education program.

Authors:
Diana Cheng, *Towson University*
Sandy Spitzer, *Towson University*
Mary Stapleton, *Towson University*

An Interdisciplinary, Problem-Based Curriculum for STEM Students: an NSF S-STEM Project at Utah Tech University

Interdisciplinary collaboration in STEM is essential for addressing complex problems, fostering innovation, and preparing students for future careers. Utah Tech's Innovative Scholars Program for Interdisciplinary Research (INSPIRE) integrates student teams from various disciplines (mathematics, engineering, biology, computer science, chemistry, and environmental sciences) into problem-based learning to enhance STEM education. Funded by NSF (DUE – 2030858), INSPIRE spans three semesters, including research, design, product development, and entrepreneurship training. Students identify real-world problems, prototype solutions, and learn entrepreneurship for product marketing. This approach promotes collaboration, achieves high learning gains, and requires less faculty workload, suiting institutions prioritizing teaching. We'll share updates on this multi-year program and future directions.

Authors:
Vinodh Chellamuthu, *Utah Tech University*
Aaron Davis, *Utah Tech University*
Wendy Schatzberg, *Utah Tech University*
Alex Tye, *Utah Tech University*

Implementing Techtivities to Promote Covariational Reasoning and Instructional Transformation in College Algebra (ITsCRITiCAL #2013186)

This project aims to enhance college algebra instruction and improve students' mathematical reasoning. The initiative is a collaboration between CU Denver and three Hispanic-serving institutions: MSU Denver, Santa Fe Community College, and Texas State University. These institutions cater to substantial populations of students from underrepresented groups. The project promotes mathematical reasoning skills over answer-finding. To achieve this, interactive, web-based activities, called "Techtivities", have been developed. They are built around video scenarios, such as the movement of a Ferris wheel, and require students to represent covariant properties. To promote effective implementation, the project provides instructor PD and fosters Communities of Transformation. Instructors receive support in utilizing the Techtivities to promote student reasoning. By transforming instructional practices in foundational math courses, the project aims to bolster student persistence in STEM majors.

Authors:
John Carter, *Metropolitan State University of Denver*
Gary Olsen, *University of Colorado Denver*
Bikai Nie, *Texas State University*
Belin Tsinnajinnie, *WestEd*
Heather Johnson, *University of Colorado Denver*

The Deep End of the Pool: Studying Early Undergraduate Research Experiences in Mathematics

The authors share preliminary findings from an investigation of the ways in which mathematics research projects, conducted early in students' undergraduate mathematical careers (often before precalculus) and around mathematical questions that students pose, can spark students' engagement and interest.

Author:
Terrance Pendleton, *Drake University*

OPEN Math: Online Professional Enhancement and Capacity Building for Instructional Practices in Undergraduate Mathematics

This collaborative project (DUE #2111260 and #2111273) serves the national interest by implementing, assessing, and understanding effective practices in delivering online, teaching-focused professional development to instructors of undergraduate mathematical sciences. Current models limit impact by tacitly restricting participation, largely because those models require travel or other support that is neither universally available nor sustainable in the long term. To this end, MAA and CU-Boulder will implement and study a new online PD program that will reach higher education professionals, including those less able to participate in traditional models. We will determine effective use of online tools and practices to deliver professional training around themes of active learning in the mathematics classroom, leading to a broad impact on mathematics instruction. Additional attention to capacity building and institutional change will exponentially increase the level of impact.

Authors:
Doug Ensley, *Mathematical Association of America*
Sandra Laursen, *University of Colorado - Boulder*
Stan Yoshinobu, *University of Toronto*
Deirdre Smeltzer, *Mathematical Association of America*
Tim Archie, *University of Colorado*

Challenges and Celebration a NSF S-STEM Supported Program

The NSF S-STEM SEER: Supporting, Engaging, Empowering and Retaining New Scholars in Science, Technology, Engineering and Mathematics project (#1930437), builds upon lessons learned from two successful NSF S-STEM grant programs. Improving retention and graduation to increase the participation of underrepresented minority or female students in STEM undergraduate programs and in the New York City workforce are essential programmatic goals, with the purpose of providing life-transforming socio-economic opportunities to our students that should lower the equity gaps in the wider community. The overall goal of this project is to increase STEM degree completion of low-income, high achieving undergraduates with demonstrated financial need, by increasing the number of URM graduates and shortening the time to graduation. The project is particularly concerned with generating useful knowledge about academic success, retention, graduation, and academic/career pathways of low-income students.

