MAA MATHFEST

2022 | PHILADELPHIA, PA

Abstracts of Papers
Presented at MathFest 2022

August 3 – August 6, 2022

MAA
MATHEMATICAL ASSOCIATION OF AMERICA

Contents

Invited Addresses

MAA Earle Raymond Hedrick Lecture Series

Suzanne Lenhart, *University of Tennessee*

Lecture I - One Health and Modeling: Connecting Humans, Animals, and the Environment
Thursday, August 4, 11:00 a.m. - 11:50 a.m.

'One Health' is a multidisciplinary approach to improving the health of people, animals, and the environment. Mathematical models of infectious diseases involving animals, environmental features, and humans contribute to this approach. We will start with calculating the basic reproductive number R0 for a simple S-I (susceptible-infected) model with two differential equations. These models can suggest management policies and predict disease spread. We will discuss a model involving La Crosse virus in Knox County, Tennessee. This system of differential equations represents animals (specifically mosquitoes) carrying the virus and shows the connection with environmental features. Additionally, we will present a model of Buruli ulcers, a disease caused from environmental exposure, from our collaborations in Africa.

Lecture II - From Calculus to Optimal Control: Optimization for Sustainable Fishery Harvest
Friday, August 5, 10:00 a.m. - 10:50 a.m.

Marine fisheries are a significant source of protein for many human populations, and models can suggest management policies for natural renewable food resources. We will start with the concept of maximum sustainable yield modeled with one ordinary differential equation including constant proportional harvesting using calculus. Optimal control techniques can be used to design time varying harvest rates in systems of ordinary differential equations. We will illustrate these techniques with an example of a food chain model on the Turkish coast of the Black Sea. Incorporating data from the anchovy landings in Turkey, optimal control of the harvesting rate of the anchovy population in a system of three ordinary differential equations (anchovy, jellyfish, and zooplankton) gives management strategies. Finally, the idea of marine reserves in simple spatial models will be introduced.

AMS-MAA Joint Invited Address

Manuel Reyes, *University of California, Irvine*

How Noncommutative Algebra Points toward Quantum Geometry
Thursday, August 4, 10:00 a.m. - 10:50 a.m.

Noncommutative algebra is the study of algebraic systems in which the order of multiplication can affect the outcome of a product. I invite you to explore this weird and wonderful world, beginning with familiar examples from linear algebra and visiting some historical sources of noncommutative algebra. We will learn about its physical relevance through its remarkable connection with quantum mechanics. Then we will discuss its potential to reshape the foundations of geometry as mathematicians try to reconcile noncommutativity with an algebraic perspective on geometry.

MAA Invited Address

Chris Jett, *University of West Georgia*

Empowering Black Male Students in Mathematics Contexts: Insights from a Critical Race Scholar
Thursday, August 4, 9:00 a.m. - 9:50 a.m.

Black male students' mathematics experiences have gained traction in the research literature. The majority of this scholarship has employed a critical race theoretical perspective. Moreover, discussions about critical race theory have entered into mainstream discourse, and these debates have implications for mathematics education. In this talk, I will draw upon my critical race praxis to provide an overview of scholarship regarding the plight of Black male students in mathematics contexts. I will also share evidence-based practices and recommendations that seek to positively influence and ultimately empower Black male students in mathematics classrooms.

Steve Strogatz, *Cornell University and National Museum of Mathematics (MoMath)*

Synchronization in Nature
Friday, August 5, 11:00 a.m. - 11:50 a.m.

Every night along the tidal rivers of Malaysia, thousands of male fireflies congregate in the mangrove trees and flash on and off in unison. This display extends for miles along the river and occurs spontaneously; it does not require any leader or cue from the environment. Similar feats of synchronization occur throughout the natural world and in our own bodies. This lecture will provide an introduction to the simplest mathematical model of collective synchronization. Amazing videos of synchronous fireflies and London's wobbly Millennium Bridge will also be shown.

Karen Marrongelle, *National Science Foundation*

Teaching Mathematics for the Future: Centering Student Thinking to Diversify STEM
Saturday, August 6, 11:00 a.m. - 11:50 a.m.

Research and reports over the past three decades have highlighted the gaps in diversifying the nation's STEM workforce and the critical need to reach and foster STEM talent. The most recent data from the National Center for Science and Engineering Statistics projects that close to four million additional individuals are needed by the year 2030 for the STEM workforce to be representative of the U.S. population and reflect the full diversity of our nation. Mathematics is a critical inflection point on many students' journeys into, though, and out of STEM. Several decades of research on teaching mathematics have pointed to those characteristics of classrooms that can make a difference in keeping students on their pathways to their STEM goals, and what can deter them. I will set the national context, discuss findings from research on mathematics teaching, and unpack obstacles to implementation and the impacts on students.

MAA James R.C. Leitzel Lecture

Pamela Harris, *Unviersity of Wisconsin – Milwaukee*

Parking Functions: Choose Your Own Adventure
Friday, August 5, 9:00 a.m. - 9:50 a.m.

Consider a parking lot consisting of n consecutive parking spots along a one-way street labeled 1 to n. Suppose n cars want to park one at a time in the parking lot and each car has a preferred parking spot. Each car coming into the lot initially tries to park in its preferred spot. However, if a car's preferred spot is already occupied, then it will proceed forward in the street parking in the next available spot. Since the parking lot is along a one-way street, it is not guaranteed that every car will be able to park before driving past the parking lot. If we let a_i denote the preference of car i and all of the cars are able to park under these conditions, then the preference list *(a1,a2,...,an)* is called a parking function of length n. For example, *(1,2,4,2,2)* is a parking function, but *(1,2,2,5,5)* is not (you should convince yourself of this!). In this talk we provide an answer to the question of how many parking functions of length n there are and we consider many new avenues for research stemming from this enumerative question.

AWM-MAA Etta Zuber Falconer Lecture

Suzanne Weekes, *Executive Director of the Society for Industrial and Applied Mathematics (SIAM)*

Continuity at Interrfaces
Thursday, August 4, 2:00 p.m. - 2:50 p.m.

Rather than thinking of interfaces as barriers that must never be crossed, we look at the wonderful opportunities and outcomes that come about when we bridge two states and embrace a harmonious coupling.
With this mindset of seeking continuity at interfaces, I consider **[Material 1 | Material 2]** wave propagation through materials that vary in space and time, **[Academia | Industry]** successful programs between universities and industry, and **[Intellectual Merit | Broadening Participation]** ensuring the progress of mathematics and its applications.

Chan Stanek Lecture for Students

Jeanette Shakalli, *Panamanian Foundation for the Promotion of Mathematics*

FUNDAPROMAT: My Story
Thursday, August 4, 1:00 p.m. - 1:50 p.m.

After earning my PhD in Mathematics, I knew that my career would follow a different path than academia or industry. It wasn't until many years later that I finally discovered what my true purpose in life is. In this talk, I will share my story starting from the very beginning as a young kid who loved eating pasta and opening Christmas presents to a woman whose dream about sharing her passion for mathematics with others came true. It brings me so much joy to have created a safe space where kids and adults can have the

opportunity to learn mathematics by playing games and solving puzzles. Join me and discover the beauty of FUNDAPROMAT!

Christine Darden Lecture

Marissa Kawehi Loving, *University of Wisconsin-Madison*

Determining Metrics Using Lengths of Curves
Saturday, August 6, 9:00 a.m. - 9:50 a.m.

There are many different metrics that you can put on a surface. So, how can you tell when two metrics on a surface are the same or different? What is the least amount of information you need to answer this question? One approach is to keep track of the lengths of curves on your surface, and then use this data to determine your surface's metric. This is more formally known as "length spectral rigidity". In this talk, we will explore length spectral rigidity questions for both flat and hyperbolic surfaces. I will discuss both my own solo work as well as joint work with Tarik Aougab, Max Lahn, Nick Miller, and Sunny Yang Xiao (in various configurations). This talk will be accessible to a wide audience of both students and faculty.

Martin Gardner Lecture

Jason Rosenhouse, *James Madison University*

The History and Future of Logic Puzzles
Saturday, August 6, 2:00 p.m. - 2:50 p.m.

A hallmark of Martin Gardner's writing was his ability to use games and puzzles to illuminate broader themes in mathematics. In honor of this aspect of his work, we will tell the history of logic by discussing some of its most interesting puzzles. For example, Lewis Carroll saw logic puzzles as a device for illuminating subtle questions in Aristotelian logic. Later, Raymond Smullyan took a similar view with regard to propositional and mathematical logic. We will also look to the future by considering the opportunities afforded to puzzlers by the current interest in nonclassical logics.

NAM David Harold Blackwell Lecture

Tai-Danae Bradley, *SandboxAQ*

When Information Theory Meets Algebra and Topology
Friday, August 5, 2:00 p.m. - 2:50 p.m., Salon GH

In recent years, a few surprising connections have arisen between information theory, algebra, and topology. This talk is in a similar vein. We will discuss a certain correspondence between Shannon entropy and continuous functions on topological simplices that satisfy an equation akin to the Leibniz rule. The correspondence relies heavily on a particular operad, which is an abstract tool with origins in algebraic topology. Explicitly, the theorem gives a way to think about Shannon entropy from a pure mathematical

perspective: it can be thought of as a derivation of the operad of probabilities. A broad goal for this talk is to unwind this result and share why one might find the confluence of these ideas interesting.

Student Activity Speaker

Allison Henrich, *Seattle University*

How to Turn Your Knots from Blah into Fabulous
Friday, August 5, 1:00 p.m. - 1:50 p.m.

Are you tired of tying boring old shoelace knots? Frustrated with messy knots in your spaghetti that are impossible to undo? Wish you could make friends and influence people with your amazing knot-tying ability? Then come join us in the Student Activity Session! You'll learn to harness the power of mathematics and the fourth dimension to unlock the secrets of knots. Discover how to make tangled up messes magically disappear and make knots apparate out of thin air. *But wait! There's more!* Impress your friends and family with fancy phrases, like "persistent tangle" and "Reidemeister moves." Make your rivals wish they had come to MathFest 2022! Come to the Student Activity Session, and all your wildest dreams will come true.

Invited Paper Sessions

Trends in Mathematical and Computational Biology
Thursday, August 4, 8:00 a.m. - 10:50 a.m., Salon B

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

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.

Behind Enemy Lines: How Neutrophil Dynamics Affect *Mycobacterium tuberculosis* Granuloma Outcomes and Dissemination
8:00 a.m. - 8:20 a.m.
Mathematical models, data analytics, statistical analysis, and visualization techniques are valuable tools in the effort to determine the mechanisms that drive the spatiotemporal dynamics and organization of complex biological systems. In this talk, I will discuss how mathematical modeling enhances understanding of the immune response to human infection with the bacteria *Mycobacterium tuberculosis* (Mtb), which results in the formation of unique, emergent lung structures called granulomas. Due to the duration and dynamic nature of this immune response (years to decades), as well as the involvement of processes that occur over tissue, cellular, and molecular scales, we take a multiscale and mechanistic computational modeling approach. We build a hybrid agent-based model through which we generate simulated granulomas whose range of spatial configurations reflects the heterogeneity observed experimentally, and we investigate how the behavior of neutrophils, a newly added model cell type, contributes to Mtb pathology. Through the use of uncertainty and sensitivity analyses, we predict which neutrophil processes drive granuloma severity and structure and we suggest that neutrophils influence CFU burden during both innate and adaptive immune responses. We also show that neutrophils can facilitate local dissemination of granulomas and thereby enable the spread of infection. Through our work, we hope to advance understanding of the nuanced role of neutrophils in determining granuloma outcome beyond current experimental capabilities.
Authors:
Caitlin Hult, *Gettysburg College*
Joshua T. Mattila, *Gettysburg College*
Jennifer J. Linderman, *Gettysburg College*
Denise E. Kirschner, *Gettysburg College*

Effects of Optimally-Performed Healthcare Measures on Clostridioides difficile Infection Rates
8:30 a.m. - 8:50 a.m.

Clostridioides difficile (*C. difficile*) is the leading cause of infectious diarrhea and one of the most frequently identified healthcare-acquired infections 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. *C. difficile* infections are potentially fatal to those with a weakened immune system, killing approximately 30,000 patients each year. This study investigates the contributions of precautionary measures in minimizing *C. difficile* transmission and infection in healthcare settings. A six-dimensional system of nonlinear differential equations describes the patient and pathogen populations. Optimal control theory is used to investigate management strategies to minimize colonized and diseased patients by focusing on measures such as antibiotic prescription rates and surface cleaning efficacy. Results can be applied by healthcare professionals by focusing on precautionary measures that most reduce patient colonization with *C. difficile.*

Author:

Cara Sulyok*, Lewis University*

Modeling Frameworks that Integrate Disease and Ecosystem Ecology

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

While there are well established modeling frameworks in both disease and ecosystem ecology, these processes are often decoupled in models. Models in disease ecology rarely track organisms past death, yet death from infection can alter important ecosystem processes. In contrast, models in ecosystem ecology rarely track disease dynamics, yet elemental nutrient pools can regulate important disease processes. This separation is in part due to the different currencies and formulations of the core models used in fields rooted in population biology, such as disease ecology, and those arising from an ecosystem perspective. I will present models that link these disciplines. These models are used to investigate host-pathogen interactions and how they may be altered by considering factors such as non-living pools and immunity.

Author:

Rebecca Everett*, Haverford College*

Dynamical and Structural Specializations of Temporally-Precise Auditory Neurons

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

Specialized neurons in the auditory system are exquisitely sensitive to timing differences in their inputs. Timing differences can be created by mismatches in the arrivals of sounds at a listener's two ears due to spatial separation between the ears. Neural sensitivity to these time differences is essential, therefore, for listeners to determine the locations of sound sources in their surroundings. In this talk I will review classical dynamical systems models of neural dynamics (Hodgkin-Huxley framework) and highlight the application of these models to auditory neurons. I will identify dynamical and biophysical features of these models that explain how auditory neurons are specialized for temporal precision. In particular, we will review the classification of some auditory neurons as phasic firing (repetitive firing to constant inputs is not possible, as opposed to repetitively firing "tonic" neurons). Phasic neurons respond selectively to fast fluctuations in their inputs -- they act more like differentiators of their inputs and not as integrators. Phasic neurons are, therefore, more sensitive to timing differences than tonic neurons. We will then discuss recent results from a modeling study of neurons in the nucleus laminaris (barn owl auditory brainstem). Temporally-precise sound source localization is critical to barn owls because these animals are nocturnal predators that listen to sounds in the kilohertz-scale frequency range. We bring new insights to this sound localization circuit by showing that the phasic mechanism can operate on high-frequency fluctuations and enhance the sensitivity of nucleus laminaris neurons to sub-millisecond time differences.

Author:
Joshua H. Goldwyn, *Swarthmore College*

Bayesian Information-Theoretic Calibration of Radiotherapy Sensitivity Parameters for Informing Effective Scanning Protocols in Cancer
10:00 a.m. - 10:20 a.m.
The use of mathematical models to make predictions about tumor growth and response to treatment has become increasingly prevalent in the clinical setting. The level of complexity within these models ranges broadly, and the calibration of more complex models requires detailed clinical data. This raises questions about how much data should be collected and when, in order to minimize the total amount of data used and the time until a model can be calibrated accurately. To address these questions, we propose a Bayesian information-theoretic calibration protocol for experimental design, using a gradient-based score function to identify optimal times at which to collect data for informing treatment parameters. We illustrate this framework by calibrating a simple ordinary differential equation model of tumor response to radiotherapy to a set of synthetic data.

Author:
Katie Storey, *Lafayette College*

(Cancelled) ~~Gut Instincts: A Data-Driven Dynamical Model of Mouse Colons~~
~~10:30 a.m. - 10:50 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 measured experimentally are motor complexes (MC) often associated with the propulsion of fecal contents, and ripple contractions which are involved in mixing and absorption. 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 statistical analysis of the optogenetic and calcium measurements of mouse colons and how it is implemented in the data-driven modeling of the ICCs and neurons that also capture the global dynamics that are observed in the colon.~~
~~**Author:**~~
~~Andrea J. Welsh, *University of Pittsburgh*~~

Rethinking Number Theory
Thursday, August 4, 1:00 p.m. - 3:50 p.m., Salon B

Organizers:
Heidi Goodson, *Brooklyn College*
Allechar Serrano Lopez, *Harvard University*
Christelle Vincent, *University of Vermont*
Mckenzie West, *University of Wisconsin-Eau Claire*

Rethinking Number Theory is a new workshop series intended to broaden access to mathematical research communities and improve equity within the subject. Project leaders and participants from a wide range of Number Theory subfields participated in research projects as well as discussions about how to reimagine the number theory community. This invited paper session will simultaneously highlight the research done

during the workshop as well as bring the equity and inclusivity conversations to a broader mathematics community by intertwining mathematical research and social justice.

Counting Fields Generated by Points on Plane Curves

1:00 p.m. - 1:20 p.m.

For a smooth projective curve $C?\mathbb{Q}$, how many field extensions $\mathbb{Q}$ of given degree and bounded discriminant --- arise from adjoining a point of $C(\overline{\mathbb{Q}})$? Can we further count the number of such extensions with a specified Galois group? Asymptotic lower bounds for these quantities have been found for elliptic curves by Lemke Oliver and Thorne, for hyperelliptic curves by Keyes, and for superelliptic curves by Beneish and Keyes. We discuss similar asymptotic lower bounds that hold for all smooth plane curves C.

Author:

Allechar Serrano López*, Harvard University*

Rethinking Research Workshops

1:30 p.m. - 1:50 p.m.

Rethinking Number Theory is a virtual research workshop series that began in the early remote-working days of 2020. The goals of the workshop are for participants to learn new math, get to know colleagues, and have a joyful, affirming research experience. Our "professional development" sessions are meetings where we discuss ways to make our profession more equitable. Throughout the workshop we, the organizers, collect formal and informal feedback from both participants and project leaders. In this talk, I will describe some of the structural choices that we made to ensure that we could welcome and support all participants. I will also share my reflections on why this workshop is important and what I hope to work on to keep improving it.

Author:

Heidi Goodson, *Brooklyn College, City University of New York*

Local Data of Rational Elliptic Curves with Specified Isogeny Graphs

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

Local data of rational elliptic curves with specified isogeny graphs Abstract: Let K be a field and suppose E1 and E2 are isogenous nonisomorphic elliptic curves defined over K. Then there is an isogeny π : E1 $\rightarrow$ E2 defined over K such that ker $\pi \sim=$ Z/nZ for some integer n > 1. In particular, the K-isomorphism class of the pair (E1, ker π) is a noncuspidal K-rational point of X0(n). When n $\geq$ 2 and X0(n) has genus 0, we have the Fricke parameterizations which parameterize the j-invariants of the K-rational points of X0(n). By using these parameterizations, Cremona, Watkins, and Tsukazaki gave an algorithm to compute the isogeny class of an elliptic curve E/Q. In this talk, we discuss an improvement of this algorithm by means of an explicit classification of isogeny graphs for elliptic curves E/Q that admit a non-trivial isogeny. We conclude by discussing joint work with Chimarro, Roy, Sahajpal, Tobin, and Wiersema, which uses this explicit classification to investigate how the Kodaira-N´eron types of elliptic curves change under 2- or 3-isogeny.

Author:

Alex Barrios, *University of St. Thomas*

A Family of Thue Equations

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

With a brief introduction of myself, my coauthors Bernadette Faye, Ben Earp-Lynch, and Daniel Wisniewski, and the terms needed, I will present work on a family of Thue equations over imaginary quadratic integers.

Author:

Eva Goedhart, *Franklin & Marshall College*

BIKE Decoders and Error Detection

3:00 p.m. - 3:20 p.m.

There is a class of public-key cryptographic protocols based on linear error-correcting codes. The decoder used during error correction directly affects the security of a code-based cryptosystem. Correlations between error patterns that lead to decoding failures and the private key of a scheme have been discovered, leading cryptographers to work diligently to minimize decoding failures. We look closely at the iterative decoder used by cryptosystem BIKE, a 3rd round proposal in the NIST Post Quantum Cryptography standardization process. The nature of this iterative, bit-flipping decoder makes it difficult to analyze in a closed form. Cryptographers have thus relied on measurements of weakened versions of BIKE with a decryption failure rate that is high enough to measure with reasonable computational resources. These measurements have been extrapolated to design parameters for BIKE that are believed to provide a sufficiently low decryption failure rate for cryptographic purposes. However, such extrapolations don't account for error floors caused by error vectors that are equidistant between two different codewords. While such error vectors are rare enough that they should not affect the extrapolations, it is unclear whether similar effects might occur with error vectors that are near-equidistant between two different codewords. By examining the performance of the BIKE decoder on this class of error vectors, we can determine the accuracy of the extrapolated decryption failure analysis of the BIKE decoder.

Author:

Tyler Raven Billingsley, *Rose-Hulman Institute of Technology*

Current Research in Math Biology

Friday, August 5, 8:00 a.m. - 10:50 a.m., Salon B

Organizers:

Rebecca A. Everett, *Haverford College*
Nicholas A. Battista, *The College of New Jersey*

Mathematical biology investigates biological phenomena using mathematical techniques. This encourages collaborations between mathematicians and biologists, requiring mathematicians to learn relevant biology before applying mathematical techniques to the problem. Research in this area illustrates how biology and mathematics can work together to advance both fields. In this session, we showcase current research in mathematical biology, with an undergraduate audience in mind. With a wide variety of biological applications and mathematical techniques that can be applied to investigate biological research questions, our session will demonstrate the breadth of this research area for undergraduates and other interested researchers.

Social Dilemmas of Sociality due to Beneficial and Costly Contagion

8:00 a.m. - 8:20 a.m.

Levels of sociality in nature vary widely from solitary species to complex multi-family societies. Increased levels of social interaction can allow for the spread of useful innovations and beneficial information, but

can also facilitate the spread of harmful contagions, such as infectious diseases. In this talk, we will explore how coupled contagion processes can help shape the rules for interaction in complex social systems. We consider a model for the evolution of sociality strategies in the presence 1 of both a beneficial and costly contagion, and study dynamics of this model at multiple timescales. We use a susceptible-infectious-susceptible (SIS) model to describe contagion spread for given sociality strategies, and then employ the adaptive dynamics framework to study the long-time evolution of the levels of sociality in the population. For a wide range of assumptions about the benefits and costs of infection, we identify a social dilemma: the evolutionarily-stable sociality strategy (ESS) produced by adaptive dynamics is distinct from the collective optimum – the level of sociality that would be best for all individuals. In particular, the ESS level of social interaction is greater (respectively less) than the social optimum when the good contagion spreads more (respectively less) readily than the bad contagion. Our results shed light on how contagion shapes the evolution of social interaction, but reveals that evolution may not necessarily lead populations to social structures that are good for any or all. This project is joint work with Dylan H. Morris, Simon A. Levin, Daniel I. Rubenstein, and Pawel Romanczuk.

Author:

Daniel Cooney, *University of Pennsylvania*

Modeling Seasonal Malaria Transmission: A Methodology Connecting Regional Temperatures to Mosquito and Parasite Biology

8:30 a.m. - 8:50 a.m.

Temperature is a factor affecting mosquito population dynamics and the rate of development of the malaria parasite within the mosquito, and hence significantly affects malaria transmission dynamics. While data fit to a sinusoidal function is commonly used to incorporate temperature effects in malaria models, this choice misses the within and between seasonal monthly and yearly variations in the parameter traits and temperature profiles. We address this in our seasonal malaria framework by employing a spline methodology that integrates temperature-dependent mosquito and parasite demographic traits with regional temperature data to create a seasonal profile unique to each region. The embedded time-varying parameters yields a non-autonomous system of differential equations. We compute periodic and invasion threshold numbers for two strains of malaria parasites, one sensitive to drugs and the other resistant to drugs, to shed light on the impact of variable temperature on disease dynamics. We present numerical simulations illustrating how climatic temperature changes will alter the monthly entomological inoculation rate and the number of malaria infections over a multi-year timespan.

Author:

Katharine Gurski, *Howard University*

Multiple Feeding Attempts by Mosquitoes - A Mathematical Study

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

The evolutionary need for survival impacts animal behavioral patterns. In particular, the need for female blood sucking mosquitoes to draw blood from humans or animals, an essential need for the maturation of their eggs, would drive mosquitoes that fail to feed to attempt to feed again. What impact does a successful subsequent blood feeding attempt, following earlier failed attempts, have on mosquito population dynamics and growth? In this talk, I will illustrate with the use of mathematics how multiple feeding attempts by female mosquitoes on humans, following earlier failed attempts, can impact mosquito dynamics and population growth.