Authors:
Urmi Duttagupta, *New York City College of Technology, CUNY*
Nadia SKennedy, *New York City College of Technology, CUNY*
Diana Samaroo, *New York City College of Technology, CUNY*
Viviana Acquaviva, *New York City College of Technology, CUNY*
Armando Solis, *New York City College of Technology, CUNY*

Calculus with Algebra, a Two-Semester Long Calculus I Course

We discuss logistics and results regarding a 2-semester long extended Calculus course with no prerequisites. We compare success rates between students in this course and students starting in a prerequisite course. The course used Standard Based Grading (SBG), an assessment system that lets students demonstrate learning throughout the semester on any learning objective. SBG was new to both the instructor and the students. We used a 3-step grading system for each assignment: M-meets expectations, R-revision needed, I-insufficient; receiving an M in a topical learning objective corresponding to an A or A- level work. Students carefully read the detailed feedback they received, and discussions focused on learning the material instead of getting some additional points on any assignment. Very few students preferred the traditional grading system to SBG. WebWork was the electronic platform for homework during the course. This project is partially supported by NSF IUSE grant #2120720.

Authors:
Jenna VanSickle, *Valparaiso University and Lilly Fellows Program*

Zsuzsanna Szaniszlo, *Valparaiso University and University of Chicago*

A Data-Oriented Probability and Statistics Course at the U.S. Air Force Academy
In the fall of 2022, the Department of Mathematical Sciences (DFMS) at the U.S. Air Force Academy (USAFA) modernized our introductory probability and statistics course for non-technical majors. We undertook this effort in response to guidance from the Mathematical Association of America (MAA) and the American Statistical Association (ASA), and direction from leadership in the Department of Defense (DoD), who have stressed the need for officers with better data acumen. We changed this course from what had been primarily a statistical literacy course to a more data-oriented and technologically relevant course. We adopted a textbook that provides an intuitive introduction to statistical inference utilizing modern computing tools (R and the Tidyverse). Furthermore, we adopted a series of in-class activities completed via Posit.Cloud. Our poster will summarize the changes, lay out the current structure, display examples of work presented by cadets, and discuss proposed changes.
Author:
Ken Horton, *U.S. Air Force Academy*

Inclusive Course Design for Enhancing Active Learning in Mathematics and Statistics
Inclusive Course Design for Enhancing Active Learning in STEM (IDEALS) aims to change classroom culture in a Department of Mathematics and Statistics and four additional STEM departments through focused workshops and a learning community for faculty. This poster focuses on the components of the workshop, which will start in 2024 at Auburn University, supported from NSF DUE award #2236315. Our project will investigate how interdisciplinary faculty professional development can impact student engagement and success. In this presentation, we will share our theory of planned behavior that we posit will allow us to predict whether faculty plan to adopt what they learn in the professional development in their teaching, by measuring attitudes toward professional development, social climate surrounding the intervention, and level of perceived control over ability to engage in the recommended teaching strategies.
Authors:
Melinda Lanius, *Auburn University*
Lindsay Doukopoulos, *Auburn University*
Karen McNeal, *Auburn University*
Stephanie L. Shepherd, *Auburn University*