Author:

Miranda Teboh Ewungkem, *Lehigh University*

Topological Data Analysis Reveals Insights into Blood Vessel Development and Disease

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

Vascular networks deliver nutrients and remove waste from tissues and play a pivotal role in many biological processes, including development and homeostasis. As the structure of vascular networks determines their overall function, we develop and analyze several statistical and topological approaches to quantify morphological patterns observed from data. We highlight the success of these methods through two case studies. In the first, we show that a topological filtration can be used to stratify the parameter space from many simulations of a math model of blood vessel development. In the second case study, we apply statistical and topological methods to several public datasets of retinal vascular network images and find that both approaches can be used to accurately predict images disease status. The methodologies we consider are broadly applicable to biological data that may arise from cancer, wound healing, development, and plant biology.

Author:

John Nardini, *The College of New Jersey*

Connecting the Dots between Math Modelers and Clinical Oncologists

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

How can we bridge the gap between complex mathematical models (which can predict tumor evolution and response to treatment), and the decision-making that occurs at the clinical level with regards to how individualized treatment protocols should be designed? This talk will focus on questions within the field of data-driven mathematical oncologywith a focus on how tumor dynamics models can provide useful information for predictive purposes despite clinical data constraintsand will feature projects completed by undergraduate researchers.

Author:

Allison Lewis, *Lafayette College*

Exploring the Predictive Abilities of a Mathematical Oncology Model

10:30 a.m. - 10:50 a.m.

Mathematical models of biological systems are often validated by fitting the model to the average of an often small experimental dataset. Here we ask the question of whether mathematical predictions for the average are actually applicable in individuals that deviate from the average. We will explore this in the context of a mouse model of cancer treated with two cancer drugs. The talk will demonstrate how a mathematically optimal protocol for treating the average mouse can lack robustness, meaning the best for the average protocol can fail to be optimal (and in fact, can be far from optimal) in mice that differ from the average. We also show how mathematics can be used to identify an optimal treatment protocol that is robust to perturbations from the average.

Author:

Jana Gevertz, *The College of New Jersey*

Recent Advances in Harmonic Analysis and Partial Differential Equations

Friday, August 5, 3:00 p.m. - 5:50 p.m., Salon B

Organizers:

Irina Mitrea, *Temple University*

Nsoki Mamie Mavinga, *Swarthmore College*
Shari Moskow, *Drexel University*

The proposed invited paper session has as focus the dissemination of recent developments in the area at the confluence between the fields of Harmonic Analysis and Partial Differential Equations. Particular themes of emphasis are: Integral Equations, Elliptic Boundary Value Problems, PDEs in periodic media.

Asymptotic Analysis of Resonances of Periodic Scatterers
3:00 p.m. - 3:20 p.m.
We consider the asymptotic analysis of the resonances of a bounded scatterer with a periodic index of refraction with small period size ε for the scalar Helmholtz equation. The resonance problem is formulated as a nonlinear eigenvalue problem, for which we can derive formulas when the homogenized resonance is simple. In this case we derive an explicit formula for the first order corrections and find that they are nontrivial in general. For convex polygonal scatterers of rational normal, the resonances converge only $O(\varepsilon)$, even for scatterers which are unions of period cells. For smooth domains with no flat parts the resonances converge $o(\varepsilon)$, but the convergence is nonetheless sub-quadratic in general.
Author:
Alexander Furia, *Drexel University*

Singular Integral Operators Associated with Second Order Elliptic Systems in Two Dimensions
3:30 p.m. - 3:50 p.m.
The goal of this talk is to investigate coefficient tensors associated with second order elliptic operators in infinite sectors in $\mathbb{R}^{2}$ and properties of the corresponding singular integral operators, using Mellin transform techniques. Specifically the discussion is focused on the relationship between distinguished coefficient tensors (those leading to chord-dot-normal type double layer potentials) and L^{p} spectral and Hardy kernel properties of the associated singular integral operators.
Author:
Jeongsu Kyeong, *Temple University*

Logarithmic Sobolev Inequalities on Non-isotropic Heisenberg Groups
4:00 p.m. - 4:20 p.m.
In this talk, I will discuss logarithmic Sobolev inequalities with respect to a heat kernel measure on finite-dimensional and infinite-dimensional Heisenberg groups. Such a group is the simplest non-trivial example of a sub-Riemannian manifold. First, I will talk about logarithmic Sobolev inequalities on non-isotropic Heisenberg groups and discuss the dimension (in)dependence of the constants. In this setting, a natural Laplacian is not an elliptic but a hypoelliptic operator. The argument relies on comparing logarithmic Sobolev constants for the three-dimensional non-isotropic and isotropic Heisenberg groups, and tensorization of logarithmic Sobolev inequalities in the sub-Riemannian setting. Moreover, I will mention the application of these results to an infinite-dimensional Heisenberg group.
Author:
Liangbing Luo, *University of Connecticut*

Electroconvection in Porous Media
4:30 p.m. - 4:50 p.m.

We consider an electroconvection model describing the evolution of a charge density carried by a two-dimensional incompressible fluid flowing through a porous medium. Electrical forces are created by the charge density and balanced by Darcy's law. The resulting partial differential equation obeyed by the charge density is nonlinear and nonlocal. In this talk, we study the global existence, uniqueness, and regularity of solutions in Besov spaces for small initial data.

Author:

Elie Abdo, *Temple University*

Fredholm Theory for Boundary Value Problems Associated with Powers of the Laplacian
5:00 p.m. - 5:20 p.m.
In this talk I will discuss the Dirichlet problem for even powers of the Laplacian in regular SKT domains in ${\mathbb{R}}^n$. In connection with this I will analyze bilinear forms associated with powers of the Laplacian and the associated double multi-layer potential operators arising in this setting.

Author:

Artur Henrique de Oliveira Andrade, *Temple University*

Shape-Perturbation of Steklov Eigenvalues in Nearly-Spherical Domains
5:30 p.m. - 5:50 p.m.
We consider the Steklov eigenvalue problem on nearly-spherical domains. The domains of interest are represented as geometric perturbations of spheres, governed by a perturbation function ρ, represented in spherical harmonics, and a perturbation parameter ε. We will discuss the analytic dependence of the Steklov eigenvalues on the parameter ε for suitable perturbation functions ρ. A surprising connection between the first-order perturbation and Wigner-$3j$ symbols will be revealed and discussed. Time permitting, we will conclude with applications to local isoperimetric and eigenvalue shape-optimization results.

Author:

Robert Viator, *Swarthmore College*

Contributed Paper Sessions

MAA Session on Mathematical Experiences and Projects in Business, Industry, and Government (BIG)
Thursday, August 4, 1:00 p.m. - 4:20 p.m., Salon E

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*
Sponsor:
SIGMAA on Business, Industry, and Government (BIG SIGMAA)

Providing Data-Driven Solutions in a Local Nonprofit Context with PIC Math
1:00 p.m. - 1:15 p.m.
In Spring 2022, Converse University partnered with a local nonprofit, the Upstate Family Resource Center (UFRC), for a PIC Math course. The UFRC takes a comprehensive approach to providing assistance to families in need in Spartanburg County, South Carolina and the surrounding area. For the semester-long project, the UFRC allowed the class to pore over their data from assistance given in 2020 and 2021, with a focus on Spartanburg County. This talk will give an overview of the data science projects that came out of this course while providing context of the history and mission of the UFRC and how COVID impacted their services. Insights and comments about how to extend the projects and build effective resources will be welcomed from the audience as well.
Author:
Amanda Mangum, *Converse University*

Procuring Aid for a Local Nonprofit through Data-Driven Analyses
1:20 p.m. - 1:35 p.m.
The Upstate Family Resource Center (UFRC) is a non-profit organization that provides assistance to members of Districts 1 and 2 in Spartanburg County, South Carolina. We partnered with them in Spring 2022 for a PIC Math course and worked to provide data-driven solutions that would help the UFRC apply for an upcoming United Way of the Piedmont Grant. We worked with their 2020 and 2021 data and explored the data using k-means. We then implemented a random forest in order to classify clients based on data pertaining to income and expenses. Visuals were also created to help the UFRC track aid category usage, total money spent, and total hours provided for each month in this timeframe. Focus was given to data concerning different categories of assistance, household income and expenses, and the dollar amount

of financial help each client received. The 2021 aid amounts were greatly impacted by new types of available aid, such as ERAP, due to the COVID-19 pandemic. Despite the large impact of COVID, we were still able to compare the household income of the clients across both years to the state and national averages.

Authors:

Angela Brobson, *Converse University*

Sierra Godfrey, *Converse University*

Neely Vander Ploeg, *Converse University*

Surprising Challenges from the Paper Industry

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

Paper and paper-based products offer surprising challenges from a seemingly low-tech industry. Paper and paperboard are extremely complex materials - they are nonuniform, fiber-based, layered materials with rate and moisture dependent properties. Process control, physical testing, and correlation of physical properties to end-use performance offer unique challenges at all levels of mathematics and engineering. The presenter will review several challenges encountered while serving as a research engineer in the industry. These range from ill-conditioned linear systems and moving web dynamics to reverse engineering of industry-dedicated slide rules in support of automation. There are many open problems - the manufacturing process, the material, and the modelling are complicated. In the words of an external FEA support analyst, "We roll out the carpet for the aerospace industry, but we hide when we see you coming!"

Author:

Donato Fortin*, John & Wales University - Charlotte*

Statistical Methods for Predicting Future Patterns of Life Through Aerial Collection

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

One of the most potentially useful methods for developing an individual's pattern of life behaviors is by observing the data captured by a cellular device. In 2009, Nokia launched the Lausanne Data Collection Campaign, which was designed to collect behavioral data from 170 volunteers through data collection software on contributed phones. In particular, GPS and WiFi connection data depicted the location of volunteers for the duration of their participation in the study. Analysts can use this location data to predict future movements of an individual with appropriate statistical techniques. This research investigates a methodology for conducting predictive analysis of individual movement based on past known movements through analysis of several time series statistical methods and machine learning techniques. Based on this analysis, recommended applications of this method include use in developing Named Areas of Interest (NAIs) for aerial collection platforms, queuing of non-aerial sensors, and development of kinetic and non-kinetic targets. Given recorded GPS locations through a target's cellular device, graphical depiction of these locations provides an opportunity for modeling past behavior and predicting future movements. By applying machine learning techniques and statistical modeling such as ARIMA and SARIMA models, trends, seasonality, and random error can be estimated. Given such parameters, the target's future locations can be predicted with a degree of confidence suitable for tasking aerial collection platforms. Proposed ARIMA and SARIMA models are conceptually simplistic to support transparency in the process for senior leaders while being non-computationally demanding to enable calculations to be run at tactical formations.

Author:

Jen McClary, *United States Military Academy*

Estimating Sustainable Yield for White-Tailed Deer Populations in New Jersey with Annual Harvest Data

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

White-tailed deer hunting plays an important role in the New Jersey (NJ) economy benefiting a wide variety of businesses. However, white-tailed deer are perceived as the cause of a growing urban wildlife management problem. In this project, we use mathematical models with different hunting strategies to study deer population dynamics and determine population response to harvests. Models were fitted to white-tailed deer annual harvest data collected by NJ Department of Environmental Protection. Sustainable yield was estimated under each harvest strategy. Our results indicate the white-tailed deer population size in New Jersey is much larger than the estimates NJ currently provides, and that more harvest effort should be put on the doe population to optimize sustainable yield.

Authors:

Baoling Ma, *Millersville University of Pennsylvania*
Sarah Stinchcomb, *Millersville University of Pennsylvania*

Does ESG Investing Affect International Capital Flows? Some Evidence from Statistical and Machine Learning Methods

2:40 p.m. - 2:55 p.m.

Environmental, social and governance (ESG) challenges recently have been the subject of much attention from individuals, companies, and governments worldwide. In response to investors' demand to generate long-term financial profit and make positive societal impact, ESG investing, also known as sustainable investing, incorporates environmental, social and governance standards into asset allocation and risk management. Using the sample of U.S. residents' holding value of foreign stocks and long-term bonds from 2012 to 2020 and implementing the traditional OLS model and the machine learning LASSO model, I find that ESG investing strategies play an important role in international capital flows. Specifically, I find that (1) higher ratings in some country-level ESG criteria, such as less pollution, stronger law enforcement, and more innovations, attract more cross-border capital because ESG investors ultimately seek long-term financial returns. Conversely, (2) lower ratings in other ESG criteria, such as poor health and nutrition, also attract more capital, reflecting the ESG impact investing strategy. Among the three pillars of ESG, the governance pillar (especially innovation) is most influential in capital allocation decisions. Furthermore, I find that ESG considerations explain more variation in stock investments than bond investments. Overall, the empirical evidence suggests that ESG investing strategies influence international capital flows, and that U.S. investors use ESG principles to align long-term financial performance with societal values, positively impacting global sustainability. The findings highlight specific investor-preferred policy objectives, such as reducing pollution, protecting human rights, and encouraging innovation, for governments seeking to attract U.S. investments.

Author:

Leon Luo, *Wayzata High School*

Twenty-four Years of Service-Learning

3:00 p.m. - 3:15 p.m.

When I come back into the room the students are absolutely silent. The community partner has just presented the class with their service-learning project. When the community partner concluded their presentation, I had stepped into the hall to thank them leaving the students in my MATH 425 Introduction to Mathematical Modeling course to think about what they'd been asked to do. Now they have the "deer in the headlights" look of someone with no idea what to do next. Six weeks later, they will be confidently deciding how to organize the presentation to that same community partner. In this talk I will describe my experience with using real-world projects as the culminating experience in my mathematical modeling course. Spoiler alert - the most important lesson for me was to get out of the way.

Author:

Olivia Carducci, *East Stroudsburg University*

Experimental Learning through a Sustained Collaborative Project

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

In this session we will introduce a sustained collaborative project with faculty members in the Business school and Mathematics department, in which 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 that focused on analyzing the impact of the Covid-19 pandemic using real data provided by the company. Some successful tips and lessons we learned will also be discussed.

Authors:

Fei Xue, *University of Hartford*
Kenneth Goroshko, *University of Hartford*
Kenneth Goldstein, *University of Hartford*

Mathematics Applied to Modeling Team Formation at In-Person and Virtual Conferences: An Academic-Science Philanthropy Partnership

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

The impact of interaction on the scientific process was brought to the fore as the COVID-19 pandemic forced gatherings to shift to a virtual setting. One of the main ways that new and innovative collaborations are catalyzed is by gathering scientists together at conferences. In the US alone, conferences amount to billions of dollars per year in terms of travel expenses, organizing costs, and loss of research time. In this talk, we present a new nonlinear dynamical model for the origin of scientific collaborations at conferences. Our model takes as input the pattern of interactions among participants and predicts the probability that any given team will form. We test the model with a novel dataset tracking multi-year "Scialog" scientific conferences organized by the Research Corporation for Science Advancement, one of the oldest philanthropies in the US that supports science. The data includes room-level participation data from 12 in-person and six virtual meetings, each with about 50 participants. Our model agrees well with data and outperforms seven other candidate models. This talk will also cover new empirical evidence for the causal role of interaction---including prescribed interaction---in subsequent team formation, and will touch on the question of whether virtual conferences can effectively replicate the in-person experience. Our work illuminates a key role conferences play in steering the direction of team formation, and could help organizers of scientific, professional, and governmental conferences optimize future ones, regardless of their format.

Authors:

Emma Zajdela, *Northwestern University*
Kimberly Huynh, *Research Corporation for Science Advancement*
Andy Wen, *Northwestern University*
Andrew Feig, *Research Corporation for Science Advancement*
Richard Wiener, *Research Corporation for Science Advancement*
Daniel Abrams, *Northwestern University*

Zillion Particles-in-a-box

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

Disintegrating plating inside an electronics box destined for zero-gravity was creating many metal flakes; some >20mils (0.020"), with most <1mil. The power-to-ground minimum voltage gap was: S/o\≡10mils=8u; 1u={1.25mils}, and the box could tolerate some electrical shorts. BIG need: Within ~2 months, develop a simulation to estimate: N (number of electrical shorts) vs M (number of particles captured in voltage gap). Simplifications to avoid intractability: Use an X-Y grid of P×Q unit cells (1u×1u). Assume each particle is equivalent to an L/o\ length rod, which aligns with the X-direction electrical field.

Only particles near the voltage gap adhere, as electrical fields force them into place. Count only particles protruding into the voltage gap. Smaller particles can agglomerate together, to bridge the gap. Each simulation has all particles of the same L/o\ length.

Results: All plots of {N vs M} showed power-law behavior: N=k M^(+γ) , with nearly integer γ: I(S/o\; L/o\) = 1 + |[S/o\ / {L/o\+(1/2)}]| ≈ γ(S/o\; L/o\) . Here, I(S/o\; L/o\) is the minimum number of particles needed to bridge the voltage gap, and |[∗]| is a greatest-integer function. This system mimics multi-step reaction chemistry, in which γ is the number of reaction steps needed for a final product.

Author:

Genghmun Eng, *Retired Scientist*

Project-Based Teaching
4:20 p.m. - 4:35 p.m.

In this presentation, I will share my experience in using computational and project-based approach to teach mixed audiences -- undergraduate math majors, beginning graduate students, and students from the field of science and engineering. I will share a few of my teaching strategies, for example introducing the materials with an emphasis on computational applications; providing illustrative examples by software packages; arranging students project presentations in departmental seminar or professional conferences. This approach bridges the gap between abstract theory and the real life applications.

Author:

Haohao Wang, *Southeast Missouri State University*

Dual-Balanced Political Redistricting
4:40 p.m. - 4:55 p.m.

The one person-one vote principle for political redistricting requires balancing populations across districts. We address the matter of simultaneously balancing a second attribute across districts, proving that this is always possible to within reasonable tolerances. Feasibility is demonstrated through different computational approaches – one implementing a pancake theorem-inspired algorithm; the other by formulating the problem as a constrained partitioning problem on graphs. These computational results demonstrate the practicality of obtaining dual-balanced districts whose balance for both attributes is well within reasonable deviations from the ideal values. An application will be discussed in which city wards are redrawn to help avoid differential population growth leading to malapportionment between 2022 and the next decennial census in 2030.

Authors:

Ryan Zerr, *University of North Dakota*
Daryl Deford, *Washington State University*

Innovative Ideas in Teaching Mathematics - Lessons from the Pandemic and its Aftermath
Part A: *Friday, August 5, 8:00 a.m. - 11:55 a.m., Salon I*
Part B: *Saturday, August 6, 8:00 a.m. - 11:55 a.m., Salon J*

Ideas that have worked to support student learning through the pandemic, especially for courses in the first two years and ways to facilitate the high school to college transition. Presentations should demonstrate how the ideas can continue to be useful as we return to "normal" and should provide evidence of success.

Organizers:
Andrew Bennett, *Kansas State University*
Chris Oehrlein, *Oklahoma City Community*
Erica Whitaker, *University of Kentucky*

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

Part A: *Friday, August 5, Salon I*

Engaging Preservice Teachers in a Synchronous Mathematics Course through Technology
8:00 a.m. - 8:15 a.m.
Preservice teachers can be timid discussing mathematics, which an online environment can intensify. This presentation focus on technologies used to promote classroom discussions in an online class during that pandemic that carried over well now to the face-to-face classroom.
Author:
Roger Wolbert, *Pennsylvania Western University of PA*

Using Technology and Programming to Guide Mathematics
8:20 a.m. - 8:35 a.m.
Technology tools and programming can be used to enhance the learning of mathematics especially for courses that are hybrid and or online. The use of excel, R and Python can engage students taking courses in statistics especially those majoring in computer science or a related field. This paper will show how using these tools can be engaging to the students learning statistical topics.
Author:
Joan E. DeBello, *St. John's University*

Teaching Proof Writing Courses During and After the Pandemic
8:40 a.m. - 8:55 a.m.
When the pandemic hit, we all needed to change the way we teach. This was certainly true for courses that are heavy on proof writing. In this talk, I explain how I adapted my proof writing courses (graph theory, real analysis, abstract algebra) so they could be taught in a hybrid in-person/online fashion. More importantly, I will discuss the lessons I learned from these adaptations and how they permanently changed the way I teach proof writing courses - even as the pandemic is subsiding.
Author:
Jason Molitierno, *Sacred Heart University*

(Cancelled) ~~Remote Teaching of Proof-based Math Courses~~
~~9:00 a.m. - 9:15 a.m.~~
~~Upper-level math courses such as discrete mathematics and real analysis require a deeper understanding of the subject material. Proof writing is an important component of such courses. There is value in working with students to construct proofs on the board in a classroom – it is active leaning, deliberate reasoning, improves logical thinking and enhances understanding of the material. We will share how such a classroom environment can be simulated in a remote environment. We will also share innovative tools for assessment such as 'video proof presentations' in which students create videos of themselves explaining proofs. Even~~

My Experiences with Ungrading in Mathematics

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

The pandemic has increased stress levels on all of us, maybe especially students. One method that I adopted this academic year that can reduce stress on students is ungrading. Without the pressure and judgement of grades, students can focus on learning rather than just working toward grades. Students in my classes never get a grade on any assignment. Instead, they receive significant feedback and are given the opportunity to reflect and revise their work. I will share my, and my students, experiences with ungrading in several freshman level undergraduate courses including trigonometry, calculus, and linear algebra.

Author:

Steven Schlicker, *Grand Valley State University*

Modules of Inclusion for a Learning Management System

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

Following a full year of online pandemic learning, there was a clear need to intentionally welcome all incoming students and to guide them in developing effective learning strategies for their university mathematics courses. At Santa Clara University, a Jesuit university in Silicon Valley, we developed and deployed four modules of inclusion which were integrated with our learning management system. The four modules focused on key topics for fostering growth and inclusion in math education: growth mindset, metacognition, embracing diversity, and academic integrity. Research based student activities, as well as instructor notes, were developed by three math and computer science faculty members with the assistance of a consultant from ethnic studies to ensure the materials were equitable and inclusive. These modules were designed in a way that faculty could easily select individual activities for use in their first year math classes. This talk will outline the modules, describe some specific activities, and present usage data as well as revisions being made to further implementation in subsequent years.

Authors:

Linda Burks, *Santa Clara University*
Natalie Linnell, *Santa Clara University*
Josh Grice, *Santa Clara University*

Making Do with Less: A Summer Math Program in Transition

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

Bloomfield College (a PBI, HSI, and MSI) is a small, liberal arts college in Bloomfield, New Jersey. Prior to the pandemic, we had a limited number of upper-level classes available online. Each summer, we run an incoming first-year student program, in-person, consisting of a math and writing component. During summer 2020 and 2021, this program shifted to online only. This format change involved a total overhaul of the math portion which had previously been project-based with the use of computer labs and the TI-84 graphing calculator. Also, during the summer of 2021, we transitioned to a new learning management system (Blackboard Original to Ultra) and had to make additional modifications. In this presentation, I will share both successful and unsuccessful practices for the online mathematics classroom and expand upon the ones that will continue in our return to an in-person program this summer. Due to a number of constraints, we weren't always able to provide all students with the technology (computers, Wi-Fi, graphing calculators) they needed for the program, so I will also discuss our free and creative solutions to these

issues. I will conclude with an analysis of the success of the program through assessments, pass/waive rates, and grades in first year and second year math classes.

Author:

Grace Cook, *Bloomfield College*

Mathematics Classroom during and now post Pandemic
10:20 a.m. - 10:35 a.m.

In this presentation we will discuss some of the technologies we implemented in the "new classroom" during the Pandemic and how we use some of these strategies today. Our focus will be on how we accommodated students attending virtually or in the classroom, as well as the technologies we used to support students' learning in and outside of the classroom. We will share our experiences with using MyLab Math for our introductory and remedial courses for our students in our on-ground courses. Then we will explore how WebAssign was implemented in our higher level courses, such as Calulus. We will discuss the use of Zoom for hosting classroom as well as office hours. Finally, we will discuss the technologies that we were able to use in the physical classroom to best connect with students virtually, such as the "pringles box" cameras in each class, the XP-pen to be able write mathematics so you can do examples in the Zoom whiteboard. Finally, we will discuss the good, the bad, and the ugly of the "new classroom" and how we will moving forward use what we feel improved learning and also search for alternative ways for what did not work.

Author:

Monika Kiss, *Saint Leo University*

Standards-Based Grading in Difficult Times: Precalculus Student Outcomes and Perceptions
10:40 a.m. - 10:55 a.m.

Standards-based grading, also known as mastery grading, gives students multiple opportunities to demonstrate proficiency in the course standards. It is designed to reduce student testing anxiety without sacrificing rigor. In this presentation, I discuss the results of a study where I implemented standards-based grading in my Precalculus courses during the Covid-19 pandemic. Through surveys given at the start and end of the courses, as well as reflections throughout the semester, I explore how the grading system affected their math and testing anxieties, their growth versus fixed mindsets, and their perceptions of their abilities to do math. In addition, the students shared how their learning has been impacted by the pandemic and their thoughts on taking a course that used standards-based grading during the pandemic. I will also discuss the challenges presented by the grading system and suggestions for future courses.

Author:

Rachel Epstein, *Georgia College*

Turning Lemons into Lemonade: Flipping the Precalculus Class
11:00 a.m. - 11:15 a.m.

During 2020-2021, my precalculus class was taught synchronously via WebEx using video lectures, daily discussion board posts and online homework. Students really liked the video lectures. In an effort to capitalize on this interest, the class was successfully flipped (following best practices for flipping classes) in Fall 2021, with students watching the video lectures outside of class and class devoted largely to working homework problems in teams. This talk will outline the course structure and compare student success with the pre-pandemic non-flipped class model.

Author:

Jenna Carpenter, *Campbell University*

Virtual Manipulatives: Tools to Make Mathematics Class More Engaging
11:20 a.m. - 11:35 a.m.
Everyone found the method that worked best for their virtual teaching during the shutdown of 2020; mine was synchronous teaching via Zoom. An unexpected benefit of this synchronous teaching was the extensive use of the chat and breakout room features in Zoom—use that brought my students together despite being physically separated. As we've returned to in-person learning, I've (also unexpectedly!) continued to use variations of these features in my classroom. This talk will focus on strategies for bridging the communication gap for in-person students and techniques for engaging the lone online learner in a class of mainly in-person students.

Authors:
Angie Hodge-Zickerman, *Northern Arizona University*
Barbara Boschmans, *Northern Arizona University*
Brian Beaudrie, *Northern Arizona University*

Lessons in Teaching an Origami Gen-Ed Math Course Pre- and During the Pandemic
11:40 a.m. - 11:55 a.m.
The Art and Math of Origami is a general education math course. I taught it twice in standard (in-person) format and then twice in remote (Zoom) format. The math featured in the class includes observations on shapes, symmetries, and transformations from 2D to 3D; what I term re-introduction of concepts in geometry, algebra, and trigonometry that students may not have understand in the past; and glimpses of advanced mathematics, for example number theory, applied to what they are doing with their fingers when they fold. I will explain the math involved in several specific models. Classes fill quickly during registration and the end-of-term anonymous surveys and informal feedback are strongly positive. The course inspired two books: Origami with Explanations and More Origami with Explanations that will be available at MathFest at discounted prices. I will compare the in-person and remote classes and share my current ideas for the return to campus in the Fall.

Author:
Jeanine Meyer, *Purchase College/State University of New York*

Part B: *Saturday, August 6, Salon J*

Video-Based Tasks on Graphs of the Quadratic Function
8:00 a.m. - 8:15 a.m.
This session will present an exploratory study of a college algebra course, focusing on the topic of graphing quadratic functions. In particular, the effects of a video-based task as a formative assessment and students' perceptions including their thoughts of the video-based task experience will be discussed. More specifically, we will discuss the positive effect of improving both students' conceptual and procedural knowledge of graphing quadratic functions and students' mathematical understanding and critical thinking ability. Furthermore, we will discuss how the students illustrated their understanding of creating graphs of quadratic functions using examples of their problem-solving skills. The video-based task can provide math instructors with the opportunity to use a different way of assessment that enhances students' different needs and interests.

Authors:
Miran Byun, *John A Logan College*
Eunmi Joung, *Utah Valley University*

A Mastery-Based, Small-Group, Vector Calculus Course
8:20 a.m. - 8:35 a.m.
A mastery-based approach to teaching vector calculus. Mastery is demonstrated via a collection of WeBWorK assignments that are available for download on a dedicated GitHub repository. A tree-based approach to measuring overall progress and assigning grades is described. Implementation details that work and do not work will be shared: due dates vs. flexibility, retakes vs. instructor time commitment etc. A couple of useful references are shared.
Author:
Albert Schueller, *Whitman College*

From Zooming to Flipping: Pandemic Lessons in Introductory Statistics
8:40 a.m. - 8:55 a.m.
During the pandemic, while teaching on Zoom, I recorded my lectures so that students who were absent could watch the material later. I was surprised when students who were present in class told me they were rewatching the video lectures while doing homework. This, along with professional development provided by a grant, inspired me to try flipping a class. It was so successful, as judged from students' grades, course evaluation comments, peer observations, and student participation during class, that I have flipped two more of my statistics classes.
Flipped classrooms benefit students because they have in-class support from their instructor and peers while they work on the high-level learning objectives such as application, analysis, synthesis, and evaluation, as organized by Bloom's taxonomy. They can complete the base-level learning objectives of knowledge and understanding on their own.
In this presentation, I will discuss how flipping my classes has promoted active learning, and can support students as they transition from high school to college. I'll look at the practical aspects, such as how I've created my videos and how to make sure students are doing the out-of-class learning. I'll relate some successes and challenges that I've encountered while flipping my classes, and share some helpful resources for professors flipping their own classes.
Author:
Rebecca Conley, *Saint Peter's University*

Activities That Support Statistical Analysis
9:00 a.m. - 9:15 a.m.
Undergraduate students often find our course in Statistical Analysis full of vocabulary and concepts that are challenging. When teaching online I found Padlet to be a good tool for some interactive activities. Now that we are back in the physical classroom I am adapting these for use in small groups and the Padlet remains as an online review tool. Topics include sorting histograms, estimating the area under the normal curve and hypothesis testing.
Author:
Alice Petillo, *Marymount University*

The Outcomes of Useful Teaching Lessons Learned during the Pandemic
9:20 a.m. - 9:35 a.m.
In this presentation we show how some in-class active learning approaches were changed to accommodate for diverse students' learning styles as well as for the change into the new LiveStream modality. In addition, some new activities added will be discussed (pre-class assignments, MS forms daily surveys, etc.). Many of these ideas have shown to be very useful in the back to in-person modality. Those active strategies

improve student-learning experiences and prepare them better for future math classes. At the end, we share some students' feedback on the activities.
Author:
Violeta Vasilevska, *Utah Valley University*

The Kerbal Math & Physics Lab
9:40 a.m. - 9:55 a.m.
In Fall 2020 and Spring 2021, a NASA mini-grant provided the opportunity to pilot an online math course designed to introduce community college students to the math and physics of rocket science and promote STEM pathways and careers. The course used the computer game Kerbal Space Program as a virtual lab for an interactive online learning experience. Lessons and material developed as a result of the grant can inspire interest in math and physics in students from middle-school through college, support bridge-to-college programs, after-school and summer enrichment programs, and promote learning in traditional math courses from algebra through differential equations.
Author:
Christopher Vaughen, *Montgomery County Community College*

Transforming Your Online Calculus Class with the Deconstruct Pedagogy
10:00 a.m. - 10:15 a.m.
Do you have trouble getting your students to really understand calculus concepts in an online format? Are you worried that your asynchronous class isn't active enough? This talk will present the Deconstruct Calculus pedagogy that have helped with these issues and more in an introductory Business Calculus course over multiple semesters.
Author:
Kathryn Pedings-Behling, *College of Charleston*

Precision Calculus: A Rigorous Approach to the Early Concepts
10:20 a.m. - 10:35 a.m.
The way to learn mathematics is by writing mathematics. This is a statement that many instructors include on their syllabus as well as say to their students when emphasizing the importance of doing homework. However, today, with the emergence of the internet, doing mathematics can mean copying a complete solution to a problem directly from an internet website. This presents a problem since writing mathematics is important to the learning process. So, is it time to consider teaching the first calculus course in a more rigorous manner? What are the contents of a rigorous focused first-year calculus course? Who are the students that are prepared to take this course? I will answer these questions by describing Precision Calculus: A Rigorous Approach to the Early Concepts.
Author:
Elaine Terry, *Saint Joseph's University*

(Cancelled) ~~The Self-Care Syllabus~~
~~*10:40 a.m. - 10:55 a.m.*~~
~~Students often recognize that self-care is important but often do not have an understanding of how to practice it, or where to start. To support students, we created the Self Care Syllabus: a collection of assignments that students have an option to complete throughout the semester. It involves a survey that serves as a reminder for all of the ways students could engage in self-care, some obvious, some less so. It also features a follow-up, brief journal assignment. In exchange for completing the self-care assignment,~~

~~students earn the ability to revise assignments to earn a higher grade. In this way, the final grade still reflects their math content knowledge and the students are incentivized to practice self-care. In this talk I will discuss surprising ways the assignments were used and ideas for new directions.~~

~~**Authors:**~~
~~Justin Dunmyre, *Frostburg State University*~~
~~Michael Murtagh, *Frostburg State University*~~
~~Anne Murtagh, *Frostburg State University*~~

Inclusive Early Undergraduate Mathematics: Evolution through the Covid-19 Pandemic
11:00a.m. - 11:15 a.m.

Mathematics Departments and instructors with demonstrated commitments to equity and inclusion leveraged those perspectives as they adapted their early undergraduate mathematics instruction during the Covid-19 pandemic. Their instructional strategies and pedagogical perspectives from before the pandemic, and the ways they adapted those approaches during the pandemic, provide insight into ways of supporting students to succeed and thrive in undergraduate mathematics courses. This presentation will share results from interviews conducted with instructional faculty and department leaders at two Minority Serving Institutions during the online phase of the pandemic, with a focus on strategies that inform equitable and inclusive instruction moving forward.

Authors:
Nancy Kress, *University of Colorado at Boulder*
Rebecca Machen, *University of Colorado at Boulder*
David Webb, *University of Colorado at Boulder*

Welcoming Students Back: Focusing on Progress, not Perfection
11:20 a.m. - 11:35 a.m.

At the University of Nebraska at Omaha we spent the last year completely redesigning our first-year mathematics courses. Although a need for change was identified before the pandemic, the pandemic amplified issues that were already present and made change even more important. Prior to Fall 2021, our first-year courses used an emporium model in which students spent most of their class time learning mathematics in a computer lab, largely disconnected from their instructors and classmates. The pandemic exacerbated this issue.

Over the past academic year, we have sought to "rehumanize" our first-year mathematics courses. Starting in Fall 2021, first-year mathematics courses returned to an in-person format: students were back in physical classrooms with an instructor and learning assistants. For several students, mathematics was their only in-person course, making it crucial to form a sense of community in the classroom.

To facilitate this transition, a team of faculty, including both mathematicians and mathematics educators, came together to develop a common vision for course redesign. Efforts focused on engaging students in class using evidence-based teaching practices, helping students develop growth mindsets through standards-based grading, and forming social support networks for students. We discuss our successes and lessons learned from the past year of changes and reflect on our plans for the future.

Authors:
Keith Gallagher, *University of Nebraska Omaha*
Karina Uhing, *University of Nebraska Omaha*
Nicole Infante, *University of Nebraska Omaha*
Gregory P. Sand, *University of Nebraska Omaha*
Larissa Schroeder, *University of Nebraska Omaha*

MYMathApps Calculus
11:40 a.m. - 11:55 a.m.
I am writing an online Calculus text called MYMathApps Calculus. You can see a sample at https://mymathapps.com/mymacalc-sample/
the text is highly interactive and visual. Graphics, both 2D and 3D, static and animated, visual and interactive, have been made with Maple and Three.js. The use of plots and animated plots helps students understand concepts such as:
• the definitions of a derivative as the limit of slopes of secant lines, an integral as limits of Riemann sums, partial derivatives as slopes of traces, curvature and torsion, tangential and normal acceleration, divergence and curl, multiple integrals, curvilinear coordinates and Jacobians.
• The proofs of the triangle inequality, the mean value theorem and formulas for applications of integrals.
• Plotting functions, polar curves, and parametric curves and surfaces.
• Solving applied problems involving linear approximation, related rates, max/min, area, arc length, surface area, volumes by slicing, volumes of revolution, work, mixing problems, geometric series, Taylor series, directional derivatives, Lagrange multipliers, expansion and circulation.
• How to use the right hand rule in Green's, Stokes' and Gauss' theorems.
Since the book is totally online, it was extremely useful during the pandemic, since I show the book on the screen and share it on Zoom.
Author:
Philip Yasskin, *Texas A&M University*

Logic and Intuition in Everyday Mathematics
Friday, August 5, 1:00 p.m. - 2:55 p.m., Salon I

Many of us likely believe--and teach--that the role of proof is essential to the practice of pure mathematics. However, history is full of examples that suggest intuition may also play a meaningful role in the development of mathematical knowledge. Furthermore, computers can now supply (or at least verify) many of the logical steps in a mathematical proof, and even generate mathematical conjectures. This raises the question: what roles do logic and intuition play in mathematics? Is logic largely a scheme for demonstrating rigor and "correctness" after intuition has led us to a proposition that we believe to be correct? Or is logic more of an essential companion, informing our intuition and the very way think about our subject matter? This contributed paper session welcomes submissions reflecting on the relative roles of logic and intuition in mathematics, based on the contributor's historical/philosophical scholarship or lived experience as a working mathematician.

Organizers:
Jason Douma, *University of Sioux Falls*
Tom Morley, *Georgia Institute of Technology*

Sponsor:
SIGMAA on Philosophy of Mathematics (POM SIGMAA)

Re-Imagining Theorem-and-Proof in a Guided-Inquiry Geometry Course for Future K-8 Teachers
1:00 p.m. - 1:15 p.m.

What does it mean for elementary and middle school students to "prove" something about shapes and measurements? What does "geometric proof" mean for those students' teachers? What role can dynamic software or apps play in developing future K-8 teachers' concepts of evidence and proof related to geometric formulas, facts (theorems), and constructions? Reflections written by and discussions among these future teachers in a geometry course reveal what and how they comprehend pattern and evidence.

Author:

Chris Oehrlein, *Oklahoma City Community College*

Related Rates and Right Triangles: Developing Intuition in a Calculus Course

1:20 p.m. - 1:35 p.m.

Often one area where first year Calculus students run into significant difficulties is in setting up word problems. For instance, there are many types of related rates questions involving right triangles that are approached in different ways. These problems provide an interesting interplay between the firm logical rules students are used to working with to that point, and intuition in choosing how to approach a problem that they have not seen before. In this talk we discuss our observations of how the surface similarities of these problems can confuse students, and methods we've used to help students develop an intuition for deciding which method will be appropriate.

Author:

Benjamin Gaines, *Iona College*

Developing Mathematical Intuition with a History of Math Course

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

We have been offering a course on History of Mathematics at UNR. The course focuses on the development of mathematical concepts and techniques through different epochs. Many of the methods discussed in the course were conceived by mathematicians working before rigorous proofs were found in later centuries. In the talk, I will review some of the beautiful intuitive proofs developed by Archimedes, Arab mathematicians, and even Isaac Newton. I will argue that the course has shown to be a very useful tool for building mathematical intuition in math majors and provide them with an overview of the fields of mathematics and their interrelationships. Some of the intuitive proofs are also useful for teaching a diverse variety of subjects.

Author:

Raul Rojas-Gonzalez, *University of Nevada Reno*

Some Ways of Reasoning Productive for the Logic of Mathematical Reasoning

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

Our research team has been exploring the relationship between mathematical thinking and logic by exploring whether and how undergraduate students can reinvent key logical concepts by reflecting on mathematical statements and proofs. Observing that modern formalized logic developed quite late historically (in comparison to much of the rest of the undergraduate curriculum) and that logic primarily arose among mathematicians, we were inspired by the hypothesis that logic is formulated on the foundation of mathematical reasoning. By observing novices trying to abstract logic in our experiments, we have come to recognize some important ways of reasoning that we think constitute preconditions for abstracting logic for proof-based mathematics. We will briefly summarize some insights we have gained from eight years of such experiments. While these important ways of reasoning may not be surprising (e.g., associating to any property the whole set of objects that have the property), we think they are insightful for two reasons. Pedagogically, they help us understand what students need to develop to learn mathematical practice.

Psychologically, they help identify some of the essential practices of mathematics that may be so familiar we take them for granted. (supported by NSF DUE#1954768 & 1954613)

Authors:
Paul Christian Dawkins, *Texas State University*
Kyeong Hah Roh, *Arizona State University*
Derek Eckman, *Arizona State University*
Steven Ruiz, *Arizona State University*
Anthony Tucci, *Texas State University*

Logic, Intuition, and Infinity
2:20 p.m. - 2:35 p.m.

Mathematics survived, even flourished, through the late 19th Century while for the most part the mathematical community rejected the concept of an actual infinity. Then following the inspirational work of Cantor, the existence of infinite sets as completed totalities has become accepted to the point mathematicians now view properties of infinite sets as part of their mathematical intuition. But how can this be justified when we have no direct experience with infinite sets? Can we explain reasoning about infinite sets in a finitary way (in the spirit of Hilbert's program)? Results in proof theory, briefly described in this talk, provide a finitary, or even finite, interpretation of the infinitary mathematics of number theory and analysis. We explain that our mathematical domains can be interpreted as finite approximations that capture the content and meaning of their infinitary counterparts, allowing us to formally justify use of infinite sets in mathematics without having to change our use of "infinity" in the language of mathematics. This prompts the question of how can logical reasoning about infinite sets be understood? What is the relationship between our intuitions of infinite sets and the results of our formal theory of infinite sets? In this talk we explore these questions and offer an outline on approaching this problem through the apparatus of proof theory.

Author:
Rick Sommer, *Stanford University*

Defining Abstraction
2:40 p.m. - 2:55 p.m.

While there is a long philosophical tradition of examining abstract objects, along with their ontological status, definitions, and epistemic standing, the discussion takes on a uniquely important role in mathematics. Mathematicians might care to define abstraction for a better view of the connections between sub-fields and for precision of language. We provide an account of the process of abstraction, both on the micro-level of a student learning a new, abstract mathematical concept, and on the macro-level of the mathematical community spanning decades. This description gives us a better understanding of the importance of intuition in the creation of abstract mathematical objects, and the need for logic in their reification. It also allows us to compare the abstract concepts and structures that are formed, in order to delineate levels of abstraction.

Authors:
Rahmat Rashid, *Rollins College*
Mark Anderson, *Rollins College*

Research in Undergraduate Mathematics Education
Part A: *Friday, August 5, 8:00 a.m. - 11:55 a.m., Salon J*
Part B: *Friday, August 5, 1:00 p.m. - 2:40 p.m., Salon J*

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, *CSU Long Beach*
Nicole Infante, *University of Nebraska Omaha*

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

Part A: *Friday, August 5, Salon J*

Coming to Discern the Appropriateness of Exponential Models in Contextual Situations
8:00 a.m. - 8:15 a.m.
Exponential function is a difficult, yet essential, mathematical concept that plays an important role in the study of advanced mathematics (Ellis et al. 2016; Weber 2002). Teaching in a developmental mathematics program illustrates that students appear to have a deep understanding of exponentiation in context-dependent problems, rather than the already structured symbolic form of exponential models. This led to the question of what type of contexts could promote more appropriate use of exponential or make profitable conflicts (disequilibrium) to transfer from context to abstraction. This work presents case study of undergraduate students coming to perceive and understanding of exponentiation across a series of word problem. Data for this research were taken from a few in-depth online interviews (100 minutes of problem solving). This work is following a Microgenetic Learning Analysis (MLA) (Parnafes and diSessa, 2013). As MLA's nature, the data analysis of this work is seeking a moment-by-moment explanatory account of individuals' learning in exponential contexts, in which open consideration of relevant aspect of data focused on theories of learning.

This work represents and discuss three episodes of in-depth interviews illustrating how students shift back and forth between the use of linear and exponential models in response to three different contextual problems. To elaborate, participants' mathematical behavior demonstrated understanding a concept is, indeed, inseparable from developing logical readout strategies and coordination of knowledge resources. The analysis of students' exponential understanding is thus consistent with Wagner's (2006) Transfer-in-Pieces, where readout strategies and coordination of knowledge resources were matched with affordances of the contexts. In the direction of trying to understand what is behind whether transfer does or does not occur, the affordances of contexts is another point that participants' protocol allowed me to interrogate and consider. The fundamental role of embodied recursion in the context in establishing exponential understanding appears to be an important key for provoking profitable conflicts and disequilibrium. References: Ellis, A. B., Ozgur, Z., Kulow, T., Dogan, M.F., (2016). An exponential growth learning trajectory: Students' emerging understanding of exponential growth through covariation. Mathematical Thinking and Learning, 18 (3):151- 181. Parnafes, O., & diSessa, A. A. (2013). Microgenetic learning analysis: A methodology for studying knowledge in transition. Human Development, 56(1), 5–37.Wagner, J, F. (2006). Transfer in pieces, Cognition and Instruction, 24 (1): 1-71 Weber, K. (2002). Students' understanding of exponential and logarithmic functions. Second International Conference on the Teaching of Mathematics (pp. 1–10). Crete, Greece: University of Crete.

Author:
Elahe Allahyari, *Western Michigan University*

Learning and Developmental Experiences after College Enrollment and the Influence of Mathematics: Further Contextualizing Research Findings through the Lens of Pandemic Teaching
8:40 a.m. - 8:55 a.m.
Our longitudinal cohort studies of tens of thousands of college students have contributed to a robust explanatory framework for learning and development at the postsecondary level. Our ongoing work continues to show that students' experiences after enrollment in college are far more influential in predicting their overall academic success, persistence, and graduation than elements of their unchangeable incoming student profile. Additionally, we have found that students' experiences in mathematics play a particularly important role in this. Our findings have shown that these experiences early in college as well as students' belief systems in mathematics are among the most consistent predictors of collegiate academic outcomes. We believe our work has increased in relevancy in the time that the pandemic has impacted learning at all levels. In this talk, the findings briefly described here will be expounded upon and contextualized through firsthand experiences teaching mathematics in high school and college before and during the pandemic.

Authors:
Brian Darrow Jr., *Southern Connecticut State University*
Michael Ben-Avie, *Quinnipiac University*

Lectures and Answers and Barriers, Oh My!: Undergraduate Math Students' Strategic Use of Online Resources
9:00 a.m. - 9:15 a.m.
We present results from a mixed-methods investigation of undergraduate students' use of online resources in mathematics courses. Our analysis explores how students' use of video lectures, answer engines, and other tools varies according to the types of mathematics classes that students are taking. We also describe which aspects of college mathematics courses push students to make more extensive use of these resources and how students feel that these resources benefit them.

Authors:
Ander Erickson, *University of Washington Tacoma*
Anthony Archie, *University of Washington Tacoma*

Attitudes Matter! A New Instrument in Motivational Attitudes Toward Statistics / Data Science
9:20 a.m. - 9:35 a.m.
Attitudes matter in mathematics education, especially in fields like statistics, which sometimes suffer from a poor reputation, and data science. Understanding the relationship between both student and instructor attitudes and student achievement is crucial for improving instruction. Through an NSF grant (DUE-2013392), our research team is developing two new sets of attitudinal instruments - one in statistics and one in data science. In addition to student surveys, we are developing instruments to measure the learning environment and instructor attitudes. We will share our rationale for developing these six instruments, the theoretical framework for these instruments, Expectancy Value Theory, and we will discuss recent results and psychometric properties of piloted items. Statistics and data science instructors and educational researchers are invited to get involved in data collection.

Authors:
Michael Posner, *Villanova University*
April Kerby-Helm, *Winona State University*

Alana Unfried, *CSU - Monterey Bay*
Douglas Whitaker, *Mount Saint Vincent University, Canada*

Student Perceptions of a Changing Classroom Culture

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

Students' experiences in introductory-level mathematics courses are crucial to their overall success in college. In recent years, mathematics departments across the country have undertaken initiatives to incorporate evidence-based instructional practices into introductory courses to increase student learning. Our work examines students' experiences in College Algebra while the course was undergoing extensive changes. The data in this study come from a "Mathography" assignment completed at the end of Fall 2021 by students enrolled at a large, metropolitan university. Students responded to a set of prompts that had them reflect on their mathematical experiences in the course, including both a "high point" and "low point" during the semester. In our research, we sought to address the question: How do students perceive their mathematical experiences in a newly redesigned, introductory-level, mathematics course? Three themes emerged from our data: community, assessment, and mindset, with students discussing both positive and negative emotions throughout their reflections. Our findings suggest that students appreciated the community and culture that developed in the classroom, and that the assessment structure helped lessen stress but anxiety related to grades was still present. Several students commented on how their perceptions of learning had changed, which often reflected a new found growth-oriented mindset. Examining these experiences helps us, as educators, to be more knowledgeable and better equipped to make further changes to support students' learning.

Authors:

Karina Uhing, *University of Nebraska at Omaha*
Nicole Infante, *University of Nebraska at Omaha*
Gregory P. Sand, *University of Nebraska at Omaha*
Larissa B. Schroeder, *University of Nebraska at Omaha*
Keith Gallagher, *University of Nebraska at Omaha*

What is Instruction Like in Geometry Courses for Prospective Secondary Teachers?

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

We report on a survey designed to better understand students' experiences in geometry courses for teachers (GeT). The items in the survey help identify how prevalent different practices associated with one or another case of the instructional triangle (Cohen et al., 2003) are in courses across the country. For example, one set of items assesses the extent to which students engage in conjecturing and proving while another set assesses the extent to which students have the opportunity to engage in geometry teaching practices. Data collected from 75 students from 7 universities identified some similarities and differences in students' course experiences regarding the aspects hypothesized in distinct instructional triangles as well as across edges of the triangles. Some of our findings show that the GeT courses include: 1) more interactive lecture than traditional lecture, 2) more practices of helping students solve their own problems than telling students the answers to difficult questions, and 3) more providing definitions and proofs of theorems than having students participate in creating definitions or developing proofs. In the presentation, we will show a summary of students' responses on their perceptions of the content of studies and interactions with their peers and teachers they experience in the GeT courses. After sharing the findings, we aim to have a discussion with the audience about how we might use this information to improve the teaching of geometry courses.