Developing Mathematical Knowledge for Teaching Using MODULE(S2) Materials
The Mathematics of Doing Understanding Learning and Educating for Secondary Schools [MODULE(S2)] project created curricular materials for university mathematics instructors to use as they teach prospective secondary mathematics teachers in algebra, geometry, modeling, statistics, and capstone courses. The materials provide opportunities for prospective secondary teachers to develop mathematical knowledge for teaching and are designed to be taught with equity-based teaching practices. These practices include going deep with mathematics and affirming mathematics learners' identities for everyone taking the course. Research findings reveal that prospective teachers who learn with MODULE(S2) materials not only increase their mathematical knowledge for teaching, but they also increase their expectancy using research-based mathematics teaching practices while teaching secondary content. Free access to the materials and links to additional research findings can be found at WWW.MODULES2.COM
Authors:
Jeremy Strayer, *Middle Tennessee State University*
Christopher Bonnesen, *Middle Tennessee State University*

Professional Development Gets a Facelift: Qualitative Feedback of an Inclusive Active Learning Mentoring Cohort

Funded by an NSF grant (Award Number: 2111262), Valencia College designed a series of professional development for mathematics instructors to develop inclusive active learning lessons. The professional development has a cohort design, with mentors guiding mentees in their design and implementation of inclusive active learning techniques. This session will describe both the study design and the novel professional development, as well as report on the qualitative feedback from the mentors and mentees of the first cohort. Faculty perceptions of the impact on themselves and their students will be detailed.

Authors:
Sidra Van De Car, *Valencia College*
Brandon Armstrong, *Valencia College*
Deb Howard, *Valencia College*
Ryan Kasha, *Valencia College*
Keri Siler, *Valencia College*
Dori Haggerty, *Valencia College*

PVAMU SUMS Scholars: Report on the Results of the Project's Mathematics Cohorts

The Prairie View A&M University Scholars in Undergraduate Math and Sciences (SUMS) project is funded by the NSF S-STEM program. This is a multidisciplinary effort, with Biology, Chemistry, Physics, and Mathematics working together to provide a program for high-achieving students who demonstrate financial need and plan to enter the workforce or pursue a post-undergraduate degree or licensure in the aforementioned fields. Housed at an HBCU, this project provides a multiyear learning and mentoring experience preparing students for undergraduate research, internship opportunities, and overall preparation for life after undergraduate studies.

In this poster, we will review and discuss the cohort treatment implemented, where the students enrolled in Calculus I in cohorts. Strategies implemented, and their successes and failures, will be discussed. Some focus will also be devoted to the differences observed between the online synchronous cohort and the in-person cohorts that followed.

Authors:
James Valles Jr., *Prairie View A&M University*
Asia Ballinger, *Prairie View A&M University*
Fred Bonner II, *Prairie View A&M University*
Orion Ciftja, *Prairie View A&M University*
Alphonso Keaton, *Prairie View A&M University*
E. Gloria C. Regisford, *Prairie View A&M University*

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Authors:
Sidra Van De Car, *Valencia College*
Brandon Armstrong, *Valencia College*
Deborah Howard, *Valencia College*
Ryan Kasha, *Valencia College*
Keri Siler, *Valencia College*

Outreach Activities Poster Session

Thursday, August 3, 9:00 a.m. - 10:30 a.m., West Hall (Exhibit Hall)

All members of the mathematical community are welcome to present posters about their outreach activities. Some possible activities are camps, math days, math circles, Sonia Kovalevsky Days, and anything else that makes math more exciting and fun for the broader community. The goal of the session is to showcase these activities and present ways to get involved in outreach activities.

Organizers:
Zsuzsanna Szaniszlo, *Valparaiso University*
Candice Price, *Smith College*
Rachelle DeCoste, *Wheaton College*

The Arizona Women's Symposium in Mathematics (the AWSiM Conference)
Through the MAA Tensor Grant for Women in Mathematics, we organized the first Arizona Women's Symposium in Mathematics (AWSiM) that took place on November 5-6, 2022 at Embry-Riddle Aeronautical University in Prescott, Arizona. This weekend-long conference was the first of its kind in Arizona where women mathematicians across the state shared their research in a supportive environment, formed a network of women mathematicians within the state, and developed action plans to increase the recruitment and retention of women in mathematics in their respective institutions in Arizona. This conference included two plenary speakers, contributed research talk sessions, a teaching workshop on equity and inclusion, and a session centered on the challenges encountered by women in mathematics. This presentation will highlight our experiences in organizing this state-wide conference and how AWSiM was a starting point for the mathematical community to support women in mathematics in Arizona.
Authors:
Angelynn Alvarez, *Embry-Riddle Aeronautical University*
Angie Hodge-Zickerman, *Northern Arizona University*