Authors:

Michael Ion, *University of Michigan*
Pat Herbst, *University of Michigan*
Inah Ko, *University of Michigan*

Developing a Structural Perspective: Prospective Teachers Connecting Group Axioms with Additive, Multiplicative, and Compositional Inverses and Identities

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

Secondary mathematics teachers are tasked with teaching students to "look for and make use of structure" (CCSSM standards) and "understand how mathematical ideas interconnect and build on one another to produce a coherent whole" (NCTM standards). These tasks require teachers to have a structural perspective (Lee & Heid, 2018) and a connected, coherent understanding of mathematical structures that span the curricula. The study of abstract algebra provides a rich opportunity for prospective secondary mathematics teachers (PSMTs) to develop a structural perspective because it can lead PSMTs to develop a unified understanding of similar algebraic structures in different contexts. In this research study, I examined PSMTs' development of a structural perspective, focusing on how they developed unified understandings of algebraic inverses and identities. I discuss how PSMTs in a senior-level undergraduate Mathematics for Secondary Teachers course reasoned about the group axioms to make connections among additive, multiplicative, and compositional inverses and identities. I describe how their instructors' pedagogical practice of juxtaposing these inverses and identities guided the PSMTs to recognize the shared overarching structure of these concepts and attend to their differences with respect to their corresponding set and binary operation. I conclude with implications for the mathematical preparation of PSMTs.

Author:
Kaitlyn Serbin, *University of Texas Rio Grande Valley*

Planting Formal Seeds in the Embodied World

10:40 a.m. - 10:55 a.m.

In this presentation we share an embodied cognition researcher's teaching of abstract algebra. We delineate ways in which she integrated play, diagrammatic reasoning, and gestural modeling of abstract concepts in order to introduce or reinforce formal and symbolic concepts. We will also share students' reactions to embodied activities and how if at all, these teaching strategies benefited her students' understanding of abstract algebra concepts such as equivalence relations and homomorphisms. Finally, we will discuss the challenges and affordances of implementing a learning theory into the practice of teaching.

Authors:
Jessica Lajos, *Colorado State University*
Hortensia Soto, *Colorado State University*
Alissa Brown, *Colorado State University*

Rigor and Elegance in Proof Strategies (REPS): Perceptions among U.S. and African Graduate Students and Faculty

11:00 a.m. - 11:15 a.m.

When faculty describe proofs as "elegant," do mathematics graduate students know what this means? Perhaps proof elegance carries different meanings to students, and perhaps perceptions of elegance vary with cultural context. This REPS study (Rigor and Elegance in Proof Strategies) used a phenomenological case study methodology to investigate this. Participants, 8 mathematics graduate students (5 from the U.S. and 3 from Ghana) and 3 mathematics research faculty from the U.S., were given one geometry theorem. For each participant, four interviews were interwoven with take-home tasks and questionnaires. Participants tried to prove the theorem themselves, responded to sample proofs of it, and evaluated given proofs

according to aspects like rigor and elegance. In this presentation, we compare faculty and student perceptions of elegance, compare U.S. and African students' perceptions, and compare perceptions of elegance with perceptions of rigor, creativity, surprise, and validity.

Authors:

L. Jeneva Clark, *University of Tennessee - Knoxville*
Brooke Denney, *University of Tennessee - Knoxville*
Jonathan Clark, *University of Tennessee - Knoxville*

Facilitating Logic Learning As a Joint Endeavor: The Case of Carl and Sarah

11:20 a.m. - 11:35 a.m.

The purpose of this study is to explore how students' cooperative discourse with instructional guidance might provide support for students' learning of logic. As part of a larger study, we developed a sequence of set theory and proof-reading tasks to help students link set-based reasoning with logical principles that are relevant to mathematical proofs of conditional statements. We have implemented these tasks in several exploratory paired teaching experiments over the last five years. This presentation documents findings from our sixth iteration of the teaching experiment, conducted at a large public university in the US in Spring 2022. Initially, Carl and Sarah often displayed a lack of knowledge of logical principles such as universal generalization, contrapositive equivalence, and converse independence. As the teaching experiment progressed, they were often exposed to their partner's alternative representations for set relationships and corresponding interpretations of theorem-proof texts. We will discuss several episodes in which our instructional interventions played a critical role to facilitate students' joint reflection and modification of their reasoning about logical principles in the context of proof-reading tasks.

Authors:

Kyeong Hah Roh, *Arizona State University*
Paul Dawkins, *Texas State University*
Derek Eckman, *Arizona State University*
Anthony Tucci, *Texas State University*
Steven Ruiz, *Arizona State University*

University Students' Evaluations of Quantified Statements in Mathematics and Their Choices for Preferred Interpretations: A Survey Study

11:40 a.m. - 11:55 a.m.

Students' ability to interpret formal mathematical statements appropriately is crucial to their success in university-level mathematics courses. We designed a survey instrument to investigate how students with various degrees of proof experience interpret formal statements. This survey constituted an initial effort to scale our group's six years of qualitative research regarding how students interpret quantified mathematical statements. Each survey item consisted of a statement with several interpretations of the statement and its quantified variables. Respondents (1) evaluated if the statement is true or false, (2) determined if each interpretation about the statement is viable, (3) selected their preferred interpretations among those they identified as viable interpretations, and (4) re-evaluated if the statement is true or false. We collected data from 108 students enrolled in calculus and geometry courses at two post-secondary institutions over three semesters in 2021 and 2022. Our preliminary analysis indicates a positive association between proof-based course experience and selecting an appropriate truth value for a given statement. However, students' evaluation of truth for the statement did not always align (in the normative sense) with their preferred interpretations of the statement. Our presentation describes these misalignments and posits potential cognitive underpinnings for these students' reasoning about quantified mathematical statements.

Authors:

Derek Eckman, *Arizona State University*

Kyeong Hah Roh, *Arizona State University*
Erika David Parr, *Rhodes College*
Morgan Early Sellers, *Colorado Mesa University*

Part B: *Friday, August 5, Salon J*

Utilization of Representations in Introducing Differentiation to Calculus I Students when Teaching with Inquiry
1:00 p.m. - 1:15 p.m.
In this study, I present preliminary results from my dissertation research that investigates college calculus instructors' using and ordering of tasks, given an initial representation or context, for introducing differentiation to students when teaching with inquiry. Using a survey instrument (INQUIRE, Shultz, 2020), eight instructors with three different patterns of inquiry practices were chosen to be interviewed. During four 2-hour long interviews, the instructors were asked to propose eight tasks for introducing differentiation to their students given four initial representations—physical, graphical, verbal, and symbolic (Zandieh, 2000)—and students' assumed pre-conceptions before working on the tasks. The instructors were encouraged to use their teaching materials, design new tasks, and use other representations when necessary. The findings focus on the instructors' utilization of various representations of differentiation and their ordering. I present preliminary findings on the instructors' choices and whether their patterns of inquiry influenced their utilization of various representations in introducing differentiation to their students. The presentation would benefit both researchers and educators because it extends the research on teaching of calculus by focusing on the content and pedagogy and it showcases novel ways of teaching differentiation.
Author:
Saba Gerami, *University of Michigan*

High School vs. College Teaching: Perspectives from Math Educators with Experience in Both
1:20 p.m. - 1:35 p.m.
Past research typically assumes that an instructor is either a high school or college instructor, but not both. The mechanisms to obtain teaching credentials for high school and college-level mathematics are also traditionally separate, but many instructors teach at both levels or transition between them during their careers. In fact, some even teach both levels simultaneously (e.g., a high school teacher who is also an adjunct at a college). To better understand and support these educators, we surveyed instructors with experience in both high school and college teaching. In our initial round of qualitative data collection, we asked a series of questions centered around the Pedagogical Content Knowledge domains within the well-known Mathematical Knowledge for Teaching (Ball et al., 2008). In particular, we asked participants to answer questions about high school teaching versus college teaching. In this talk, we will discuss our initial analysis on participant perspectives for similarities and differences between their teaching at the secondary and postsecondary levels. We will share common responses and some surprising ones involving different aspects of teaching, such as instructors' choices of topics to teach, scaffolding techniques (or lack thereof), use of technology, and perceptions of autonomy. Further recognition of differences may help to inform teacher education and professional development programs for these educators.
Authors:
Anne M. Ho, *University of Tennessee*
Charlotte Beckford, *University of Tennessee*
Nathan Burns, *University of Tennessee*
Emily K. Campbell, *University of Tennessee*
Jessica L. Kingsley, *University of Tennessee*

Using Bolman and Deal's Four Frames as an Analytical Tool
1:40 p.m. - 1:55 p.m.
The Four-Frame Model by Bolman and Deal (2008, 2017) is a common analytical lens that researchers have adapted for higher education research (e.g., Reinholz & Apkarian, 2018) as a way to understand department culture and characterize change efforts. Further, theories of change are often required to be included in proposals for federal funding (e.g., NSF). The four frames, namely symbolic, structural, human resource/people, and political/power, each provide unique perspectives on understanding a situation or phenomenon. In some cases, however, we have seen the four frames simply used as an a priori coding system where data are classified as one frame or another rather than examining the data through the lens of each frame. For example, applying the four frames as a coding system to "tenure" is not straightforward, as tenure embodies all frames, which aligns with Bolman and Deal's intent to have a framework that encompasses "four perspectives" (p. 15-16). Following the recommendations of Bolman and Deal, change initiatives need to consider all frames in order to identify what frames need to be attended to in order to ensure positive lasting change. In this talk we will discuss how the Four-Frame Model can be used as a tool to guide change agents as they work on enacting and sustaining institutional change. In addition, we will discuss effective ways in which the Four-Frame Model can be used to examine data.
Authors:

Amelia Stone-Johnstone, *California State University, Fullerton*
Mary Pilgrim, *San Diego State University*

The Space Grows if We Let People be Themselves": Black Feminist Mathematics Pedagogies in Action
2:00 p.m. - 2:15 p.m.
Mathematics faculty often hold color-evasive and gender-neutral orientations to teaching (McNeill et al., in press), recreating postsecondary mathematics instruction as a marginalizing experience for underrepresented students (Ellis et al., 2016; Oppland-Cordell, 2014). Although research demonstrates that Black women faculty often disrupt oppressive teaching traditions in humanities and social science courses (e.g., Sulé, 2011), there is a void of research exploring Black women faculty's teaching in mathematics where social issues are not an explicit part of the curriculum. We present findings from a study of six Black women mathematics faculty members' experiences in their classrooms and departments. Our findings illustrate how participants' lived experiences informed socially conscious orientations to instruction. We leverage Joseph's (2021) theoretical model of Black feminist mathematics pedagogies to illustrate how participants' descriptions of their classroom practices exemplify equitable teaching. Implications are provided to support departmental efforts in recognizing, nurturing, and learning from Black women faculty's excellence in advancing equitable teaching in postsecondary mathematics.
Authors:

Taylor McNeill, *Vanderbilt University*
Aneva Jefferson, *Vanderbilt University*

Meritocrats, Wallflowers, and More: Characterizing Obstacles to DEI Engagement
2:20 p.m. - 2:35 p.m.
There is a pressing, and continuing, need for proactive efforts to increase equity and inclusion for marginalized people in all aspects of American society, including undergraduate STEM education. Proponents of such efforts must overcome resistance, both active and passive, in order to effect meaningful changes. This paper draws on data from a broader research study (Johnson et al., 2022) which collected survey data from postsecondary STEM instructors regarding their attitudes toward diversity, equity, and inclusion (DEI) efforts and how those views changed as a result of the events of 2020 (e.g., the onset of the COVID-19 pandemic, nationwide protests in support of racial justice). While many participants reported

changes in their views, particularly increased awareness of systemic inequities (Johnson et al., 2022), this report focuses on those who stated that their views were unchanged. In particular, we present profiles of the attitudes of 21 people who may represent obstacles to further gains in DEI: those who were not previously invested in social justice, and did not change their views in 2020. From these data, and supported by a broad literature base, we identified examples of archetypes including: meritocrats, who believe in the myth of meritocracy; opposers, who actively reject DEI efforts and initiatives; and wallflowers, those who evince some awareness but "stay out of it." We further discuss how each archetype might impact DEI efforts, and how we might work with (or around) such obstacles to effect change.

Authors:

Steven Ruiz, *Arizona State University*
Naneh Apkarian, *Arizona State University*
Estrella Johnson, *Virginia Tech University*

Share the Joy in Teaching Differential Equations through Modeling

Part A: *Thursday, August 4, 8:00 a.m. - 10:55 a.m., Salon D*
Part B: *Friday, August 5, 9:00 a.m. - 11:40 a.m., Salon D*

Share experiences and the joy in using modeling to motivate and teach differential equations in context, both as an introduction to the mathematics and as a narrative of a complete modeling cycle from experiencing a real-world phenomenon, through data collection, to model building with parameter estimation, and finally model validation.

Organizers:

Brian Winkel, *Director SIMIODE, Cornwall NY* Kurt Bryan, *Rose-Hulman Institute of Technology*

Sponsor:

Systemic Initiative for Modeling Investigations & Opportunities with Differential Equations (SIMIODE)

Part A: *Thursday, August 4, Salon D*

Simulating the Pandemic in a College Dorm

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

In this session, I will describe how I modified the "Spread of the Common Cold" Simiode project by Richard Corban Harwood to model Covid19 in a dorm. This project was used in the beginning of the course to help students understand how different strategies to reduce the spread of disease could affect the spread throughout the dorm. We used a floor plan of one of the actual dorms at our University. I made some modifications to the original project by redoing the simulation with heightened cleaning and then again with masking and social distancing. This presentation will describe how the project was modified and the results.

Author:

Nora Strasser, *Friends University*

Is Bike Throw a Real Throw? No? YES! Solution to SCUDEM VI 2021 Problem B: Throw The Bike Or Throw The Race

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

Modeling and optimizing racing performance has recently become popular, with optimal strategies being calculated for running as well as for cycling. SCUDEM Modeling Challenge provides us with an opportunity to have a thorough and academic understanding of the bike throw using differential equations. The bike throw is a common strategy used in bicycle racing whereby the cyclist pushes the front wheel of the bike across the finish line in a manner that moves the bike forward by millimeters, which gives the rider an advantage over sprinting. Our mission is to estimate the effectiveness of a bike throw. We derive differential equations from the force analysis and thoroughly examine how cyclists make their bike throws effective. Specifically, we consider under different wind conditions and gradients, what would be the optimal strategy for the cyclist to throw the bike.

Authors:

Zefan Qian, *Macalester College*
Yuhang Zhang, *Macalester College*
Weixiang Zhao, *University of California San Diego*

Illustrating the Dynamics of Gliders with Differential Equations, Mathematica, and Flight Simulators

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

We use Newton's laws to describe the motion of gliders under gravity and quadratic lift and drag forces. The resulting nonlinear system of differential equations -- Zhukovskii's equations-- is solved numerically. These solutions are then compared with data collected from flight simulators (geo-fs and Kerbal Space Program), for various gliders. By fitting Zhukovskii's equations to flight simulator data we find lift and drag constants and thus the lift-to-drag ratio for various gliders --which turn out to be fairly accurate estimates. This work exploits physics engines available in computer games, to provide students with immersive learning experiences, which are akin to a playable virtual physics experiment: enhanced skills in scientific computing, data collection, data analysis, mathematical modeling, curve fitting, and aerodynamics are learning outcomes.

Authors:

Hector Mera Couto, *Montgomery County Community College*
Christopher Vaughen, *Montgomery County Community College*

Applications of Computer Algebra Systems and R to Differential Equations Modeling

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

In this presentation we would like to explore using Computer Algebra Systems and Numerical tools like R to significantly enhance students' learning of Differential Equations Modeling. Among the topics considered are Differential Algebraic Systems, Delay Differential Equations, discontinuous ODEs with events, slope fields and phase portraits, cooling in variable temperature media, motion of the projectiles with realistic air resistance, population dynamics.

Author:

Leon Kaganovskiy, *Touro College*

Differential Equations for Modeling Blood Glucose Dynamics and Detecting Diabetes

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

In this talk we discuss a simplified model that uses differential equations to explain how the blood glucose regulatory system works. A nonlinear least square method is used to determine the parameters of the system

of differential equations based on the data from the glucose tolerance test. The model can be used to detect diabetes and to study the glucose dynamics in response to challenge stimuli.

Author:

Viktoria Savatorova, *Central Connecticut State University*

For the Love of Calculus: First Encounters with Differential Equations using Math Modeling
9:40 a.m. - 9:55 a.m.

Many students' initial experience with Differential Equations starts in a high school Calculus Class, often an AP or similar course. Using math Modeling Activities to teach the Differential Equations Unit gives the material meaning, and engages the students' critical thinking skills. This leads to more robust discussion and understanding in the classroom. Students develop the differential equation and use relevant information to determine the initial conditions for a modeling scenario instead of getting a word problem where they are given a differential equation and initial conditions. The benefits of using math modeling as a teaching approach is that questioning for conceptual understanding arises naturally and learning math from the students' perspective is an active participatory process.

Author:

Cheryl Potocki, *The Charter School of Wilmington*

Application of Differential Equations for Simulating Vehicle Suspension Performance
10:00 a.m. - 10:15 a.m.

Quarter-car model as shown in Figure 1 is used to simulate the dynamic behavior of a vehicle suspension system, which provides the necessary ride isolation at each wheel. In its most basic form, a quarter-car model is comprised of sprung mass (the mass of the vehicle supported on the suspension), unsprung mass (the total mass of the parts being connected to the wheel), suspension and wheel assembly. The dynamic behavior can be characterized most meaningfully by considering the input-output relationships. The road excitation (Zr) is chosen to be the input. From the ride quality point of view, designers are mostly interested in the vibration of the sprung mass, which is used as the system output. The term "transmissibility" is usually adopted to represent the non-dimensional ratio of the response amplitude of the sprung mass to the excitation amplitude of the rough road surface. The equations of motion of the sprung mass and unsprung mass are derived from free body diagrams based on the Newton's Second Law, which must be second-order differential equations including all parameters shown in Figure 1. Next, Laplace transform is applied to manipulate the derived differential equations to yield system transmissibility as a function of exciting frequency. By plotting the transmissibility with respect to variable stiffness and damping coefficient within the predetermined ranges, the effects of the "coefficients" in the differential equations on the system response characteristics (e.g., natural frequency, under/critical/over damping) are investigated in the frequency domain. The project is conducted based mainly upon the strategy shown in Figure 2 Figure 1. Schematic diagram of quarter car model Figure 2. Flowchart of model development.

Author:

Shengyong Zhang, *Purdue University Northwest*

Lessons Learned in Mentoring Student-Led Projects in Mathematical Biology: Mechanisms and Quantification
10:20 a.m. - 10:35 a.m.

This study discusses a long running REU in mathematical biology. A characteristic of the program is that students choose their own topics. This creates a reversal of hierarchy, where students know more about their topic of interest than mentors, and mentors serve as consultants providing mathematical guidance and expertise. But how does this reversal of hierarchy really function? In this study four undergraduate research

groups made presentations over six days while developing their research question and model. Analysis of the presentations' recordings, mentors' comments, and project final papers show that this reversal of hierarchy does not always function smoothly. In these examples, students struggled with identifying mechanisms that would inform model development, and with understanding the box metaphor in differential equation flow diagrams.

Author:

Carlos Castillo-Garsow, *Eastern Washington University*

Part B: *Friday, August 5, Salon D*

An Interdisciplinary Initiative towards Modeling-First Differential Equations
9:00 a.m. - 9:15 a.m.

Mathematics and engineering faculty at VCU have collaborated together over the past several years to improve curriculum alignment between disciplines. One facet has entailed incorporating more applications into our introductory Differential Equations course. A simple shift in focus of the types of problems given as student work has evolved into large-scale efforts to engage differential equations students in the complete modeling cycle. We will present several examples of differential equations modeling projects created and adapted for this effort by interdisciplinary faculty teams as part of the NSF-funded SUMMIT-P initiative. We will also report on our process for developing these projects, strategies for using them with a large multidisciplinary student population, and lessons learned from their most recent implementation in Fall 2021.

Authors:

Laura Ellwein Fix, *Virginia Commonwealth University*
Rebecca Segal, *Virginia Commonwealth University*
Afroditi Filippas, *Virginia Commonwealth University*

Data Challenges in Epidemic Models
9:20 a.m. - 9:35 a.m.

Researchers study SIR (Susceptible-Infectious-Removed) and related differential equation-based models to build understanding of the dynamics of disease outbreaks. These models can show the rise and fall of infections, the importance of interactions between Infectious and Susceptible people, and the potential impact of different public health interventions. Yet connecting such models to real data is filled with challenges. Data may be difficult to gather; the data we collect may not match the precise compartments modeled; time units may vary between data and model; we may need to choose parameters that fit the timing of an outbreak, or that fit the size of an outbreak, without being able to fit both well. These difficulties are real. However, such struggles prompt fantastic classroom conversations about connecting models with data, and this talk will focus on the role of these struggles in building better mathematical thinking.

Author:

Meredith Greer, *Bates College*

A Condensed Course in ODEs via Modelling
9:40 a.m. - 9:55 a.m.

This re-designed 3-week course on ODEs covers the standard topics of a first course in differential equations, motivated and inspired by solutions to toy models from STEM fields. We discuss aims and results appropriate for the shortened time-frame along with differences between similar courses on the standard 15-week schedule or courses with limited offerings for hands-on student/problem interactions.

Author:

Gerasim Iliev, *University of Georgia - Department of Mathematics*

Investigating the O in SIMIODE: Providing Opportunities for Students to Bring Aspects of their Own Identities into the Differential Equations Classroom
10:00 a.m. - 10:15 a.m.
Math models are used to study human experiences, observations, or needs in real life. Therefore, human aspects should be incorporated into the modeling first approach. It is important to be culturally sensitive introducing the modeling scenarios. In this session, we present culturally responsible activities for modeling in differential equations courses that introduce context to engage students from various backgrounds. For example, one might think Star Wars or baseball could provide suitable contexts for mathematical problems, however, these contexts may not be engaging all students, but rather a subset of students from the dominant culture. In this talk we will introduce some potential activities with contexts that allow for opportunities for students to demonstrate their interests, strengths, "cultural knowledge, abilities, skills, strategies and networks" (Denton et al, 2019). That is, the activities focus on students' "existing strengths to drive instruction, assessment and curriculum design" (Gay, 2010 as cited by Aronson et al, 2016, p. 164). We will provide teacher practices that accompany these activities that focus on opening the whole class interaction to include students' cultural backgrounds.
Authors:
Yanping Ma, *Loyola Marymount University*
Gail Tang, University of La Verne
Gulden Karakok, *University of Northern Colorado*

Differential Equations from Invisibility Cloaks with Metamaterials
10:20 a.m. - 10:35 a.m.
In June 23, 2006's issue of Science magazine, Pendry et al and Leonhardt independently published their papers on electromagnetic cloaking. Since then, there is a growing interest in using metamaterial, an artificial nanomaterial with many interesting exotic properties, to design invisibility cloaks. In this talk, I will present some differential equations obtained from the invisiblity cloaks with metamaterials. in recent years. Some interesting numerical simulations of invisibility cloaks will be presented.
Author:
Jichun Li, *University of Nevada Las Vegas*

Laplace Meets Tesla in a Differential Equations Course - A SUMMIT-P Project Maila As Well - Yes
10:40 a.m. - 10:55 a.m.
Tesla's ambition of wirelessly transmitting electricity using radio frequency resonance was never realized. Now, more than a hundred years after Tesla's experiments, wireless transmission of electricity via magnetic induction is currently used in a humble household electronic: the wireless toothbrush. The wireless toothbrush is one of many household applications of a 2-coil wireless power transfer (WPT). In this talk, we will look at a mathematical model of this WPT via magnetic induction. The system consists of two second-order differential equations coupled by a mutual inductance. We will then use several methods from Differential Equations course to solve the resulting system. The methods are Laplace Transform method, Systematic Elimination method, and the Method of Undetermined Coefficients. The closed-form solutions will allow us to determine the so-called transient and steady-state response of the WPT system. We will also show how this topic may be embedded in a Differential Equations class and technologically supported by various software: symbolab.com, desmos.com, Excel, MultiSim, and Matlab.
Authors:

Shahrooz Moosavizadeh, *Norfolk State University*
Maila Hallare, *Norfolk State University*
Makarand Deo, *Norfolk State University*

(Cancelled) ~~Facilitating Modeling Project with Numerical Labs~~
~~*11:00 a.m. - 11:15 a.m.*~~
~~In this talk, we discuss our experience incorporating MCM projects in our differential equations courses. We discuss the introduction of numerical methods via Python labs to help students come up with more interesting solutions to these projects.~~
~~**Authors:**~~
~~Yajun An, *University of Washington, Tacoma*~~
~~Alan Bartlett, *University of Washington, Tacoma*~~

Inviting High School Students to Explore Advanced Mathematics
Friday, August 5, 1:00 p.m. - 3:55 p.m., Salon E

This session is for participants to share innovative ways to invite all high school students to further explore these advanced mathematical topics, such as discrete mathematics, number theory, linear algebra, and topology. This exploration can include, but is not limited to, specialized high school courses, dual enrollment courses, extracurricular programs, online courses, or including lessons within existing high school courses.

Organizers:
Chuck Garner, *Rockdale Magnet School for Science and Technology*
Bill Shillito, *Oglethorpe University*

Sponsor:
SIGMAA on Teaching Advanced High School Mathematics (TAHSM-SIGMAA)

Girls Talk Math – Making Advanced Mathematics Accessible to High School Students through Inquiry-Based Learning
1:00 p.m. - 1:15 p.m.
Girls Talk Math (GTM) is a free mathematics and media day camp for girls and nonbinary high school students. It is currently hosted on three college campuses: at the University of North Carolina at Chapel Hill (since 2016, founding chapter), at the University of Maryland, College Park (since 2018, sister chapter), and at Worcester Polytechnic Institute in Worcester, MA (since 2022, sister chapter). GTM camps target students from underserved school districts who are curious about mathematics but do not consider themselves high achieving. During the two weeks of camp, students work in groups to solve problem sets focused on advanced mathematics topics, including elliptic curve cryptography, quantum mechanics, mathematical epidemiology, network science, and knot theory. The GTM curriculum is designed for inquiry-based learning to accomplish two program goals: increasing students' confidence and strengthening interest in taking advanced mathematics courses. Undergraduate student Team Leaders provide guidance and answer questions while empowering students to take responsibility for their own learning. Campers feel ownership of their work and learn together to overcome mathematical challenges. Each group produces

media about the mathematics topic they learn, allowing participants to assimilate and share new knowledge through reflection and communication.

Authors:

Francesca Bernardi, *Worcester Polytechnic Institute*

Katrina Morgan, *Northwestern University*

MaPP Challenge: Integrating Research Mathematics into a Puzzle-hunt Format

1:20 p.m. - 1:35 p.m.

In this session, we share a puzzle-based event in the style of a scavenger hunt or campus-wide escape room, called the MaPP (Mathematical Puzzle Programs) Challenge, which combines contemporary mathematics and public outreach in an innovative way by engaging high school students with puzzles inspired by recent advances in mathematics. Traditionally, access to advanced mathematics for high school students has been limited to a very few "gifted" students who are from an already privileged population. An underlying assumption in this phenomenon is that advanced mathematics is accessible to only a selected few, and the MaPP project proposes to challenge this assumption by adapting advanced mathematics into a format accessible to a general audience of 7th-12th grade students. Some examples from the MaPP challenge event will be shared to show how the ideas from contemporary math are distilled into a format accessible to students with a wide range of mathematical backgrounds and abilities.

Authors:

Younhee Lee, *Southern Connecticut State University*

Andrew Owens, *Widener University*

Braxton Carrigan, *Southern Connecticut State University*

Steven Clontz, *University of South Alabama*

PJ Couch, *Lamar University*

High School Summer Program in Mathematical Epidemiology

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

The Adelphi Summer Institute in Mathematical Epidemiology (ASIME) is a 6-week summer program for 9-11 grade students. The program offers projects in cancer epidemiology and infectious disease models applied to New York State COVID-19 data. Students work in groups with Adelphi mathematics faculty and full-time research assistants hired from the Adelphi mathematics degree programs. Participants also experience weekly visits from external subject-matter experts to underscore the real-life applicability of their research projects. In this talk, we provide practical information on our approach to introducing high school students to the skills in mathematics, statistics, and computer science that are needed to tackle a real world problem in epidemiology. We also comment on administrative strategies we employed and external resources we secured to make ASIME a reality. Lastly, we highlight some approaches we used to attract and fund student participants from historically underrepresented groups.

Authors:

Anil Venkatesh, *Adelphi University*

Joshua Hiller, *Adelphi University*

Exploring Mathematics for Computer Science via A-level Module on Decision Mathematics

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

Decision Mathematics is one of the elective modules for the British and International Alevel course on mathematics. Much of the module's content comes from computer algorithms on graphs, although programming is not required and practice problems are designed to be solvable by hand. The module, however, provides an excellent platform for extended learning projects on various topics from a standard

undergraduate level mathematics for computer science course, such as greedy algorithms, heuristic algorithms, graph coloring, linear programming, and dynamic programming. In this talk, we take a look at the course structure of Decision Mathematics and options for introducing advanced mathematics and computer programming. Some of the activities have been implemented in past teaching, and feedback from students and observation from teachers are also discussed.

Author:
Zoey Guo, *Guangdong Country Garden School*

Math Explorations, Group Theory, and CrowdMath: Some Projects to Expose Pre-College Students to Advanced Mathematics
2:20 p.m. - 2:35 p.m.
We will discuss several projects that have been implemented by Art of Problem Solving, all with the goal of exposing pre-college students to mathematical concepts not normally seen until after high school. These include: (1) summer "Math Explorations," a series of 10-day courses for students in grades 6-9 to explore advanced math topics; (2) a 14-week group theory online course for high school students; and (3) "CrowdMath," a joint project between AoPS and MIT PRIMES for high school and college students to collaborate on original Polymath-style research projects.

Author:
David Patrick, *Art of Problem Solving*

Research Experiences with Advanced High School Students
2:40 p.m. - 2:55 p.m.
For the past few years, I have directed 4 high school students for research projects in mathematics. All of these four students have great interest in exploring advanced mathematics topics at college level. They all came to me by some sort of expert searching sources. It shows a need for college professors to direct high school student research. Among the 4 students, two are in Ph.D. programs in mathematics now, one did not finish the project, and one is currently a high school junior. These students are all talented in mathematics. I believe through doing mathematics research, their critical thinking skills and logic reasoning ability were improved a great deal. It absolutely raised their levels of appreciation of mathematics. In this talk, I will share my experience in working with high school student researchers and address questions on how to select appropriate topics to fit students' interest and background level and how to keep them motivated in doing mathematics research.

Author:
Aihua Li, *Montclair State University*

Journeys in Symmetry at Stanford Math Camp (SUMaC)
3:00 p.m. - 3:15 p.m.
Due to its abstract nature, group theory is conceptually difficult, and so high school students who are exposed to the subject may find it impenetrable. However, the topic can be intuitive, interesting and accessible, including to those without an advanced mathematical background. At Stanford Math Camp (SUMaC) we use themes of symmetry in a range of contexts to first introduce, and then further develop, key ideas throughout a course in abstract algebra. Building on students' intuitive understanding, as well as their prior experience, we explore symmetry in a rich and robust range of mathematical contexts. This wide array of ways symmetry emerges helps students develop a deeper understanding, and aids them in overcoming the challenges of abstract concepts, that too often obscure the beauty of the subject. Here we will present several examples of problems and topics from this curriculum that students find engaging and draw them into the abstract content.

Author:
Rick Sommer, *Stanford University*

Spherical Easel: An Invitation to Advanced Geometry
3:20 p.m. - 3:35 p.m.
Dynamic geometry software, such as GeoGebra, has been used in the classroom for many years to help students at all levels explore the geometry of the Euclidean plane. Spherical Easel allows students to do the same thing on the sphere. Students can create arrangements of lines, circles and other objects, dynamically move them, measure them, and then make precise conjectures concerning their arrangement. Any of the common theorems from Euclidean geometry, such as the Pythagorean, Thales', and the Inscribed Angle theorems, can be explored on sphere where they become much less inevitable. This can lead the curious learner, armed with only a knowledge of trigonometry, to accessible historical texts on spherical geometry and to create new mathematics. A beta version of Spherical Easel can be found at https://easelgeo.app.
Author:
William Dickinson, *Grand Valley State University*

Nomograms -- Visualizing Roots
3:40 p.m. - 3:55 p.m.
A nomogram is a graphical calculating device. In this talk we will focus on a nomogram for solving quadratics. We will prove how the nomogram works, and discuss classroom applications. No prior knowledge will be assumed.
Author:
Dustin Hedmark, *Montgomery Bell Academy*

Inquiry-Based Learning
Thursday, August 4, 8:00 a.m. - 10:20 a.m., Salon I

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.

Organizers:
Lee Roberson, *University of Colorado-Boulder*
Mami Wentworth, *Wentworth Institute of Technology*
Mel Henriksen, *Wentworth Institute of Technology*
Nathaniel Miller, *University of Northern Colorado*
Parker Glynn-Adey, *University of Toronto-Scarborough*

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

20 + 20 + 20 = 70: An Inquiry-based Active Learning Structure for Calculus Developed in the SUMMIT-P Project

Ready to include more active and inquiry-based learning in your calculus (or other introductory mathematics courses) but not sure how to integrate it into your everyday practice? As part of the SUMMIT-P project we implemented a model that splits each class period into approximate thirds. We open with an inquiry-based introductory small group activity often set in an applied context that was developed in collaboration with partner discipline faculty. This work leads students to questions addressed in the mini-lecture; second, a mini-lecture on lessons learned from the activity and additional applications; and third, practice time with scaffolded problem sets. In this talk, we'll present the model which we nicknamed "20 + 20 + 20 = 70" for the time, in minutes, dedicated to each type of activity in our 70-minute classes (the missing 10 minutes floats where needed); possible adaptations include "15 + 15 + 15 = 50" and "30 + 30 + 30 = 100". The key is creating a familiar routine for students and "course-in-a-box" materials for instructors. We will share examples of a typical day, student response, and some lessons learned.

Authors:

Suzanne Dorée, *Augsburg University*
Jody Sorensen, *Augsburg University*

Exploration of Inquiry-Based Learning Versus Lecture-Based Instruction on Calculus I Students' Math Anxiety: A Mixed Methods Study

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

Math anxiety affects student learning and academic performance. Highly math-anxious individuals exhibit physical, mental, and emotional symptoms. These symptoms often have a short-term and long-term impact on students' mathematics learning and their performance both inside and outside of school. Hoping to identify the possible measures to reduce math anxiety, this mixed methods study investigated the effects of inquiry-based learning (IBL) versus lecture-based (LBI) instruction on Calculus I students' math anxiety. Quantitative data were collected using a short version of the Mathematics Anxiety Rating Scale (MARS-S); qualitative data were collected through student and instructor interviews and class observations. Quantitative results show that the IBL students' math anxiety slightly decreased and the LBI students' slightly increased; however, neither of these changes were statistically significant. Qualitative results show that the IBL students experienced sense of belonging and felt confident and empowered than the LBI students. Moreover, in-class group work and optional and nongraded homework decreased IBL students' anxiety, whereas out of class group activities decreased LBI students' anxiety. However, both groups of students felt anxious about being called on for a response and responding to the instructor in front of their classmates.

Authors:

Harman Aryal, *Ohio University*
Gregory Foley, *Ohio University*

Using the Feynman Technique to Make Learning Math Fun

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

Students all over the world learn by listening and memorizing. Many of these students grow up with a misconception of what math is. This is a tragedy because math is a beautiful art. Using the Feynman technique to teach math allows the student to lead the conversation. The teacher tries to poke holes in the students' explanations, creating a socratic dialogue. This technique develops a genuine understanding of the underlying material. It fosters creative discoveries for the students, and a love of mathematics. In this talk, I'll be referring to my experiences running the Feynman mafia, my correspondence with Laurens Gunnarsen, and my future initiatives building a math program at Primer. Links: - https://docs.google.com/presentation/d/e/2PACX-1vQiy28qQeLoL5x4xvfRZGIGiXPv8M1frywBfTRqehHf1sXl7z8GsftDagNE2dmvi5k1tyqOp65VI2to/p

ub?start=false&loop=false&delayms=3000#slide=id.g1111b04fe26_0_65 - https://feynmanmafia.com/ -
https://daviderady.com/math/ - https://primer.com/blog/announcing-primer-fellowship

Author:

Davide Radaelli, *Primer (primer.com)*

Number Theory with Inquiry

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

In this talk I'll discuss what I've learned from the past 5 years of teaching my IBL Number Theory course,
including day-to-day activities, grading schemes, impact on students, and modifications made during the
pandemic.

Author:

Melissa Dennison, *Baldwin Wallace University*

~~(Cancelled) Flipping the Abstract Algebra Classroom: Notes from the Field!~~

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

~~Moving away from the Definition/Theorem/Proof/Example method of teaching proof-based courses can be
challenging because it requires both (re)training the students and creativity and flexibility on the part of the
instructor. This is a report on using inquiry-based methods in an undergraduate Abstract Algebra course.
The in-class activities are designed to help students explore and develop intuition for new concepts so that
they are not just pushing symbols around in their proofs. We will describe some of the most successful
activities, as well as some surprising things that can happen when you create a collaborative learning
community in your classroom.~~

~~**Author:**~~

~~Lauren Rose, *Bard College*~~

An Inquiry-Based Learning Approach to Object Oriented Programming

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

A student's first introduction to Object Oriented Programming (OOP) can be abstract and confusing,
especially for mathematics students who are more comfortable with an algorithmic approach to problem
solving. In this talk, I present lesson plans for a collaborative project where, through inquiry-based learning
(IBL) strategies and iterative game design, students organically discover the many benefits of OOP,
including encapsulation, inheritance, and polymorphism. Specifically, I contrast my experience teaching an
Introduction to Programming course using this IBL approach to OOP with previous experiences teaching
OOP through a more traditional lens.

Author:

Cassidy Krause, *Millikin University*

Liberal Arts Mathematics for Human Flourishing

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

In his retiring address as president of the MAA in 2017 (and the subsequent book released in 2020), Francis
Su laid out a vision for mathematics as integral to a life of flourishing. In this talk, we will describe and
share resources for an inquiry-oriented liberal arts math course informed by the vision Su describes.

Author:

Mike Janssen, *Dordt University*

Data for Good: Bringing Social and Professional Responsibility into the Statistics Classroom

Thursday, August 4, 9:00 a.m. - 10:55 a.m., Salon F

The data deluge is impacting our everyday life - whether making decisions for us through targeted ads or through the lack of data privacy rights. This session seeks to address how to critically engage with issues related to social justice, equity, inclusion, ethics, and social/professional responsibility in the statistics and data science classroom through the use of data.

Organizer:
Grant Innerst, *Shippensburg University*

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

Teaching "Responsible Data Science"
9:00 a.m. - 9:15 a.m.
In this talk, I will discuss Responsible Data Science, an innovative semester-long course curriculum developed by Dr. Julia Stoyanovich of NYU. The main topics covered are algorithmic fairness, data privacy, transparency, and interpretability. This curriculum was adopted by Ramapo College's MS Data Science program and features a mix of policy, philosophy, Python, and mathematics. Course materials, including slides, readings, and lab assignments, are freely available at https://dataresponsibly.github.io/rds/ and slide source files and homework assignments are available by request.
Author:
Debbie Yuster, *Ramapo College of New Jersey*

Data Science: A Tool to Infuse Social Justice in STEM Learning
9:20 a.m. - 9:35 a.m.
Underrepresentation in STEM is a tenacious problem, despite research identifying and addressing many of the prerequisite factors for recruitment and persistence in STEM (e.g., self-efficacy and sense of belonging). Motivated by McGee & Bentley's (2017) observation that minority students are more motivated by "equity ethic" than a big paycheck and being cognizant of the importance of incorporating personally relevant contexts and scenarios to maximize student engagement. we adopt a novel approach to STEM instruction that is likely to have a broad appeal for many underrepresented groups in STEM. In our ongoing NSF-funded project (NSF HRD#1912408), we use data science as a tool for dissecting social inequities and promoting social justice. We utilize a hub-and-spokes model to build multidisciplinary strength to broaden the reach of data science to a broad spectrum of students with wide-varying interests. The hub will be composed of the required skill set in mathematics, statistics and computer science. Each spoke will extend to the student's chosen interest. We are creating spokes on varied social justice topics (police killings, environmental justice, COVID-19, domestic violence, sexual assault, to name a few based on student input) - we make available a curated dataset on each of these topics with associated research and guiding questions. Additional resources are provided to ease the student's journey into data exploration on the social justice topic of their choice. Data Science offers the ideal starting point for highlighting to students how STEM provides a meaningful avenue for pursuing social justice and affecting policy changes.
Authors:

RN Uma, *NC Central University*
Alade Tokuta, *NC Central University*
Rebecca Zulli Lowe, *Cynosure Consulting*
Adrienne Smith, *Cynosure Consulting*

Teaching the Census
9:40 a.m. - 9:55 a.m.
Talking about sampling is a standard part of introductory statistics. Teaching the census allows extra discussion of sampling versus enumeration as well as differential undercount. Additionally discussion of data privacy techniques for census data generate interest.
Author:
Kim Roth, *Juniata College*

Anti-Racist Teaching in an Introductory Biostatistics Course
10:00 a.m. - 10:15 a.m.
To simplify data analyses, researchers will often group individuals that are from smaller groups into the "other" category. However, "othering" of people by race or ethnicity leads to inequity in US society. In the introductory biostatistics class we teach to first year public health master's students in Epidemiology, Public Health Administration and Practice, and Environmental Health, we have designed two back-to-back learning modules that explore how creating an "other" race category can result in missing important inequities in birthing outcomes for people in North Carolina in 2001. We use a widely available dataset from the R package Stat2Data. In the first module, when we teach ANOVA and multiple comparisons, we see how grouping Indigenous people and people of Asian and Pacific Islander ancestry into one "other" group can hide inequities in birthing outcomes for Indigenous people. In the second module, where we learn about power and sample size calculations, we see how lack of power results in not being able to see significance even when the effect size is large enough, which helps students better understand why we reject the null instead of accepting it. In both instances, students gain a deeper understanding of inferential techniques, as well as how to evaluate and present data to highlight inequities.
Authors:
Jennifer Czachura, *Biostatistics Division, School of Public Health, University of Minnesota*
Marta Shore, *Biostatistics Division, School of Public Health, University of Minnesota*

How Data Science Naturally Brings Social Awareness into the Classroom: Insights from a SUMMIT-P Collaboration
10:20 a.m. - 10:35 a.m.
At University of Tennessee, we have launched a new intercollegiate minor in Data Science. As the introductory core course (DS 201) includes students from engineering, arts and sciences, business and computer science, we have both a wide range of mathematical and coding (python) experience in the class. While that is one challenge, the other challenge is to use case studies in data analysis that all students can relate to. While we use some examples from earth science, basic probability (dice) and Newton's laws, one of the easiest topics for students to comprehend is socio-economic and demographic data from the world and from U.S. Aggregated at the scale of U.S. counties, abundant data include socioeconomic factors (household income, employment), race and ethnicity categories, and health (e.g. diabetes, obesity rates). When student explore how these factors affect each other in multivariate regression, for example, they see socio-economic disparities first hand. In this talk, we will discuss the pros and cons of letting students make discoveries about socioeconomic data with minimal instructor guidance.
Authors:

Senjuti Dutta, *University of Tennessee*
Alex Bentley, *University of Tennessee*
Jeneva Lauren Clark, *University of Tennessee*
Nicholas Nagle, *University of Tennessee*

Exploring Themes of Social Inequalities in Three Different Types of Statistics Courses
10:40 a.m. - 10:55 a.m.
In this talk we will discuss the use of social justice data in three different levels of statistics classes: a freshman multi-section consumer-based statistics course for healthcare majors built on projects; an R-based freshman statistics course; and an R-based junior statistics course. Sources include Medicare hospital data, Medicare healthcare disparity data, Unicef, a colonial census, and a Bureau of Justice campus climate survey pilot study.
Authors:
Kim Druschel, *Saint Louis University*
Mike May, *Saint Louis University*

Mathematics and Sports
Friday, August 5, 1:00 p.m. - 3:40 p.m., Salon F

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:
Russ Goodman, *Central College*
Hope McIlwain, *Mercer University*

Sponsor:
SIGMAA on Sports and Mathematics (Sports SIGMAA)

The Application and Implementation of Statistics in Shotokan Karate
1:00 p.m. - 1:15 p.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 and a single statistic was developed that captures the overall ability level of a karate participant. Finally, we compare these statistical results to results obtained by evaluating karate participants using artificial intelligence.
Authors:

Oliver DiDonato, *Neumann University*
Ryan Savitz, *Neumann University*
A Model for a Course-Based Undergraduate Research Experience (CURE) in Sports Analytics Utilizing Cutting-Edge Technology
1:20 p.m. - 1:35 p.m.
The authors designed an honors seminar course entitled Sports Analytics: Soccer to provide students with a course-based undergraduate research experience (CURE) using cutting-edge GPS/accelerometer athlete-tracking devices. This presentation offers details of the design and structure of the course, where a goal was for students to contribute to a longitudinal research project of performing a comprehensive performance and load analysis on Division III women's soccer athletes.
Authors:
Russ Goodman, *Central College*
Katelin Valster, *Central College*

Predictive Hockey Analytics
1:40 p.m. - 1:55 p.m.
Predicting the outcome of a hockey game can be challenging due to the fast paced and physical nature of the sport. In this talk, we share several approaches for determining the outcomes of NHL hockey games. One method involves a continuous time Markov process-based model that takes the certain state the home team is in at any point in the game and gives a winning probability statistic for that time. This state is based on the home team's shot and goal differential relative to the opposing team and approximates the probability that the home team would win depending on the state they are currently in at a given time in the game. Our second analysis technique uses hypothesis testing to determine whether variables (or combinations of these variables) like shot differential, manpower differential, face-off win percentages, the amount of time in power plays, and the number of low, medium, or high-danger shots are predictive in determining the outcome of NHL hockey games. Finally, we created Colley models, which used the results gained from hypothesis testing, to predict which teams would likely come out on top in the end-of-season standings.
Authors:
Amanda Harsy, *Lewis University*
Miles Mena, *Lewis University*
Robbert Dudzinski, *Benedictine University*
Harvey Campos-Chavez, *Lewis University*
Jacob Prince, *Lewis University*

The Scoring Method of Olympic Sport Climbing As a Case Study in Social Choice Theory
2:00 p.m. - 2:15 p.m.
For the 2019 Climbing World Championships, the International Federation of Sport Climbing created an interesting new method for choosing medalists in the Combined Sport Climbing Event. The method made its Olympic debut at the 2020 Olympics, the first Olympics to contain climbing as an Olympic event. The sport climbing event consists of three disciplines and each climber receives a ranking in each discipline based on their performance relative to other climbers. The rankings of a given climber are multiplied to give each climber a score; the climbers with the three lowest scores win the medals. Because this method depends only on the rankings of the climbers in the individual disciplines, it can be interpreted as a new voting method, connecting the study of sport climbing to the classical study of voting in social choice theory. This talk uses the new scoring method as an opportunity to consider what makes for a good voting method in the context of athletic competitions, where the competition's final results depend only on the rankings of the competitors within the event's disciplines.
Author:

David McCune, *William Jewell College*

Connecting Sports and Public Policy Through Ranking, Judging and Voting
2:20 p.m. - 2:35 p.m.
The mathematics of fairness, broadly defined from cake cutting to social choice, is an accessible topic that can be explored in many different courses. In this talk we include some examples of ranking, judging and voting that we routinely cover in an elective course on sports applications of mathematics. We then consider how to tie these topics in to other areas of interest to students, including college rankings, elections, and strategic voting.

Author:

Rick Cleary, *Babson College*

On the Use of Pythagorean Expectation to Predict NBA Records and Ranking NBA Teams
2:40 p.m. - 2:55 p.m.
Pythagorean Expectation is a common sports analytics concept that can be used to introduce early undergraduates to the use of Mathematical Modeling in Sports. This talk reports on the results obtained by our undergraduate group on the application of Pythagorean Expectation to NBA data. The results span many aspects of sports analytics: team record predictions, ranking of teams and betting strategies. We will also discuss the pedagogical aspects of this endeavor since many STEM math course sequences do not include Statistics and this kind of initiatives can provide low-stakes opportunities for students to practice data skills (collection, analysis, and visualization) that are paramount in the modern workplace.

Authors:

Brizia Chavez-Rubio, *Estrella Mountain Community College*
Alan Valladares, *Estrella Mountain Community College*
Filippo Posta, *Estrella Mountain Community College*

The Analysis of Different Cyclists in Individual and Team Time Trials: Based on the Power Profile
3:00 p.m. - 3:15 p.m.
In this paper, we build a model to give the riders a comprehensive understanding of their individual sports states in different conditions and extend the model for the team competition. The novelties of this paper are mainly presented in three aspects: Firstly, we solve the power output characteristics of riders under different terrains by building an ODE model dimensionless; Secondly, the reduction in air resistance for cyclists is considered through a second-order polynomial, especially in the team time trial. The results show that a distance of about 25cm can be maintained, and the strategy of charging and resisting resistance in turns can help obtain better results. Thirdly, considering the physical exertion and recovery of the players, we also build the Dynamic Model of Fatigue and Recovery which determines the maximal power of the cyclist as a function of anaerobic work capacity and pedaling cadence. Furthermore, we conduct a sensitivity analysis of the rider's motion state under different wind speeds, humidity, and temperature conditions. And the humidity has a relatively large impact on the riders. To check our models further, we predict the grades of Annemiek Van Vleuten at the Tokyo Olympics and UCI World Championships. The proximity between the predictions and real competition results proves the validity of our models. Therefore our models can be applied to the contest projections of riders and matching between different tracks and corresponding optimal cyclists.