GirlsGetMath@CSU
GirlsGetMath@CSU is a weeklong, non-residential summer mathematics program for high school students and is hosted by the Department of Mathematics at Colorado State University. Modeled after GirlsGetMath@ICERM, our summer program aims to develop young women's positive relationships with STEM-related fields, strengthen their sense of belonging in mathematics, and build positive self-esteem and confidence in their ability to excel in mathematics. GirlsGetMath@CSU exposes students to mathematical and computational activities in a variety of mathematical topics that are not typically taught in high school. Students are immersed in a supportive mathematical community of learners where content is delivered through inquiry-based instruction, group work, games, hands-on activities, and computer labs implemented in MATLAB and Python. The program is taught exclusively by female professors and graduate students, who serve as role models and mentors to students.
Authors:
Elizabeth Arnold, *Colorado State University*
Jamie Juul, *Colorado State University*

FGCU Mathletes Circle for Bright and Talented Middle School Students
FGCU Mathletes Circle is a non-profit year-round enrichment program for bright and talented middle school students organized by Tanya Huffman and Menaka Navaratna from the Department of

Mathematics. The Mathletes Circle consists of Mathletes Summer Camp, Saturday Mathletes Day sessions during regular semesters and AMC-8 Competitions. The ultimate objective of this program is to strengthen middle school students' interest in mathematics and provide early experience and exposure to STEM related careers with mathematical foundations.
The program has had a tremendous success since it was first introduced in the summer of 2014, attracting a diverse group of middle school students from around Southwest Florida. Over 360 middle school students have attended the program since 2014. We partnered with Immokalee Middle School to reach out to talented students from low-income and minority families. Over 130 Immokalee Middle School students have received scholarships to attend Mathletes Circle.
Authors:
Tanya Huffman, *Florida Gulf Coast University*
Menaka Navaratna, *Florida Gulf Coast University*

Mathematical Puzzle Programs
Try to solve several puzzles designed by our team at Mathematical Puzzle Programs that demonstrate how our outreach events get general audiences engaged in contemporary mathematical subjects!
Authors:
Steven Clontz, *Univeristy of South Alabama*

808 Math Island Style: Computational Modeling and Simulation of Epidemic Infectious Diseases
Our outreach initiative was developed by a team of faculty and funded by the MAA Neff Fund Outreach Program. The goal is to create a multidisciplinary learning environment for students in a relevant context. We worked for this project with groups of students from populations largely under-represented in STEM. This project was composed of three parts:
Development of a new curriculum centered around mathematical epidemiology (analyzed how the disease has disproportionately affected certain ethnic groups compared to others); Fellows have been visiting participating schools weekly for 2 months to implement the developed curriculum, observing a significant growth and engagement in the students; The State Math Challenge on April 28, 2023. An entire day dedicated to analyzing data of a new fictional virus emerging on Earth in 2078 (~100 students and teachers). Dr. Kyle Dahlin, one of only six Native Hawaiians to earn a PhD since 1964 was a guest speaker at the event.
Authors:
Monique Chyba, *University of Hawaii*
Ralph Martin Adra, *University of Hawaii*
Yuriy Mileyko, *University of Hawaii*
Winnie Lau, *University of Hawaii*

***Girl Scouts: Math in Nature*?**
Math is all around us all the time! Many mathematicians find inspiration and the roots of their mathematical concepts by observing nature. To spotlight the connection between the great outdoors and the M in STEM, Girl Scouts created the Math in Nature badge sets for Daisies, Brownies, and Juniors (K-5th grades).
These badges live in the intersection of science and math, helping girls discover patterns and shapes in nature, explore symmetry and tessellation, and learn how to use math for data collection and measurements.
By linking math with hands-on activities that girls love, we can help girls find the creativity and grow their interest in Math. Research shows that while girls and boys do not differ in their math and science abilities, they do differ in their interest and confidence in STEM subjects. Educators need to support and help grow girls' interest and confidence in math. The new Girl Scout badges are a great way to do this!
Authors:

Sarah Megyesi, *Girl Scouts of Montana and Wyoming*
Briana Black, *Girl Scouts of Montana and Wyoming*

Interleaving STEM Through Outreach

Conducting Science, Technology, Engineering, and Mathematics outreach is a critical supporting effort to the United States Military Academy's primary mission of developing leaders of character. West Point faculties and cadets integrated various aspects of a newly developed Global Positioning System outreach module that is hands-on-interactive logic board that teaches and reinforces the basics of critical thinking and problem-solving skills. Cadets and faculties led discussions on the integration of GPS into our daily lives, utilizing a 3D printed geometric dilution of precision training kit, and emphasizing the importance of STEM. Our GPS module have successfully demonstrated how mathematics, physics, and computer sciences can be interleaved into a meaningful engaging experience for students participating in afterschool enrichment programs, summer camps, and other STEM related activities at West Point and across the state of New York. This is supported by NSFIAA214–4942 and CLD STEM.

Authors:
Mai Tran, *United States Military Academy at West Point*
Diana Loucks, *United States Military Academy at West Point*
Connor Van DeMark, *United States Military Academy at West Point*

Mathematics Olympiad

With the Neff grant, ASMSA provided resources for 5 different middle schools to create and develop math teams on their campuses. The teams were then invited to take part in a Math Olympiad event, which was hosted on the campus of the Arkansas School for Math, Sciences, +The Arts in Hot Springs, Arkansas.

By using the Neff grant to create opportunities for middle school students to engage with math in a fun, competitive way, ASMSA aims to foster a more positive view of mathematics, more engagement and interest in math, and expose middle school students to further opportunities to explore math and other STEM subjects through ASMSA's outreach and residential programs in the future.

Authors:
Jason Hudnell, *Director of Admissions, Arkansas School for Math, Sciences, +The Arts*

The Kentucky Math Carnival

The Kentucky Math Carnival was a one-day event for middle school students from Lexington, Kentucky and its six surrounding counties. Engaging hands-on activities supervised by University of Kentucky graduate students and faculty introduced participants to new areas of mathematics outside the standard curriculum, as well as educational and career opportunities. A non-competitive and collaborative environment was put in place to encourage all participants, especially underrepresented groups. The overall goal was to boost the enthusiasm for mathematics at a stage when middle schoolers often disengage, and to provide outreach training and experience for graduate students.

Authors:
Ehren Dolan, *University of Kentucky*
Noah Owen, *University of Kentucky*
Lisa Reed, *University of Kentucky*

Social-Justice Based Modeling Activities for Middle School Students

Education researchers have long called for incorporating social justice into K-12 curriculum. However, it is still relatively rare for teachers to engage in this type of instruction. To support teachers in incorporating social justice into the math classroom, we worked with pre-service and in-service teachers to develop and implement social-justice based modeling activities with middle school students around greater Baltimore, Maryland and disseminated these findings to middle school teachers in the region. We

share details of the activities developed, the ways we engage school students in the community, and how we structure professional development for local teachers. We hope these types of context-based activities motivate students to learn (and continue learning) about STEM and the numerous applications of mathematics while simultaneously supporting students in developing a better understanding of relevant societal issues.