Authors:

Zhendong Li, *Shanghai University*
Linna Hu, *Shanghai University*
Wenhao Ma, *Shanghai University*

Impact and Trends of Statistical Programming and Mathematics in Sports
3:20 p.m. - 3:35 p.m.
Mathematics plays a major role in sports. Without mathematics there would be no scores, no winners and no statistics for determining the player drafts or the ranking of the players after retirement. This paper will demonstrate the impact mathematics has had in sports over time and how statistical software has changed the role of mathematics in sports.
Author:
Joan E. DeBello, *St. John's University*

The Impact of Interdisciplinary Collaborations: Lessons from SUMMIT-P and Other Projects
Thursday, August 4, 8:00 a.m. - 10:55 a.m., Salon J

Interdisciplinary collaborations between mathematics and the partner disciplines will be presented. Presentations will describe the processes of interdisciplinary collaboration and/or particular examples of results from the collaborations, such as projects within courses, revamping courses, or other curricular change. Presentations will include evidence of success in the collaborative process, as well as evidence of impact on students and/or curricula.

Organizers:
Mary Beisiegel, *Oregon State University*
Caroline Maher-Boulis, *Lee University*

Sponsors:
Math Across the Disciplines Subcommittee of the Committee on Curriculum Renewal Across the First Two Years
Subcommittee of the Committee on Undergraduate Programs in Mathematics

Sustainable Curricular Reform - SUMMIT-P at SLU
8:00 a.m. - 8:15 a.m.
The SUMMIT-P projects look at making mathematics education more transferable to applications for students in partner disciplines. At Saint Louis University, the focus has been on math courses for business students. One of our concerns has been to make course renewals sustainable, so that the impact continues not only after the end of the grant, but also after the faculty driving the renewal move on to other concerns. The point of view was motivated by an examination of earlier CRAFTY-inspired projects for business students and asking why they died out. We look at features of the teaching environment that work against sustainability and characteristics we think contribute to sustainability for multi-section courses frequently taught by contingent faculty. We will examine three subprojects of the grant that have produced deliverable courses that are sustainable, one course outside the grant, teaching statistics for health sciences, that seems sustainable done with a similar method. We also examine two subprojects of the grant that do not appear to be sustainable.
Authors:

Mike May, S.J., *Saint Louis University*
Anneke Bart, *Saint Louis University*
Kim Druschell, *Saint Louis University*
Debbie Pike, *Saint Louis University*

Scenario-Based Teaching and Learning

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

Ferris State University is a SUMMIT-P institution hosting a partnership among mathematics, nursing, social work, and business. We are working on improving quantitative reasoning in both foundational mathematics courses for our students and in the partner discipline programs. Unlike many collaborations for the improvement of teaching and learning, we did not start by comparing syllabi and textbooks. Rather, we developed scenarios. Those that were richest were those that not only integrated mathematics with partner discipline content, but also integrated amongst the partner disciplines themselves. In this talk, we will share how we developed scenarios and connected them to learning outcomes, examples of our scenarios, scenarios developed by colleagues in our departments, and what we have observed as students grapple with our scenarios.

Authors:

Victor Piercey, *Ferris State University*
Rhonda Bishop, *Ferris State University*
Mischelle Stone, *Ferris State University*

A SUMMIT-P Project: Creating Interdisciplinary Partnership between Math and Engineering to Inspire Application-Forward Content

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

This talk will showcase the collaborative process of creating class activities at Virginia Commonwealth University (VCU) with partner discipline input, allowing 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 will discuss how structured interactions between departments can enrich the mathematics curriculum and lead to stronger student engagement.

Authors:

Rebecca Segal, *Virginia Commonwealth University*
Laura Ellwein Fix, *Virginia Commonwealth University*
Afroditi Filippas, *Virginia Commonwealth University*

Science Interventions for Implementation in Algebra for Calculus Course: An Outcome of the SUMMIT-P Project

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

For the past six years Lee University has been one of the institutions that collaborated in the SUMMIT-P project. Faculty from four departments at Lee have collaborated in faculty learning communities to improve students' attitudes towards four courses: Introduction to Statistics (with Behavioral and Social Sciences as the partner discipline), Algebra for Calculus (with Natural Sciences as the partner discipline) and Concepts of Math I and II (with College of Education as the partner discipline). In this talk we describe the changes that happened in Algebra for Calculus as a result of these collaborations and share examples of interventions that were created. We discuss the interventions, the successes and challenges and best practices for

implementation.

Author:

Caroline Maher-Boulis, *Lee University*

Just in Time Review for Accounting

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

Students taking freshman accounting need certain algebra skills to do well in the course. As part of the Summit-P program we developed an online test using WeBWorK testing several topics in mathematics. An online set of resources was made available to the students to provide a review of these topics.

Authors:

Anneke Bart, *Saint Louis University*
Debbie Pike, *Saint Louis University*
Mike May, *Saint Louis University*

Trickle Down Effects from SUMMIT-P Collaboration: Helping to Bridge the Gap between Math and Chemistry Courses

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

Many chemistry courses require pre-requisite mathematical knowledge and skills to successfully understand chemical principles and solve chemistry problems. The focus of our SUMMIT-P collaboration at Lee University was to inform mathematics curriculum and instruction for pre-requisite mathematics courses, specifically Algebra for Calculus. However, the outcomes of this collaboration have also informed chemistry faculty how to help with this knowledge transfer. In this presentation, I will describe the process of our collaboration and some of the outcomes of that collaboration. In particular, I will describe some of the attempts of partner discipline faculty in helping to bridge the gap between mathematics and chemistry courses and where our efforts will be during the next few years.

Author:

John Hearn, *Lee University*

Numbers, Infinity, and Reality: An Interdisciplinary Undergraduate Philosophy of Mathematics Course

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

The philosophy of mathematics is typically not a topic to which an entire undergraduate level course is dedicated. This talk will describe such a course, "Numbers, Infinity, and Reality," taught as an accessible introduction to mathematics viewed through ontological and epistemological lenses. This course was co-taught with a philosophy professor and cross-listed with philosophy, giving the instructors and students an opportunity to collaborate with peers from another discipline. Content of the course centers around various philosophical viewpoints applied to the foundations of mathematics, results in geometry and number theory, and the culture of mathematics. This talk will include details regarding the structure of the course, assigned readings, and student outcomes.

Author:

Jessica Sorrells, *Converse University*

Important Questions for Developing Applied Mathematics Problems: A SUMMIT-P Project

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

Applied problems are a necessity for a well-rounded and rigorous education in mathematics. In this presentation, we will summarize our review of the literature on student engagement with applied problems in order to develop a set of criteria for what makes an applied problem engaging and meaningful. Based on the review of the literature, we propose that this criterion includes: (1) relevance to a student's lived

experience or interests, (2) a need for mathematical problem solving, and (3) introduces unique situations that expand a student's awareness of the uses of mathematics in the world around them. We will use this set of criteria to analyze interdisciplinary applied problems developed by the SUMMIT-P project and compare with other applied problems. Our results show that interdisciplinary collaborations help build meaningful contexts that satisfy much of the criteria for engaging applied problems.

Authors:

Lynn Gumpinger, *Oregon State University*
Mary Beisiegel, *Oregon State University*

Quantitative Literacy and Reasoning as Tools for Learning Across the Disciplines

Thursday, August 4, 1:00 p.m. - 4:40 p.m., Salon F

A beautiful characteristic of quantitative literacy and reasoning (QL/QR) is that they allow one to generate insights in myriad contexts and disciplines. In this session, we invite educators to share how they promote QL/QR as tools for accessing insights in a context or discipline within or outside of mathematics. We welcome a diverse collection of scholarly presentations.

Organizers:

Kathryn Appenzeller, *Texas A&M - San Antonio*
Samuel Luke Tunstall, *Trinity University*
Gizem Karaali, *Pomona College*

Sponsor:
SIGMAA on Quantitative Literacy (QL-SIGMAA)

Building Students' Quantitative Reasoning in Economics Courses: Lessons from the SUMMIT-P Project

1:00 p.m. - 1:15 p.m.

As an Economics professor, I view quantitative reasoning (QR) as an important component of my economics courses. QR is a habit of mind; a way of thinking that incorporates mathematical thinking and analysis across many disciplines. As a member of the NSF-funded SUMMIT-P project (Synergistic Undergraduate Mathematics via Multi-Institutional Interdisciplinary Teaching Partnerships) I have incorporated many of the lessons learned from collaborations with mathematicians into my teaching of economics. SUMMIT-P focuses on providing collaborative support between mathematics faculty and faculty from partner disciplines to design and refine mathematics courses to better meet the needs of students majoring in other areas. In this talk I will highlight several examples from introductory and intermediate level economics classes that I use to build students' quantitative reasoning skills. Also I will describe how these types of QR in economics examples have been translated back into calculus activities.

Author:

Stella Hofrenning, *Augsburg University*

Quantitative Reasoning - An Application of QR Principles to Talent Management

1:20 p.m. - 1:35 p.m.

Quantitative Reasoning (QR) principles serve to promote quantitative literacy for the development of student abilities to interpret, represent, and apply numerical information and models in personal and

academic contexts. "The test of numeracy, as of any literacy, is whether a person naturally uses appropriate skills in many different contexts" (Steen, 2001). In this session, attendees will learn about "The Time to Fill" class project for a Talent Management course at Texas A&M – San Antonio. Although outside the discipline of mathematics, students explore an application of quantitative literacy to access insights about a partnering firm's talent acquisition process. Students utilize quantitative reasoning to observe, map, measure, evaluate, and reflect the firm's talent acquisition process. Comparing the documented process performance against industry standards, sector benchmarks, or year over year performance, students communicate recommendations to improve the partnering firm's process. During this semester length engagement, students interact directly with local employers, make recommendations based on quantitative information, impact business processes, and combine experiential learning and quantitative reasoning. In this session, attendees will learn about "The Time to Fill" class project for a Talent Management course at Texas A&M – San Antonio. Although outside the discipline of mathematics, students explore an application of quantitative literacy to access insights about a partnering firm's talent acquisition process. Students utilize quantitative reasoning to observe, map, measure, evaluate, and reflect the firm's talent acquisition process. Comparing the documented process performance against industry standards, sector benchmarks, or year over year performance, students communicate recommendations to improve the partnering firm's process. During this semester length engagement, students interact directly with local employers, make recommendations based on quantitative information, impact business processes, and combine experiential learning and quantitative reasoning.

Authors:

Adrian Guardia, *Texas A&M University, San Antonio*
Kathryn Appenzeller Knowles, *Texas A&M University, San Antonio*

Management Education in a Data-driven World

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

Decision making is a critical responsibility of organizational leaders across hierarchical levels and specializations (Tichy & Bennis, 2007). Decision environments have become progressively more dynamic due to increasing volatility, uncertainty, complexity, and ambiguity (Lawrence, 2013). In response, organizations have invested vast resources to collect and analyze large amounts of data, including the employment of database managers and highly specialized analysts (Elkington, 2018). Managers, therefore, are consumers of sophisticated analytical reports and must frequently assess, interpret, and make decisions balancing their own intuition with the findings of analysts. In this session, we describe and discuss the application of quantitative literacy and reasoning (QL/QR) pedagogy in management education in both collegiate schools of business and corporate leadership development programs. Infusing QL/QR into management education, particularly through partnering activities among math and business educators, will improve the capability of organizational leaders to effectively make decisions in a data-driven world.

Authors:

Kathryn Appenzeller Knowles, *Texas A&M University, San Antonio*
Kenneth M. Sweet, *Texas A&M University, San Antonio*

Data Literacy and Visualization: A General Education Course with Service Learning

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

STAT 1100: Data Literacy and Visualization is a new course designed to make the university general education quantitative reasoning requirement relevant and meaningful to non-STEM students. This is accomplished by focusing on knowledge and skills related to mathematical reasoning associated with real-world data. This course is a designated service learning course and students work in small groups to engage with non-profit community partners who have data but lack the in-house expertise to analyze and gain value from it. As the students develop data analysis and visualization skills throughout the semester, they

collaborate to apply those skills in answering data-driven questions for their community partner. In this presentation we will describe the course, including learning outcomes, community partnerships, and lessons learned.

Authors:

Betty Love, *University of Nebraska at Omaha*
Becky Brusky, *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*
Sara D'Souza, *University of Nebraska at Omaha*

Building a Habit of Mind: An Extra-Curricular Initiative to Develop QR Outside the Classroom
2:20 p.m. - 2:35 p.m.

Educators engaged in quantitative reasoning (QR) instruction regularly encounter the challenge of motivating college students to care about QR in non-academic contexts. Strapped for time and focused on grades, many students have a myopic view of QR. As a result, it is not clear how to motivate students to make QR a habit of mind outside the classroom. In this session, attendees will hear about an interdisciplinary partnership between Texas A&M – San Antonio's Quantitative Reasoning program and the university's recreational sports department. The assistant director of recreational sports sought help from the QR program to develop extra-curricular activities related to QR wellness concepts (e.g., caloric intake, nutrition labels, activity levels, body composition, BMI). Using the interdisciplinary lens of wellness, a series of focus groups examined why college students tend to ignore or downplay QR-related health information until later in life - as well as potential strategies to motivate them to act now.

Authors:

Ruby Daniels, *Texas A&M University, San Antonio*
Kathryn Appenzeller Knowles, *Texas A&M University, San Antonio*
Amber Graham, *Collin College*

Connecting QR and Literacy Education in Teacher Preparation
2:40 p.m. - 2:55 p.m.

Classroom teachers are required to use data to track student progress and make appropriate instructional decisions daily. Data-driven decision making is particularly necessary in literacy as 60% of U.S. students are not reaching proficient levels in reading. However, literacy courses in pre-service teacher education programs typically focus on content, including how to teach literacy skills, rather than quantitative reasoning (QR) skills. In this session, we will describe the inclusion of QR skills in a literacy education course where students collected data, compared data to the nation-wide norms, and made data-driven instructional decisions focusing on oral reading fluency (ORF). Participants will complete a hands-on activity assessing a student's ORF and comparing the results to ORF norms to experience how QR provides insight to literacy development.

Authors:

Amanda Lindner, *Texas A&M University, San Antonio*
Kathryn Appenzeller Knowles, *Texas A&M University, San Antonio*
Ramona Pittman, *Texas A&M University, San Antonio*

Quantifying Democracy: Making Democratic Institutions Count
3:00 p.m. - 3:15 p.m.

Over the last century, basic literacy has become both a prerequisite of and a litmus test for a healthy, well-functioning democracy. In the next century, numeracy and civic quantitative reasoning must address the very democratic institutions that have come under attack in the last decade. In an era of democratic reversals and backslides, "I know it when I see it" is no longer an acceptable way to classify and study complex and evolving democratic regimes. In this session we will share how students, with the help of Freedom Houses' Global Freedom Scores, in an introductory American Government class used quantitative reasoning to gain insights on measuring and quantifying an abstract concept like 'democracy.' Students were tasked with quantifying, assessing, and comparing American political institutions to those in other countries.
Author:

Emily Naasz, *Texas A&M University, San Antonio*

Mark Twain's Writing, The Face of God, German Tanks and V1 Bombs to London: What Is the Connection?

3:20 p.m. - 3:35 p.m.
We will briefly discuss the NSF-funded project "Math-Stat Modeling Across the Curriculum." This work is an attempt to introduce non-STEM students to techniques of modeling and quantitative applications in their own area of study. Teams of faculty and students from non-STEM disciplines created small projects for use in their major or general education courses. We will present a sample of our projects to demonstrate the breadth of applications our colleagues have created, and the connection of subjects listed in our title. The projects are suitable for use in disciplines such as social sciences, theology, kinesiology, history, literature, and psychology. A common feature of these projects is use of real data, and commonly available technology to model current or historical events relevant to the specific disciplines. We will conclude by discussing the instruments used to measure the expected change in attitudes of students toward quantitative analysis after the use of these projects.
Authors:

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

Statistical Literacy: Tools for All Disciplines

3:40 p.m. - 3:55 p.m.
Statistical literacy goes beyond quantitative literacy. Here are 6 important distinctions between statistical literacy (statistics) and quantitative literacy (math): (1) Induction vs. deduction. (2) Statistics vs. numbers (matter vs. form). (3) Causation vs. association. (4) Confounder vs. covariate (mediator or mechanism). (5) Adjusted/standardized association vs. crude associations. (6) Experiments (doing) vs. data analysis (seeing). Statistical literacy (S/L) is a quantitative tool for all disciplines. Statistical Literacy enables students to think critically about statistics found in the everyday media. Many -- if not most -- of today's arguments use statistics as evidence. Numeracy must include statistical literacy in order to be a quantitative tool for all disciplines.
Author:

Milo Schield, *Augsburg University*

Instructor Autonomy As a Critical Variable in Quantitative Reasoning Assessments

4:00 p.m. - 4:15 p.m.
Via a multiple case study, we explored how mathematics instructors at public postsecondary institutions in Ohio implemented Quantitative Reasoning (QR) assessments, especially formative assessments. We recruited 8 QR instructors from 3 universities and 5 two-year colleges. Each instructor taught at least one section of QR during Summer 2021 or Fall 2021. Our post hoc analysis revealed instructor autonomy as a

critical variable for QR assessments. Four (4) instructors had the autonomy to select their own assessments; 4 did not. The autonomous instructors used more collaborative and innovative assessments than the nonautonomous instructors. The autonomous instructors earned higher scores on Instructional Quality Assessment rubrics than the nonautonomous instructors. And perhaps most importantly, the autonomous instructors adjusted their traditional assessments to be collaborative and innovative, while the nonautonomous instructors enacted their potentially innovative assessments as traditional homework and quizzes. These findings may have implications for QR courses elsewhere and even other gateway mathematics courses.

Authors:

Deependra Budhathoki, *Ohio University*
Gregory D. Foley, *Ohio University*

Redesign of a Large Gateway QL Course to Promote a More Equitable Environment
4:20 p.m. - 4:35 p.m.

At Michigan State University, the Quantitative Literacy 1 course (MTH 101) is a zero-entry university requirement for non-STEM majors and serves approximately 1800 students per academic year. Currently, this course is run as an asynchronous, virtual course. In this iteration of the course, we adopted weekly assessments and longer-term projects which connected specific units of content with current pieces of news media from a wide range of sources and topics such as the probability of winning the Powerball lottery and the inequity of the impacts of Covid-19 on different populations. This change in curriculum was accompanied by a structural change that sought to embed a student support program into MTH 101 in an effort to create a more equitable environment where all students can thrive. Our support program includes personalized advising and interventions for struggling students, and provides an in-depth, compassionate and humanized approach to teaching QL to a diverse population of students.In this session, we will share the process of designing the media-based assessments and project curriculum, the challenges of overcoming the barriers of systemic education approaches, and the impact of these interventions in shifting students' perceptions of their quantitative abilities.

Authors:

Chloe Lewis, *Michigan State Univserity*
Samara Chamoun, *Michigan State Univserity*
Rachael Lund, *Michigan State Univserity*

Coding Theory and its Applications
Friday, August 5, 1:00 p.m. - 2:20 p.m., Salon D

In this age of advanced communications and data storage, coding theory is inherently interesting in both theoretical and applied settings. The focus of this session is to share recent developments and applications of coding theory—such as in error-correcting codes, encoding and decoding algorithms, data compression, and codes developed from graph theory, algebraic geometry, number theory, combinatorics, and algebra.

Organizers:

Angelynn Alvarez, *Embry-Riddle Aeronautical University*
Konrad Aguilar, *Pomona College*
Rene Ardila, *Grand Valley State University*
Gustavo Terra Bastos, *Federal University of São João del-Rei*

Decrypting Cryptography with a Web-Based Toolkit

1:00 p.m. - 1:15 p.m.

A set of web-based tools has been developed to assist in teaching and learning cryptography. The website provides a uniform environment for exploring topics commonly taught in introductory courses. These include substitution and transposition ciphers, block ciphers (AES and DES), public-key infrastructure and encryption (Diffie-Hellman key agreement, RSA), and hashing. There are also tools for investigating number theoretic concepts such as modular arithmetic and the Euclidean algorithm. The applets allow users to explore visually how the methods operate. An instructor can use the tools in the classroom to explain the algorithms and present examples. Students use the site to explore methods on their own, solve problems, and crack cryptographic challenges. The tools eliminate the need for students to write programs to perform these computational tasks, enabling them to focus on important algorithmic and mathematical ideas.

Authors:

Mikel Gjergji, *University of Rhode Island*

Ed Lamagna, *University of Rhode Island*

Coding Theory Applications to Pooled Testing for COVID-19

1:20 p.m. - 1:35 p.m.

Group testing is a method for strategically pooling biological samples in order to use fewer tests than a one-per-sample approach. These methods have been revisited in view of the COVID-19 pandemic, particularly the need to efficiently test large groups of asymptomatic people for surveillance testing. A construction by Kautz and Singleton (1964) showed how error-correcting codes can be used to create group testing schemes. In this talk we will explain this connection and show a new result that implies flexibility in the number of samples being considered.

Authors:

Kathryn Haymaker, *Villanova University*

Justin O'Pella, *Thomas Jefferson University*

Bounds and Properties of Certain LCD Codes

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

A linear code with complementary dual (LCD code) is a linear code C whose intersection with its dual code is only the zero codeword. This talk will examine binary and ternary LCD codes with biggest minimal distance that meet the Griesmer bound.

Authors:

Seth Gannon, *Sewanee: The University Of The South*

Hamid Kulosman, *University of Louisville*

Algebraic Coding Theory and Code-Based Cryptography

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

Theory and implementation of error correcting codes is one of the important and elegant applications of algebra. Error correcting codes have a wide range of applications in communication and storage systems. Another application of coding theory that received much attention in recent years is code-based cryptography which is one of the candidates for post-quantum cryptography. In this talk, we will give an overview of these areas and describe some open problems.

Author:

Nuh Aydin, *Kenyon College*

Math and Art
Friday, August 5, 8:00 a.m. - 11:40 a.m., Salon F

This session is an exploration of the interplay between mathematics and the arts. We invite presentations from across this spectrum, including artists who use math in their practice, mathematicians who study art, and educators who blend math and the arts in their classroom. We particularly encourage contributions on topics historically less represented in this session, such as dance, literature, film, and architecture.

Organizers:
Anil Venkatesh, *Adelphi University*
Douglas Norton, *Villanova University*
Karl Kattchee, *University of Wisconsin-La Crosse*

Sponsor:
SIGMAA on Mathematics and the Arts (SIGMAA-ARTS)

Automaticity: Performative Image
8:00 a.m. - 8:15 a.m.
Numerical transactions in the arts in the praxis of Jesús Jiménez is the title of my doctoral thesis. Chapter V deals with automatism: performative image. Conceptual art has its central concept in an Idea, or ideas, these are executed through rules and restrictions, in some cases, the ideas or restrictions have numbers. The automatism process is governed by an Idea and/or numbers to create a performative image created from the action. This article is a journey from proto-conceptual artists to contemporary artists, myself included, on how we use numbers, transactions, and mathematics to create conceptual performative images.
Author:
Jesús Jiménez, *Universidad Politectnica de Valencia*

Mathematics in The Simpsons and Futurama
8:20 a.m. - 8:35 a.m.
In today's pop culture environment, knowledge and intellect seem to be celebrated more so than in the past. One recent example is in the success of the show The Big Bang Theory. However, to quote an episode of South Park, "The Simpsons already did it". Although not the first television show to reference science and mathematics, the writers of The Simpsons (many of which have advanced degrees in STEM fields) used such references to elevate the jokes and provide visual gags. While these references are often subtle in The Simpsons, they were front-and-center in its sister show Futurama (so much so that a mathematical paper was published based on the plot of an episode). We will look at some of my favorite moments from both shows that showcase the ability of the writers to use mathematics for entertainment purposes.
Author:
Michael Yatauro, *Penn State University - Brandywine*

Exploratory Computer Vision Application for Film Scene Composition Analysis
8:40 a.m. - 8:55 a.m.
The directorial intent of film is often conveyed through shot composition — composition that follows certain general rules and guidelines with mathematical roots. As a relatively new medium, film scene

composition, especially framing, borrows inspiration from its artistic predecessor in photography, relying on staples such as the Golden Ratio, the Rule of Thirds, symmetrical proportionment, and others. In this paper, we explore the usage of computer vision for shot composition analysis in several chosen movies. Through object detection, shape recognition, and color-contrast analysis, we are able to identify focal points and scene subjects and use their relative locations and sizes to investigate the mathematical trends behind shot framing.