Authors:
Kristin Frank, *Towson University*
Diana Cheng, *Towson University*
Kimberly Corum, *Towson University*
Anahi Aguilera, *Towson University*
Devani Sharma, *Towson University*

Cafecito con Matemática

With the growing emphasis on diversifying mathematics, we take to heart our responsibility to build partnerships with local communities to help make math more equitable and just. Cafecito con Matemática (CM) is a math outreach event run by Colorado State University which serves local elementary schools with diverse cultural and linguistic student populations. Occurring monthly during the evenings, CM provides students and their families with dinner and then engages everyone in fun, culturally relevant math games and activities, facilitated by teachers and university members (including pre-service teachers who gain valuable experience interacting with families). All materials are provided in English and Spanish to create accessibility and promote bilingualism. Ultimately, CM seeks to create a space which validates and leverages families' mathematical knowledge, while also providing them with resources to help their children develop their learning of math, excitement, and curiosity.

Authors:
Elizabeth Arnold, *Colorado State University*
Jocelyn Rios, *Colorado State University*

Building a Pipeline: Two New Diversity Initiatives at the University of South Alabama

In the past year, we have started two outreach programs at the University of South Alabama (USA) that reach from middle school to college research experiences. An NSF LEAPS-MPS grant is funding a branch of the Math Corps program to support members of underrepresented groups from underserved communities. During a four-week summer camp, Math Corps brings together middle-school campers and high-school teaching assistants, in teams that are led by college students. An MAA Tensor Women & Mathematics Grant is supporting the goal of increasing the number of women pursuing undergraduate research at USA. During a research seminar in the fall semester, students learn the basics of mathematical research and begin exploring open-ended problems. Some of the women who complete the research seminar are funded to continue their research problems during the spring semester. This puts the students in an advantageous position to apply for summer research funding from USA.

Authors:
Joanna Furno, *University of South Alabama*
Elena Pavelescu, *University of South Alabama*

Competing for Pi!

This poster will detail the pi day competition we hold at Lake Superior State University. The competition is multifaceted with both a middle school and high school component.

Authors:
Jennifer Gorman, *Lake Superior State University*
Joni Lindsey, *Lake Superior State University*

Puzzles and A Pint: A Perfect Pairing

Across the pond in the northern country of the United Kingdom, they have a lovely tradition of getting together with friends at Pubs and socializing. A bunch of friends liked math puzzles, so they called their gathering a MathsJam.
MathsJam is a monthly opportunity for like-minded self-confessed maths enthusiasts to get together in a pub and share stuff they like. Puzzles, games, problems, or just anything they think is cool or interesting. We don't have organised talks, planned activities or even strict timings - just turn up and join in.
Now there are organized monthly MathsJams all over the world. The poster will discuss the Waverly MathsJam and MathsJams more generally. MathsJam also runs an annual gathering which takes place every November.
Authors:
Mariah Birgen, *Wartburg College*

Moving Toward Data Science in Statistics and Sports

Thursday, August 3, 3:30 p.m. - 5:00 p.m., West Hall (Exhibit Hall)

Jointly sponsored by the SIGMAA Statistics Education and SIGMAA Mathematics and Sports, we hope to attract contributions from faculty, students and industry professionals who have used ideas from data science to inform their teaching and research; or used their math background to make data science more accessible.

Organizers:
Rick Cleary, *Babson College*
Grant Innerst, *Shippensburg University*

Sponsor:
SIGMAA for Statistics and Data Science Education (SIGMAA SDS-ED)
SIGMAA on Mathematics and Sports (SIGMAA SPORTS)

Embracing Data Science in the Introductory Statistics Classroom
The birthday problem is a fascinating probability puzzle that delves into the likelihood of at least two individuals in a room sharing the same birthday. It serves as a captivating illustration of permutations, combinations, and statistical significance, enriching our understanding of these fundamental concepts.
In this talk, we will explore three distinct methodologies to solve the birthday problem: the traditional approach, simulation-based methods, and the innovative data science approach. Our discussion will shed light on the advantages offered by the data science approach, particularly its flexibility and suitability for individuals with diverse educational backgrounds.
Furthermore, we will delve into the broader application of data science principles within an introductory statistics course. By integrating data science principles into various aspects of the curriculum, we can empower students with practical skills that are highly relevant in today's data-driven world.
Author:
Guadalupe Hernandez, *Instructor of Mathematical Sciences*

Sports Ranking Applications in a Math for Data Science Course
At Trinity University, we teach a Math for Data Science Course. It has a Calculus I/Math for Business and Economics (Precalculus/Calc I Lite) prerequisite and is mostly an applied linear algebra course.

There are several ranking methods that are applications of topics in the course including The Colley Matrix Method (systems of equations), The Massey Method (least squares solutions), and the modified PageRank and Oracle Methods (Markov Chains/Eigenvectors).

Author:
Tom Tegtmeyer, *Trinity University*

A Quest for Consistency: A Comparative Analysis of Figure Skating Judging Systems at the Winter Olympics

In response to a judging scandal related to the pairs & ice dance events at the 2002 Winter Olympic Games conducted under the 6.0 judging system, the International Skating Union developed a new system in hopes of improving the consistency of judges' ratings. This study uses three statistical measures of consistency to compare the ratings within event segments 2002 Olympics with the two most recent Olympics using the new International Judging System (IJS). Results from our analysis indicate that in the pairs free skate & ice dance free dance, there was decreased consistency of average scores, range, and standard deviation under the IJS. Also, between 2018 & 2022, revisions to the IJS improved consistency in the performance scores between 2018 & 2022 but decreased in technical score consistency in 3 figure skating disciplines (men's, women's, pairs).

Authors:
John Gonzalez, *US Department of Defense*
Diana Cheng, *Towson University*
Janet Liu, *Microsoft*

Ranking and Rank Aggregation for NFL Postseason using HITS

There exists a variety of different methods for ranking sports teams. Two popular methods for ranking sports teams are the Massey method and the Colley method. Additionally, the HITS-like Offense-Defense method has been used to successfully rank sports teams. Thus, we explore the use of HITS to rank NFL teams for the postseason based on regular season play. We also show some possible modifications to HITS for ranking sports teams. Then, we demonstrate rank aggregation using HITS with a rank aggregation of the Massey method and the Colley method outperforming both individually.

Authors:
Matthew Kimm, *University of West Florida*
Anthony Okafor, *University of West Florida*
Gary Marmon, *University of West Florida*
Jay Sparks, *University of West Florida*
Kelie Kan, *University of West Florida*

Combining Topological Data Analysis & Machine Learning Techniques to Predict Behavior in Mice

For 3 summers, we worked with undergraduate STEM majors to combine techniques from topological data analysis and machine learning with the goal of identifying the presence of pain in mice. Videos of mice were provided to us by the McCall Laboratory at Washington University for this project. Our student researchers have created a software pipeline that begins by running an open source program (DeepLabCut by Mathis Lab) to extract positional data of the mice from the videos. The pipeline then uses persistent homology and kernel density estimation to reduce the positional data to a few prominent features. These features are not interpretable and so do not represent physical characteristics of the mice. Finally, the pipeline runs several machine learning algorithms on the reduced set of features to predict the state (pain or no pain) of the mice. While we focus on pain in mice, the pipeline could be used in general for classifying any binary state using videos of other creatures.

Authors:
Kathleen Ryan, *DeSales University*

Carl Hammarsten, *DeSales University*
Pranshu Gupta, *DeSales University*

Research in Motion (Undergraduate Student Poster Session)

Friday, August 4, 9:00 a.m. - 12:00 p.m., West Hall (Exhibit Hall)
Note: Judges and students only 9:00 a.m. - 10:00 a.m.

This session features research done by undergraduate students. Appropriate content includes, but is not limited to, a new result, a new proof of a known result, a new mathematical model, an innovative solution to a Putnam problem, or a method of solution to an applied problem. Projects that are currently "in progress", but leading towards one of these outcomes are also welcome. Purely expository material is not appropriate for this session.