Authors:

Sally Zhao, *University of Maryland, College Park*
Philip Zhao, *DePaul University*
Cindy Pham, *DePaul University*

An Architectural Geometry Book Rediscovered

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

In her 1912 geometry book, Mabel Sykes uses complex and beautiful architectural designs from around the world to inspire exercises on geometric proof, construction and computation. In over 1800 problems, Sykes analyzes geometric patterns of ornamental and structural features including those found in tile mosaics, parquet floors, Gothic windows, trusses and arches. As Sykes' writes, "Geometry gives, as no other subject can give, an appreciation of form as it exists in the material world." We demonstrate several examples which illustrate how to incorporate these beautiful designs and the accompanying exercises of this hidden gem into any geometry course.

Authors:

Maureen T. Carroll, *University of Scranton*
Elyn Rykken, *Muhlenberg College*

A Virtual Tour of Mathemalchemy

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

Mathemalchemy brought together twenty-four mathematical artists and artistic mathematicians to create a large multimedia mathematical art installation, celebrating the creativity and beauty of mathematics. The project, which began in 2019 under the leadership of mathematician Ingrid Daubechies and fiber artist Dominique Ehrmann, debuted this year for its tour of exhibitions. In this talk, we will take a virtual tour of the installation, highlighting some specific vignettes, their mathematical connections, and their fabrication process. We will also discuss plans for related outreach programs, including workshops for K12 students.

Authors:

Samantha Pezzimenti, *Penn State Brandywine*
Kimberly Roth, *Juniata College*

A Fish Pattern on a Regular Triply Periodic Polyhedron

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

We have designed a fish pattern on the {6,6|3} regular triply periodic polyhedron described by Coxeter and Petrie. We had previously designed fish patterns on triply periodic polyhedra, but they had aesthetic problems: the fish changed colors along backbone lines, the fish changed directions along backbone lines, and the fish were angular and not very fish-like. The new pattern fixes all these problems.

Author:

Douglas Dunham, *University of Minnesota Duluth*

Superpermutations in Change Ringing

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

Change ringing is the art of ringing a set of tuned bells in various orderings, or changes. A change ringing method for n bells is written as a sequence of permutations of n symbols, with the restriction that each new change can be obtained using only adjacent transpositions. An extent on n bells is a method that includes all n! possible changes. In this talk, we will regard methods as ongoing sequences of individual bells (rather than just as sequences of changes), in order to consider all permutations of n bells that occur, including those that begin in one change and end in the next. For example, suppose a change ringing method on 4 bells begins as follows: 1234 2134. We would regard this method as a sequence that begins with 1234 2134. Thus, the first two changes of this method include not only the permutations 1234 and 2134, but also 3421 and 4213. Under this convention, we can view an "extent" as a sequence on n symbols that contains each of their n! permutations as a substring, with the objective of finding extents that are of minimal length. Such sequences are more generally known as "superpermutations," and so our objective can be restated as finding minimal length superpermutations that conform to change ringing restrictions. In this talk, we will present solutions in the cases n = 3; 4, and 5, and we will discuss conjectures about solutions for n > 5.

Author:

Kurt Ludwick, *Salisbury University*

The Mathematics of the Harp: A Look at Modeling the Classical Instrument and New Designs

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

We analyze and model the shape of the classical harp based on the length of the strings, their tension and density. We then use the results to design new and innovative harp shapes by adjusting the parameters of the model.

Authors:

Bogdan Nita, *Montclair State University*
Cristina Carr, *Montclair State University*
Vlad Nita, *Montclair State University*

Lessons Learned in an Art + Math Studio Art Course

10:40 a.m. - 10:55 a.m.

This Spring semester we (a mathematics professor and an art professor) taught a general education Art + Math studio art course. Students learned about various mathematical concepts and created mathematically inspired art. We will discuss the mathematical topics we covered, the techniques and mediums used for the student art projects, and important lessons we learned in the teaching of this course. Examples of student work will also be shown.

Authors:

M. Leigh Lunsford, *Longwood University*
Kerri Cushman, *Longwood University*

Recreating Mt. Rushmore

11:00 a.m. - 11:15 a.m.

Looking for a fun activity for a Math as a Liberal Art course? A fun, hands-on, introductory activity will be explained. This activity involves creating a 3D model using floral foam, a ruler and protractor. Skills students learn include reading a ruler, application of ratios, and using a protractor. Students also gain an appreciation for mathematics in art creation.

Author: Heidi Hulsizer, *Benedictine College*

Transformations and Symmetry of Still and Moving Figures in a Liberal Arts Mathematics Course
11:20 a.m. - 11:35 a.m.
In this talk, I'll describe the exploratory ways that I introduce rigid motion transformations and symmetry in a liberal arts mathematics course centered on art and music. We initially experiment with a variety of tools for performing transformations (e.g. miras, pencil rubbings, rulers, protractors, Cartesian coordinates) before transitioning to studying symmetry in still, two-dimensional patterns and pieces of artwork. Quilt squares provide a context for inquiry into classifying types of symmetry, while tessellations allow students to employ transformations to create artistic pieces with symmetry. After working with two-dimensional artwork, we move into the realm of dance. Shifting from two dimensions to three--and from static to dynamic situations--provides some unexpected but interesting challenges! While trying to move in symmetry with one another or watching video clips of bodies in motion, I found that students struggled to attend to the relative positions of the dancers when the individual dancers are performing a type of transformation that is different from the type of symmetry they hold in relation to one another.
Author:
Erin Moss, *Millersville University of Pennsylvania*

Responding to Policy Changes that Impact Developmental Math Courses
Saturday, August 6, 9:00 a.m. - 11:20 a.m., Salon D

This paper session will bring together presenters who are responding to recent policy changes that have eliminated or greatly reduced remedial or developmental mathematics courses at two- and four-year institutions. Presenters will focus on instructional models, curriculum, professional development and pedagogy, or other related topics. Presentations will connect these innovations to issues of equity and the impact on "minoritized learners".

Organizers:
Mary Pilgrim, *San Diego State University*
William Zahner, *San Diego State University*
Amelia Stone-Johnstone, *California State University Fullerton*
Charles Wilkes II, *San Diego State University*
Heather Johnson, *University of Colorado Denver*
Gary Olson, *University of Colorado Denver*

The History of College Algebra 1894-1909, A Trip Down a Rabbit Hole
9:00 a.m. - 9:15 a.m.
This talk grew out of a project that analyzed the contents of most College Algebra books in the era 1894-1930 to survey reform efforts and the environment in which College Algebra existed. We hope to report our curricular findings soon, but this talk deals mostly with the shocking external environment surrounding mathematics which we discovered to exist in the early decades of the twentieth century. It feels like a world as different from our own as that which faced the fictional Alice of Wonderland fame. Prestigious educational reformers and commentators either denigrated or simply disregarded mathematics. Another phenomenon that surprised us was how individualistic the culture of professors and universities was - individualistic to a point that seems extreme to us today. One of the shocks to the College Algebra world

which we discovered resulted from the rather authoritarian activities of the College Board, in opposition to the sometimes inconvenient individualism of the academic world.

Authors:

Walter Meyer, *Adelphi University*

Tom Bannon, *Adelphi University*

Larry D'Antonio, *Ramapo State College*

Michael George, *Borough of Manhattan Community College*

Joseph Malkevitch, *York College*

Howard Sporn, *Queensborough Community College*

Patrick Wallach, *Queensborough Community College*

Rochelle W. Meyer, *Nassau Community College*

Using Final Letter Grades to Optimize Course Sequencing

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

When advising students they typically ask, "Which course should I take next?". At the University of Hartford in Connecticut, once a student has taken Calculus II, the student can take Multivariable Calculus, Differential Equations and Linear Algebra in any order. Based on content, we may have our own opinions on the order in which these courses should be taken. However, is this the order in which students are most successful? In this talk we examine over 30 years of final grade data to determine the best way to sequence Multivariable Calculus, Differential Equations and Linear Algebra.

Authors:

Michelle Rabideau, *University of Hartford*

Zaher Kmail, *University of Washington Tacoma*

Shifting the Culture: Engaging Students in Introductory Service Courses, A Progress Report

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

The Department of Mathematics at Colorado Mesa University, a regional public university with 10,000 students, began a process of change in Fall 2019 with a commitment to redesign introductory course offerings. The process has been guided by the need to address state policies regarding placement requirements and the reduction of developmental education offerings, while focusing on a goal to make the courses more meaningful and engaging to students enrolled. Our early efforts included implementing new placement practices; piloting supplemental, co-requisite, and bridge courses; meeting with partner disciplines to identify the needs of their programs; and working with administration on requests having budget implications. Progress includes completing the absolute redesign and coordination of our non-STEM quantitative reasoning course; reducing class sizes and embedding tutors; establishing and promoting distinct pathways; creating new stretch courses in the STEM pathways; piloting a College Algebra course with an emphasis on applications; and implementing both peer-guided and expert-led faculty professional development activities. This talk will describe our early efforts, current progress, and next steps in the process of change. We discuss our experiences and decisions in all aspects of the process, including highlights and challenges toward reaching our goals of actively engaging students, meeting state mandates, and facilitating a culture shift in our department.

Author:

Lisa Driskell, *Colorado Mesa University*

Adapting Professional Development to Meet the Needs of Two-Year College Instructors

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

With the passing of state legislation, many two-year colleges have had to revisit their mathematics placement processes as well as gateway courses (College Algebra, Trigonometry, and Precalculus) offerings.To meet the growing diversity of needs their students have, professional development (PD) has been an important component for two-year college instructors. In most gateway courses instructors have to cover many topics and teach students who have not historically done well in these courses. This often leads to rote instruction and inequitable participation from students. In our talk we outline a PD model that we designed to support math instructors practice for inquiry and equity. Our focus on inquiry and equity highlights the significance of attending to mathematical content deeply and to students' backgrounds and prior experiences. Implications of this work include identifying the types of experiences math instructors' need that contributes to substantive change in their practice.

Authors:

Mary Pilgrim, *San Diego State University*
Charles Wilkes II, *San Diego State University*

Enhancing STEM Pathways by Fostering Students' Reasoning in College Algebra

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

Recent policy changes (Colvin, 2020) have provided an impetus for stakeholders to examine early undergraduate math courses and structures surrounding those courses. This can include allowing students to select mathematics courses commensurate with their career goals, offering co-requisite and stretch course options for existing courses, and redistributing power that skills, procedures, and answer finding can hold in such courses. Spanning four Hispanic Serving Institutions, we describe a programmatic intervention to foster students' reasoning in College Algebra, a course that can be a gateway to a STEM degree for many students. College Algebra instructors at each institution implement digital activities, which the project team calls "Techtivities," that focus on key ideas of functions and graphs. In conjunction, instructors participate in professional development in which they examine how the place, purpose, and process for implementing the Techtivities can impact students' reasoning. Instructors have agency to take up the Techtivities in ways that make sense given their course objectives, instructional modality, and class size. Hence, the Techtivities can be useful across a range of College Algebra course formats, including stretch options. We discuss how resources, such as the Techtivities, can be taken up in meaningful ways by different communities of instructors and thereby have potential to serve as catalysts for instructional change. Reference: Colvin, R. L. (2020) The math problem: Removing the math barrier to college completion. The Precision Institute at National University and the National Laboratory for Education Transformation.

Authors:

Gary Olson, *University of Colorado Denver*
John Carter, *Metropolitan State University of Denver*
Bikai Nie, *Texas State University*
Belin Tsinnajinnie, *WestEd*
Heather Lynn Johnson, *University of Colorado Denver*

Building College Level Number Sense: Bridging Conceptual Gaps in STEM

10:40 a.m. - 10:55 a.m.

In recent years, the State of California has given notice to its three college systems that students are not graduating in a reasonable amount of time (or at all). In the past, a large proportion of entering students were required to pass a one-size-fits-all developmental math course at the intermediate algebra level before taking a college-level math course. Students would languish in these courses, sometimes taking years to progress and, too frequently, dropping out of college. Students from historically underserved groups and first-generation college students were disproportionately placed in these courses. In 2018, the CSU and community college systems ended developmental math prerequisites at the CSU, and limited them in the

community colleges, requiring the faculty to develop co-requisite solutions for supporting underprepared students in college-level math courses. Co-requisite solutions typically include stretch courses or supporting lab courses. Cognition research in the 1980s-90s (Harel & Confrey, 1994) established that a key mathematical issue for many struggling students is often proportional reasoning: a complex of ideas involving multiple meanings and methods for multiplication and division, fractions, place value and decimals, measurement, ratios, proportions, and percent. Measurement, especially understanding quantities and units, is foundational for success in both math and science courses. (Dougherty and Simon (2014) While these topics are introduced in middle school or before, success in college and careers requires an adult-level understanding and ability to apply them in more sophisticated academic and real-world contexts. Mental calculation, especially with approximate numbers, is a neglected but important skill. Our response was to create innovative online curricular material treating these critical subjects conceptually, at a high level, and with the necessary foundational supports. Modules each include a pre-test, video, text that includes examples with solutions, autograded, randomized practice problems and a post-test. The materials were written with equity in mind, for a diverse student population: our own students are predominantly first generation college students, majority Latinx, with significant Black and Asian subgroups. Materials have been screened for culturally responsive pedagogy and accessibility. We will discuss various ways to use the materials: tightly or loosely integrated with math courses, supplements for science courses, and courses for future teachers, among others. References Dougherty B., Simon M. (2014) Elkonin and Davydov Curriculum in Mathematics Education. In: Lerman S. (eds) Encyclopedia of Mathematics Education. Springer, Dordrecht. https://doi.org/10.1007/978-94-007-4978-8_56 Harel, G., & Confrey, J. (Eds.). (1994). The Development of Multiplicative Reasoning in the Learning of Mathematics. Albany, NY: State University of New York Press.

Authors:
Susan Addington, *California State University, San Bernardino*
Mary Legner, *Riverside City College*
Kelli Wasserman, *California State University, San Bernardino*

Mathematical Investigations: An Application-Based, Active Approach to Quantitative Reasoning
11:00 a.m. - 11:15 a.m.
In response to state legislative changes in Colorado that place caps on student enrollment in developmental courses, the Mathematics Department at Colorado Mesa University has made significant, evidence-based changes to first-year mathematics courses, both in design and implementation. We have been intentional about making changes that improve and enhance the student learning experience while also addressing the legislative requirement. This talk will focus on the transformation of our non-STEM quantitative reasoning course from a traditional, computational, lecture-based course into a course that emphasizes relevant, real-world applications and is taught using a modified flipped classroom approach. We will describe details of our curricular redesign as well as our modifications to placement and professional development opportunities provided for our instructors.

Author:
Tracii Friedman, *Colorado Mesa University*

Complex Analysis: History, Pedagogy, Innovation, and Research
Friday, August 5, 9:00 a.m. - 11:20 a.m., Salon E

Complex analysis, despite its beauty and power, seems to have lost some of the prominence it once enjoyed. To remedy this situation, we seek presentations that survey an episode in complex

analysis of particular historical interest, demonstrate the use of complex analysis in art, elaborate on a new approach to a standard theorem, describe interesting applications, or report on an innovative pedagogical strategy.

Organizers:
Russell Howell, *Westmont College*
Mike Brilleslyper, *Florida Polytechnic University*

Cauchy's Integral Formula As an Act of Combinatorics
9:00 a.m. - 9:15 a.m.
In the field of combinatorics, a generating function is a formal power series whose coefficients correspond with a sequence of numbers. When treated as functions of a complex variable however, generating functions bridge the gap between enumerative combinatorics and complex analysis. By using Cauchy's integral formula to extract the coefficients of a generating function, problems which we traditionally identify as "combinatorial" can transform into analytic ones. In this talk, we will survey some classic examples of just how well generating functions and Cauchy's integral formula go together.
Author:
Charles Burnette, *Xavier University of Louisiana*

Van der Pauw's Theorem on Sheet Resistance
9:20 a.m. - 9:35 a.m.
The sheet resistance of a semiconducting material of uniform thickness is analogous to the resistivity of a solid material and provides a measure of electrical resistance. In 1958, L. J. van der Pauw found an effective method for computing sheet resistance that requires taking two electrical measurements from four points on the edge of a simply connected sample of the material. In this talk we outline the result and include the details of an in-class demonstration. The relevant mathematics includes electrostatic potentials, cross-ratio, conformal mapping, and the Riemann mapping theorem.
Author:
Mike Bolt, *Calvin University*

The Coefficient Space of Unimodular Palindromic Polynomials
9:40 a.m. - 9:55 a.m.
A polynomial with all its roots on the unit circle in the complex plane is called a unimodular polynomial. It is well known that the coefficients of a real unimodular polynomial must form a palindrome or an anti-palindrome, though the converse is in general false. In this talk, we outline necessary and sufficient conditions on the coefficients of both 4th and 6th degree real palindromic polynomials to have associated unimodular polynomials, allowing a complete description of unimodular palindromic polynomials up to degree 7 and anti-palindromic polynomials up to degree 8. Furthermore, we visualize the coefficient space for each case and discuss interesting features along surfaces, edges, and vertices. Some generalizable results are discussed for higher degree cases.
Authors:
Aaron Bardall, *Florida Polytechnic University*
Michael Brilleslyper, *Florida Polytechnic University*

Properties and Artistic Qualities of the Iterates of Complex Poles and Critical Points

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

We explore the family of rational functions $f(z) = \frac{(z-1)^k}{z^n}$, examining their critical points and poles under finite iteration. The contour diagrams of the real parts of these iterates reveal the behavior of the critical points and poles of each function in beautiful ways. The poles appear as "flowers" and the critical points appear as standard saddle shapes whose contours are intersecting curves or curves that bend near the critical point. We describe, for this family of functions, how orders of the critical points and poles in the original function affect the shapes of the contours after repeated composition of that function with itself (iteration). This in turn tells us information about properties of the critical points and poles under iteration. These properties also give us insight on how to create artwork from other complex functions based on their critical points and poles.

Authors:

Beth Schaubroeck, *United States Air Force Academy*

Julie Barnes, *Western Carolina University*

Teaching Complex Analysis with Primary Source Projects (PSPs)

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

This talk will discuss the use of Primary Source Projects (PSPs) in an undergraduate complex variables/analysis course. Many textbooks for these courses develop the foundations of complex analysis with minimal discussion of the original problems that led to modern mathematical concepts and results. Fortunately, PSPs can help develop the foundational theory with a sense of the human element and progression of the mathematics over time. In this talk, we will discuss several PSPs that have been written and used with the TRIUMPHS (https://blogs.ursinus.edu/triumphs/) program for using primary source material in undergraduate education. We will focus on PSPs using selections from Euler, Cauchy, Gauss and Riemann.

Author:

David Ruch, *Metropolitan State University of Denver*

Poisson's Exploration of Complex Line Integrals

10:40 a.m. - 10:55 a.m.

In a 1820 paper published in the Journal de l'Ecole Polytechnique, Poisson wrote about complex line integrals. In the first hesitant steps in history, Poisson struggles with how to interpret line integrals in the complex plane, thinking that they potentially give rise to different values for associated real integrals. In this talk we will look at the details of the first complex line integrals and Poisson's early considerations of the results.

Author:

Jeff Johannes, *State University of New York, Geneseo*

Complex Analysis in MAA Convergence

11:00 a.m. - 11:15 a.m.

The MAA's free online journal for the history of mathematics and its use in teaching offers classroom resources for a wide variety of mathematical subjects that are taught in grades 8–16. In this talk, we will provide a brief tour of the materials available for courses in complex analysis, such as translations of primary sources, interactive lessons, images and descriptions of landmark texts, and portraits of mathematicians. We will also offer a few suggestions for finding articles and other features on Convergence that relate to a specific topic, such as complex analysis. Finally, we will invite the audience to contribute

translations, guided readings of primary sources, and Mathematical Treasures that they use in their own teaching of this subject.

Authors:
Amy Ackerberg-Hastings, *MAA Convergence*
Janet Heine-Barnett, *Colorado State University – Pueblo*

Integrating Math Modeling and Interdisciplinarity into Your Classroom
Friday, August 5, 8:00 a.m. - 10:55 a.m., Conf. Room 410

The Consortium for Mathematics and its Applications (COMAP) promotes applied mathematics and interdisciplinary problem solving through curricula and contests. COMAP contests challenge undergraduate students to use mathematics, computation, and scientific knowledge to solve real-world interdisciplinary problems. Faculty motivate and support these efforts by integrating modeling and interdisciplinarity into the curriculum. We encourage presenters to share and discuss their activities, practices, and experiences.

Organizers:
Kathleen Snook, *COMAP, Inc.*
Amanda Beecher, *Ramapo College of New Jersey*
Steve Horton, *U.S. Military Academy (Emeritus)*
Kayla Blyman, *St. Martin's University*

Sponsor:
Consortium for Mathematics and Its Applications (COMAP)

Memorable Moments in the Mathematical Modeling Classroom
8:00 a.m. - 8:15 a.m.
Mathematical modeling is one of my favorite courses to teach, and students have generally enjoyed the opportunity that the class presents to investigate various applied problems. The natural flexibility in terms of course content has allowed for experimentation with many different topics and activities, as well as technology to facilitate these explorations. In this talk, I will share some of the experiences that have been most popular among students. In some cases, students' second majors or minors inspired the content. In others, current events played a role. Sometimes it was simply the case that a particularly interesting mathematical concept couldn't be left out. But, regardless of the motivation, the modeling instances presented here all proved to be winners that may be worthy of consideration for other courses, either in mathematical modeling or another area such as graph theory, differential equations, probability, or optimization.

Author:
Janet Fierson, *La Salle University*

Not Just Physics --Applications from the Partner Disciplines in Calculus: A SUMMIT-P Project
8:20 a.m. - 8:35 a.m.
A cross-disciplinary team at Augsburg University has worked to include many more authentic applications into our Calculus I and II courses. Each class day begins with an applied exploratory activity, and there is also a weekly applied lab with a goal of improving transference of knowledge. This talk will discuss

examples such as titration from chemistry, elasticity from economics, and irrigation modeling from environmental science and how they fit into Calculus. This project was supported by the NSF SUMMIT-P project (Synergistic Undergraduate Mathematics via Multi-institutional Interdisciplinary Teaching Partnerships).

Author:

Jody Sorensen, *Augsburg University*

Modeling Beyond the Classroom: Linking Students and Industry

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

I have taught Operations Research and related classes (probability, sabermetrics) for years, and have had great success in developing enough theory for students to model real world problems, gather and analyze data, and produce outputs useful to industry. We have partnered with companies in a variety of fields (finance, health, sports, entertainment, construction). I will discuss how I have been able to successfully engage students, ranging from freshman with just intro-stats to seniors with advanced coursework, emphasizing pedagogical lessons I have learned and the impact these projects have had on student learning and post-college career paths.

Author:

Steven Miller, *Williams College*

Not Your Standard First Population Modeling Project

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

To give students enrolled in Mathematical Modeling a more genuine modeling experience, several "stake-holders" from various disciplines on campus were asked to present a problem they had to the students. The students would then work for a couple of weeks to solve the problem and would present their solutions in the form of a modeling paper. When asked if she had any interesting population problems for the students, ecology professor Dr. Megan Friesen asked what I thought of giving them a decade's worth of capture-recapture data for the Grey-Faced Petrel. This was clearly not the simple capture-recapture problems we find as applications of proportions in textbooks. It was a beautifully messy and complex modeling problem accompanied by an equally complicated data set to invite students to explore. In this talk, we will discuss the preparation of the students, introduce the population problem, and share some student work.

Authors:

Kayla Blyman, *Saint Martin's University*
Megan Friesen, *Saint Martin's University*

Active Listening in Mentoring Student-Led Projects in Mathematical Biology

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

This study discusses a long running REU in mathematical biology. A characteristic of the program is that students choose their own topics. This creates a reversal of hierarchy, where students know more about their topic of interest than mentors, and mentors serve as consultants providing mathematical guidance and expertise. But how does this reversal of hierarchy really function? In this study four undergraduate research groups made presentations over six days while developing their research question and model. Analysis of the presentations' recordings, mentors' comments, and project final papers show that this reversal of hierarchy does not always function smoothly. In these examples, students struggled with communicating biology in standardized ways, and confusion led to mentors making decisions to guide more than necessary.

Author:

Carlos Castillo-Garsow, *Eastern Washington University*

Mathematical Interpretation of China's Economic Outputs

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

It is widely accepted that China's economic growth is due to the large labor force derived from its huge population basis. In this research, we look for a relationship between the extent of the impact of the labor force on China's aggregate production, which in turn will help us analyze whether policies on population control make their stand. We believe China's current Family Planning Policy serves as a solution to maintain population growth, thus preserving the basis of the labor force. Therefore, we use Panel Data Regression and Fixed Effect Model in this research to determine whether the size of the labor force is critical in maintaining China's current economic growth.