Organizers:
Sara Malec, *Hood College*
Emily Cilli-Turner, *University of San Diego*
Amber Russell, *Butler University*
Thomas Langley, *Rose-Hulman Institute of Technology*

Sponsor:
Committee on Undergraduate Student Programming (CUSP)

Deborah and Franklin Tepper Haimo Awards

Saturday, 3:00-4:20 p.m., Ballroom B & C

In 1991 the Mathematical Association of America instituted Awards for Distinguished College or University Teaching of Mathematics to honor college or university teachers who have been widely recognized as extraordinarily successful and whose teaching effectiveness has been shown to have had influence beyond their own institutions. In 1993 the MAA Board of Governors renamed the award to honor Deborah and Franklin Tepper Haimo. Each year at most three college or university teachers are honored with this award. Recipients of the Haimo Award receive $1,000 and a certificate of recognition; recipients must be members of the Association (teaching in the U.S. or Canada). At least one of the Award recipients must be a current Section nominee. The Section nominee may be the current recipient of the Section Award for Distinguished Teaching or a previous recipient of a Section Award for Distinguished Teaching from any Section. At most one of the Award recipients may be other than a current or past recipient of a Section Award for Distinguished Teaching.

Winners of the Deborah and Franklin Tepper Haimo Awards for Distinguished College or University Teaching will give presentations on the secrets of their success. This is moderated by MAA President Hortensia Soto, Colorado State University.

Chaos

As a mathematician, I encounter chaos constantly, from the amazingly rich families of complex dynamical systems that I study to the summers that I get to spend working with the absolutely incredible kids in the Math Corps Summer Camp at the University of Michigan. In this talk, we will contemplate the chaos and discover a wealth of riches.

Speaker:

Sarah Koch, *University of Michigan*

Learning to Listen

We improve our teaching by better understanding how others learn. Thus, the best "self-improvement tool" in a teacher's arsenal is learning to listen---to our colleagues, to our students, to the lessons for the scholarship of teaching and learning. Even to our families and friends.

Speaker:

Carol S. Schumacher, *Kenyon College*

Teaching math is hard -- a fifteen-year retrospective

Math is hard." That was the first sentence in my teaching statement when I applied to be a professor 15 years ago. Looking back, there are many things I got right, even more that I got wrong, and there is much I have yet to learn. In this talk, I will share reflections, experiences, and lessons learned from my time teaching at Bates College, promoting equity in mathematics, volunteering for MAA, AMS, and AWM, and interacting on social media.

Speaker:

Adriana Salerno, *Bates College*

Alder Award Session

Friday, 3:00-4:20 p.m., Ballroom B & C

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 Hortensia Soto, Colorado State University.

***Finally felt like I had something to contribute…"* Nurturing student's mathematical discourse by teaching with primary source projects.**

Many instructional approaches in undergraduate mathematics classrooms do not invite, nor recognize, the kinds of discursive shifts that characterize increased participation in the mathematical community. Primary Source Projects immerse students in a mathematical world where they can witness firsthand how ideas evolve over time, and how mathematics is shaped by people and culture. In this talk I describe how I use such projects in my courses and how I've seen students become more flexible, adaptable, confident, and enthusiastic about mathematics as evidenced by changes in their own discourse.

Speaker:

Richard (Abe) Edwards, *Michigan State University*

And Thus, a Writer of Truths: On Identity in Mathematics

We all hold intersecting identities (i.e. race, gender, sexual orientation, disability status, and more) that influence how we traverse through mathematical spaces. Our definitions of success, failure, and progress are informed by our identities and experience. We bring lifetimes into the classroom. Our joys, our suffering, all of it comes with us as we teach and learn from one another. What barriers have we had to overcome? What barriers are we currently overcoming? As we engage in the science of truth, what truths are we being asked to leave behind?

Speaker:

Andrea Arauza Rivera, *California State University, East Bay*

Doing Big Things Together – Building Relationships In and For Mathematics Teaching

As mathematics educators, building relationships with our students allows us to learn their strengths and help them achieve their goals. The same is true of building relationships among educators. In this talk, I'll share lessons learned from three projects that brought together mathematics educators to tackle big challenges – revamping our Precalculus/Calculus I course sequence, developing a 12th-grade math course for high school students, and learning to teach online effectively during the pandemic.

Speaker:

Allison Lynch, *California State University, Monterey Bay*