Author:

Yichen Qian, *New York University*

Network Science for Preservice Elementary Educators

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

Early in their lives, children learn the concept of relationships between individuals. For many students, they have an intuitive understanding of these relationship connections and their resulting structures (families, friends, neighborhood, etc.) during their elementary school years. This intuition and these informal concepts are sufficient to give educators an exciting and meaningful entre into the growing discipline of network science. However, there is a barrier to this opportunity in that few students have teachers that are familiar and comfortable with this growing and important area of science having only developed their own intuitive understanding through social networks. This talk will discuss preliminary attempts to introduce these concepts in a course Math for Elementary Educators.

Author:

Amanda Beecher, *Ramapo College of New Jersey*

Gold-Bitcoin Trading Strategy using a LSTM-Based Method for Asset Returns Prediction

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

Investors make different decisions, buying and selling varied financial assets every day in the world. Among a variety of financial assets, gold has been a proven asset as currency and a store of wealth throughout human history, from ancient Egypt through the modern era. In recent years, new financial assets have emerged, and among these new assets to take center stage has been Bitcoin, and other crypto currencies, as it has gained an increasingly significant role in the investment scene and financial press articles. In this article, Artificial Neural Networking models offer predictions on financial markets with outstanding precision and efficiency, which renders it a powerful tool in developing trading strategies. Our trading strategy based on the Deep Recurrent Neural Network (DRNN) and Long Short-Term Memory network (LSTM) model effectively identifies profiting opportunities and generates $3,502,240 for the five-year trading period.

Authors:

Zefan Qian, *Macalester College*
Yuhang Zhang, *Macalester College*
Zifan Yu, *Macalester College*

Lattice Gas Cellular Automata as a Parallel Computing Laboratory

10:40 a.m. - 10:55 a.m.

Cellular Automation (CA) is a discrete model often used in computer science, mathematics, physics sciences, and biological sciences to model complex behavior using a simple set of rules. The most recognizable example of CA is John Conway's Game of Life, which is presented in many introductory

computer science and mathematics courses. Here, I discuss the use of lattice gas cellular automata (LGCA) to simulate fluid flow in a domain from the perspective of parallel and distributed computing (PDC). In recent years, high-performance computing (HPC) and the need for powerful supercomputers are becoming a staple in many areas of academia and industry. Thus, understanding and using these powerful systems is more important than ever. LGCA, and specifically the model of Hardy, Pomeau, and de Pazzis (HPP), will allow students to become familiar with the computational aspects of a complex model in multiple parallel computing environments, including multicore, manycore, and distributed contexts.

Author:
Micah Schuster, *Wentworth Institute of Technology*

Mathematics and the Life Sciences: Initiatives, Programs, Curricula
Thursday, August 4, 1:00 p.m. - 1:55 p.m., Salon J

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)

But What If I Ever DO Need to Know This? Just-in-Time Math and Stats for Biomedical Researchers
1:00 p.m. - 1:15 p.m.
On the other side of "Will I ever actually need to know this?" separated by years or even decades, are a whole lot of people thinking "I wish I had learned that better, or at all." I work on the research side of the Children's Hospital of Philadelphia, with people conducting cutting edge biomedical research. Some of them have MDs, PhDs, or both, and while all of them had to pass some mathematics and statistics courses as students, that was a long time ago. These researchers are collecting and analyzing data, but would never consider themselves "data scientists," much less statisticians or mathematicians. So how do we quickly get working biomedical researchers up to speed so they can dive into machine learning and Bayesian analysis methods? As part of a National Institutes of Health initiative to improve the quality and reproducibility of research, my colleagues and I in Arcus Education (part of the Department of Biomedical and Health informatics) are developing short, open access, learning modules to get researchers the tools and knowledge they need, as they need it. We are in the pilot stage of our research on the effectiveness of this learning method. This talk will focus on how the mathematical content fits into the larger project: Educational Pathways in Data Science for Biomedical Researchers.

Author:
Elizabeth Drellich, *Children's Hospital of Philadelphia*

Extension of Fundamental Transversals and Euler's Polyhedron Theorem
1:20 p.m. - 1:35 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. Recently, we have found that an EOC could be useful and applied to further description and tabulation of certain Capsids. Since Capsids are in the majority of either helical or icosahedral structure – then applying our extension theorem could possibly help create a limpid view of the various virus we encounter. Keywords: Euler, Polytopes, Convex, Orbit, Biology, Cells, Capsids, Vertex, Edges, Faces, Polygons.

Author:
Joy D'Andrea, *University of South Florida*

Introductory Student Research Projects Involving Modeling with Agent-Based Models
1:40 p.m. - 1:55 p.m.
This presentation will discuss some entry-level ideas for student research projects modeling biological phenomena primarily using agent-based models. We will discuss how students with no prior experience in mathematical biology or in working with agent-based models can begin to explore problems and then progressively learn to ask and investigate further questions. The projects will focus on ecological and epidemiological phenomena.

Author:
Timothy Comar, *Benedictine University*

Supporting Pandemic Prepared Students
Saturday, August 6, 9:00 a.m. - 11:55 a.m., Salon F

Due to COVID-19, students are arriving in calculus and other mathematics classes in college with the same high school math classes as typical, but with notably different preparation due to the pandemic. How do departments and faculty provide extra support for students with weaker preparation or larger holes in their background? This session welcomes talks on this topic that offer analysis or effective models such as supplemental instruction or corequisite courses, to help us all serve our students as well as possible.

Organizers:
Kim Roth, *Juniata College*

Russell Goodman, *Central College*
Melissa Innerst, *Juniata College*

Space and Grace: Focusing on Student Learning and Not the Grade

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

Space and grace. These are the two words I have approached my students with this year, in an effort to support their learning and, subsequently, their mental health. Through the use of review sheets, hands-on activities, and a semester-long series of written learning reflections in Calculus I, students shifted their focus from grades to actual learning, a shift that many student noted made them more confident, and less anxious, especially given their level of unpreparedness in algebra and trigonometry. In this talk we will review these items and draw connections between their use and support of pandemic prepared students to grow their math knowledge, both in the new material being presented as well as topics they were underprepared in.

Author:

Elizabeth Donovan, *Murray State University*

Towson University STEM Major Math Prep Program

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

Recognizing the unique needs of incoming freshmen in 2021, we developed a four-part program to assist these students in their transition to university mathematics. The four parts included: increased summer course offerings, free summer tutoring and lectures on key topics from high school mathematics to help students fill in gaps and improve their math placement, an early move-in "Bootcamp" program, and semester long "companion courses" for precalculus and calculus, with the Bootcamp and the companion courses being the highlights of the program. The four-day Bootcamp took place just before the semester started and consisted of daily math lectures from full-time faculty, sessions working on challenge problems under the supervision of an undergraduate learning assistant (ULA), and more general sessions aimed at helping students adjust to the difference between high school and college mathematics courses. The companion courses featured weekly sessions with a ULA that were intended to help students review or relearn material just before it became needed in their calculus or precalculus course. Qualitative data from this program suggests that it contributed to students' perceived mathematics confidence. While this confidence might not be directly correlated with student success it has been shown to increase students' persistence pursuing STEM degrees. Additionally, the companion courses may also be of benefit to continuing students. Although the companion courses were intended to support incoming freshmen, they were open to all students enrolled in the precalculus and calculus courses. Preliminary data suggests the companion courses are appealing to students who already took some college classes and recognize they need extra support with college mathematics. For example, our data shows that calculus students who had previously taken a prerequisite and enrolled in the companion course had a mean course grade almost an entire letter grade higher than their peers who did not complete the companion course.

Authors:

Miram Parnes, *Towson University*
Kristin Frank, *Towson University*

Surviving Pandemic – Various Techniques from Text Message Communication to GeoGebra

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

In this short presentation, I will describe some of the techniques and steps that I had taken to survive during the long pandemic. Some examples include use of "Remind" for text message communication, "extra credit" to entice students to participate, "Zoom white board for classroom activity, and GeoGebra, Desmos,

WolframAlpha, Calculu3D plot to make my desktop computer a smart classroom. There are several other techniques that I have adopted as I went along semester to semester. I will very briefly talk about all of these techniques and steps that helped me during the pandemic. This talk will be based on my personal experiences.

Author:

Tanvir Prince, *Hostos Community College, City University of New York*

Designing Quizzes to Enhance Learning

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

Weekly quizzes are a common method for assessing student learning between unit tests. However, with a few small changes, quizzes can be a useful tool not just for assessing learning but also for promoting student learning. Here I will describe my experience replacing weekly quizzes with more frequent, shorter quizzes and introducing the option for revisions. This strategy takes about the same amount of time in class and requires little extra preparation, but I have found that it encourages students to stay up-to-date on their homework rather than procrastinating, and it increases student test scores.

Author:

Erin Griesenauer, *Eckerd College*

When the Flip Flopped: Items to Consider When Implementing Teaching Innovations with a Pandemic Prepared Population

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

In this session, I will share my reflections on flipping an introductory statistics college classroom during the COVID-19 pandemic. After running the flipped-classroom over 3 of the past 4 pandemic-adjusted instructional semesters, there are valuable lessons that were learned, and useful information for any instructor wishing to implement any pedagogic innovation (not just the flipped-classroom model). Additionally, I will discuss potential issues that were exacerbated by the pandemic, and consequently may be attributes for the incoming cohorts of students for the next few years.

Author:

Allen G Harbaugh, *Longwood University*

Reaching Success in a Mathematics Course for Elementary Teachers

10:40 a.m. - 10:55 a.m.

I will present my research on the impact of using a Specification Grading model in mathematics courses for preservice elementary teachers. Prior to the implementation of the model, the % of teachers showing competence in the top 5 hardest topics was only about 50%. Additionally, approximately 10% failed the course each semester. Since the implementation (4 years ago), both DFW rate and competency rate on the hardest topics is significantly better than control groups. In fact, since the implementation, 100% of the students have passed and 100% of the students have demonstrated competency in top 5 hardest topics, while maintaining competency in the easier topics. We will discuss the details of the intervention, results, limitations, and future research efforts.

Author:

Michael Matthews, *University of Nebraska at Omaha*

Promoting Access through Structured Placement Support: Lessons from a Pilot Course

11:00 a.m. - 11:15 a.m.

Over the last three years at Trinity University, we have made several changes to our mathematics placement process, with the biggest change being a switch from an in-house placement exam to use of the ALEKS Placement, Preparation, and Learning platform. In recognition of the fact that a nontrivial portion of our incoming students place in coursework below Pre-Calculus–the lowest-level mathematics course we offer at Trinity–this year we created and piloted a free one-credit hour summer course for students seeking to use ALEKS to improve their mathematics placement in a structured, confidence-building environment. In this presentation, I will discuss our program and share preliminary data on its efficacy in improving students' placement outcomes.

Author:

Samuel Tunstall, *Trinity University*

Time and Attention: Corequisite Support for College Algebra

11:20 a.m. - 11:35 a.m.

This talk describes a corequisite support model that was implemented in Fall 2021. Students whose placement scores fell below the typical cutoff for College Algebra were placed in a special College Algebra section that met for an additional 80-minute session each week, with the same instructor. Enrollment was capped at 19 to ensure plenty of individual attention, and an active-learning environment made it possible to identify and address any points of confusion as soon as they arose. Students in this course have gone on to succeed in Precalculus in Spring 2022.

Author:

Zoë Misiewicz, *State University of New York Oswego*

A Characterization of College Algebra Assessment During the Transition to Emergency Remote Teaching

11:40 a.m. - 11:55 a.m.

The COVID-19 pandemic led to a global lockdown and compelled the institutions to shift to emergency remote teaching. This transition and the lack of knowledge of using technology affected teaching practices, including assessment. Confronted with new contexts for assessment and threats to validity caused by ineffective proctoring, many instructors had to rethink how to evaluate student progress. This study investigates the common characteristics of college algebra assessment in six dimensions and determines any changes during emergency remote teaching. In addition, the analysis compares the college algebra instructors' views about the purpose of evaluation. Finally, the study tested the efficacy of a new tool that instructors can use to analyze their assessments.

Author:

Ash Demian, *Texas State University*

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

Part A: *Saturday, August 6, 9:00 a.m. - 11:55 a.m., Salon I*
Part B: *Saturday, August 6, 1:00 p.m. - 1:40 p.m., Salon I*

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)

Part A: *Saturday, August 6, Salon I*

Playing Wordle with Entropy
9:00 a.m. - 9:15 a.m.
The game Wordle is built around guesses and analyzing how close each guess is to being a correct match for a hidden word. One important strategy is choose guesses that give you the most information at each stage. Since we can't know the result of the guess in advance, we seek the most information on average for a given guess, which is known as entropy. This talk will discuss the entropy of a probability distribution and choosing guesses that maximize that entropy in Wordle as well as how to generalize this concept to other games.
Author:
Jeffrey Clark, *Elon University*

Permutation Groups, the 15-Puzzle and Its Variations
9:20 a.m. - 9:35 a.m.
In this talk we will look into the popular 15-puzzle that was originally introduced in 1870 by Sam Loyd. We will look at its history, and then see how group theory specifically permutation groups help us in determining the solvability/un-solvability of this puzzle. We will then look at some interesting variations of the puzzle itself.
Author:
Dibyajyoti Deb, *Oregon Institute of Technology*

A Mathematical Exploration of Enemy-Protector
9:40 a.m. - 9:55 a.m.
In this talk we mathematically investigate the summer camp activity known as "Enemy-Protector." Participants of Enemy-Protector try to arrange themselves according to "enemy" and "protector" assignments, and these assignments can lead to interesting behavior as the players move. In an effort to explore the dynamics involved, we model the activity as a discontinuous dynamical system. We will share several observations from our simulations, discuss some of Enemy-Protector's underlying mathematical structures, pose a few questions, and explore avenues for future research.
Authors:
Edward Fuselier, *High Point University*
Adam Graham-Squire, *High Point University*

Classroom Blackjack: A Tool for Introducing Optimal Gaming Strategy
10:00 a.m. - 10:15 a.m.

In this talk, we introduce a simplified version of Blackjack. The purpose for developing this variant is for use as a pedagogical tool that is accessible to students who have learned the basics of probability. In particular, this variant of the game more easily enables students to explore a strategy for making optimal decisions based on probability and expected value.

Author:

Daniel Martin, *University of Hartford*

Pascal's Gambling Problems

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

By rolling two dice, how many tosses are needed to have at least an even chance of getting double-six? How do you divide the winnings of an interrupted game of chance? In this talk, we will discuss Pascal's solutions to these gambling problems and the Pascal-Fermat correspondence that laid the foundation for modern probability theory.

Author:

David DeSario, *Shawnee State University*

Magic Squares "Trick" on National Television

10:40 a.m. - 10:55 a.m.

On the television show Little Big Shots, hosted by Steve Harvey, there was an episode featuring a "little mathematician" who performed what was billed as an "amazing math trick". In this talk, we will discuss this "trick" and its solution, involving Magic Squares, which is a square array of numbers where the sum of every row, column, and main diagonal is the same.

Authors:

Lyn McQuaid, *Kutztown University of Pennsylvania*
Lindsey Moyer, *Kutztown University of Pennsylvania*

An Impartial Combinatorial Game on a 3 x 3 Board with Magic Square Constraints

11:00 a.m. - 11:15 a.m.

An impartial combinatorial game on a 3x3 board whose entries must adhere to the constraints of a magic square is defined. Entries for the game are nonnegative integers from 0 to n. We show the second player has the winning strategy for n=1 and the first player has the winning strategy for all other values of n. A winning strategy for each case is provided.

Author:

Matthew Coppenbarger, *Rochester Institute of Technology*

Arrangements of Mutually Non-Attacking Chess Pieces of Mixed Type

11:20 a.m. - 11:35 a.m.

We present placements of mutually non-attacking chess pieces of mixed type that occupy more than half of the squares of a rectangular board. If both white and black pawns are allowed as separate types, there are arrangements, which we also present that occupy at least two-thirds of the board squares.

Author:

Doug Chatham, *Morehead State University*

A Lucas Surprise

11:40 a.m. - 11:55 a.m.

When securing the possible next term in an integer sequence, one often employs the method of finite differences and finds the sequence models a polynomial function. Recently a friend emailed me concerning the sequence 2, 4, 5, 8, 12, 19, 30, 48, 77, 124, ... In this instance, the set of first differences is the Lucas sequence! This paper explores divisibility and periodicity ideas as well as securing prime outputs (which are rare apart from the primes 2, 5, 19 and 5779 corresponding to the first, third, sixth and eighteenth terms respectively) and any palatable number tricks associated with the sequence. Using MATHEMATICA 12.0, I was able to completely factor all but one a few of the initial five hundred terms in this shifted Lucas sequence (each term is one greater than the corresponding terms in the standard Lucas sequence) and discovered the initial entry points of each prime less than one thousand. Even in the case of failing to secure a complete factorization, I was able to achieve a partial factorization of each of the initial five hundred terms in the sequence. In addition, we show using the recursion relation in our sequence that each prime, power of a prime and composite integer (using the least common multiple) is guaranteed to enter our sequence no later than one place prior to the end of the Pisano period. Of course, an integer may enter the sequence earlier as well. This is in contrast to the standard Lucas sequence where one-third of the primes never enter the sequence as factors and seven hundred forty-six of the first one thousand positive integers do not appear as factors of any Lucas number. The lengths of the Pisano periods of each integer are the same as those in the traditional Lucas sequence. Please join us to view a neat sequence in action.

Author:

Jay Schiffman, *Rowan University (Retired)*

Part B: *Saturday, August 6, Salon I*

Fitch Cheney's 5-Card Trick Reduced to 2 Cards

1:00 p.m. - 1:15 p.m.

In 1951, one of the best card tricks ever invented was published. Martin Gardner mentioned it in his Scientific American column. Since the 1980s, it has found new popularity thanks to the efforts of Art Benjamin, Elwyn Berlekamp, Paul Zorn, and others. Five random playing cards from a regular deck are given to Aodh by any audience member. Aodh hands one back, and places the remaining four in a face-up row. Bea, who has not been privy to any of the proceedings so far, arrives on the scene, looks at the row of cards, and promptly names the hidden fifth card. This is the classic Fitch Cheney's 5-Card Trick. Aodh and Bea have agreed in advance on a strictly mathematical system of communication. In 1999, this was scaled down to 4 cards, and in due course to 3 cards (see Math Horizons, November 2014). In 2015, the speakers conjured up a 2-card version in a bar in Easton, PA, which was subsequently lost in the mists of time. We are finally ready to reveal the sobering details.

Authors:

Colm Mulcahy, *Spelman College*
Derek Smith, *Lafayette College*

Magic from Coin Weighing

1:20 p.m. - 1:35 p.m.

We will describe and perform a magic trick that can involve many simultaneous volunteers in a large crowd setting or even remotely via Zoom. We'll then explain how this trick was created from one of the most famous coin-weighing problems and its solution via positional representations of numbers.

Author:

Tom Edgar, *Pacific Lutheran University*

Pursuing Justice in and through Mathematics
Thursday, August 4, 1:00 p.m. - 5:20 p.m., Salon D

We invite presenters to share their efforts in pursuing justice, diversity, equity, and inclusion in their teaching, curriculum development, and assessment practices for students, evaluative processes for faculty, departmental climate, enriched story-telling about mathematicians, and broader public outreach. We are particularly interested in the integration of social justice into traditional mathematics courses, including special topics, quantitative reasoning, and/or the redesign College Algebra, Calculus, or Differential Equations.

Organizers:
Alex McAllister, *Centre College*
Joel Kilty, *Centre College*
Victor Piercey, *Ferris State University*
Prayat Poudel, *Centre College*
Adriana Salerno, *Bates College*
Janet Fierson, *La Salle University*

Sponsor:
Association for Women in Mathematics

Sharing the Story of Dr. Euphemia Haynes
1:00 p.m. - 1:15 p.m.
While much is known of civil rights battles on busses, school steps, and lunch counters, equally important battles were being fought by educators within schools and on school boards. Several years ago I worked with two undergraduate students on an AMS Notices article on Dr. Haynes, the first African American woman to earn a PhD in mathematics and a civil rights leader in education. Since writing that article, I have written a middle grade manuscript on this amazing woman. I will discuss Haynes, the goals of this project, the process I am on for reaching this younger audience, and the impact the work has had on me and my classes.
Author:
Susan Kelly, *University of Wisconsin La Crosse*

The Need for Teaching a More Accurate and Inclusive History of Mathematics and Science
1:20 p.m. - 1:35 p.m.
Even though it is not accurate, a Eurocentric history of mathematics and science has been commonly taught in schools. This distorted version of the history of science, called Classical Narrative (CN) by some, is rooted in colonial times and mindset, and has caused much damage. It ignores or belittles contributions to mathematics and sciences from non-western civilizations, and falsely attributes many scientific discoveries to European scholars. Using the Islamic Civilization, which was directly connected to Europe, as an example we can observe and demonstrate the distorted nature of the CN. Based on research on primary sources since the middle of the twentieth century, we now know that some of the most fundamental notions of modern mathematics and science come from the medieval Islamic Civilization. Moreover, modern researchers also discovered that Islamic science was highly influential on Renaissance scholars such as Copernicus. However, there is a huge disconnect between the most accurate academic knowledge on the subject and what is being taught, or not taught in schools. Despite the passage of many decades, accurate

knowledge based on primary source research did not become common knowledge or part of the school curricula. Part of the reason for the general lack of knowledge on this topic is the fact that prospective teachers do not learn about this material during their education. This combined with the general lack of inclusion of Islamic contributions to sciences in official curricula results in the current state of affairs. Therefore, the inclusion of this material in school curricula and teacher training and education programs is an important need that needs attention. The purpose of this talk is to draw attention to this need, exhibit some sample activities and resources that can be useful, and to invite the larger community to develop strategies to achieve this goal.

Author:
Nuh Aydin, *Kenyon College*

Alternative Grading Systems As Resistance
1:40 p.m. – 1:55 p.m.
Rating students undermines learning. Grading diminishes students' intrinsic motivation and interest in whatever they're learning, makes students prefer easier tasks, and reduces the quality of their thinking. Nevertheless, grading is currently a part of the architecture of virtually every educational institution. How can we resist grading and thereby promote learning? How can we comply with our institutional requirements while critiquing the assumptions they're based on? In this talk I'll discuss the history of grading in the United States, give an overview of various alternative grading systems, and share results on how I have been able to employ them.

Author:
Spencer Bagley, *Westminster College*

OER Textbook Revision with a Focus on Diversity, Equity, and Inclusion
2:00 p.m. - 2:15 p.m.
This talk explores how a department-wide push towards integrating diversity, equity, and inclusion into the mathematics curriculum influenced the creation of a customized edition of an introductory Statistics textbook. Over the last ten years, math faculty at Stevenson University have led a push towards the adoption of open educational resources. In the lead-up to Spring 2022, we finally took advantage of a key feature of OER: the ability to create our own edition of the book. The goals for the new edition gradually evolved from a simple reorganization and clarification of material to a more extensive revision reflecting the department's faculty guidelines on DEI. We'll look at what prompted the creation of the new edition, how DEI considerations translated to modifications of the contents, and opportunities for future improvements.

Author:
Sarah Blanset, *Stevenson University*

Helping Prepare Teachers to Teach for Justice
2:20 p.m. - 2:35 p.m.
Future secondary math teachers have been at least moderately successful in the educational system, and many of them experience a large number of university courses that implicitly accept the status quo. As a result, preparing future teachers to teach for justice involves questioning disciplinary ways of knowing, critiquing systems, and reimagining concepts from an advanced perspective. Thankfully, many students come to my classes wanting to be ready to lead more just and inclusive classes than they experienced. In this talk I will share some of the ways that I try to help my students meet this large challenge.

Author:
Brian Katz, *California State University Long Beach*

Redesigning Calculus to Increase Accessibility and Persistence in STEM

2:40 p.m. - 2:55 p.m.

Amidst growing concerns that the Calculus sequence poses considerable barriers for prospective STEM students, the mathematics program at Centre College has spent the past several years redesigning our calculus curriculum to better serve all our students. In this talk, we give an overview of our work to improve the content and pedagogy of the Calculus sequence to create a more inclusive classroom. We present the goals for the curricular reform, our use of emerging technologies to teach Calculus, and how we have restructured the course to improve student persistence in Calculus. We also talk about our attempts at incorporating mathematical modeling using real world data to promote students' innovative and real-world abilities as well as share some of the projects that were implemented in the redesigned sequence.

Author:

Prayat Poudel, *Centre College*

Alex McAllister, *Centre College*

Course-based Undergraduate Research Experience (CURE) to Integrate Justice in the Linear Algebra Curriculum

3:00 p.m. - 3:15 p.m.

Linear Algebra is often the first abstract course that non-math majors encounter. It can provide quite a culture shock to the students. Therefore, it is important to provide applications that create connections with the many abstract concepts. Learning and teaching of Mathematics is often associated with the objectivity of the content. This can lead educators to dismiss the possibility of adding discourse about socio-political issues. In this talk, we discuss how Crime Forecasting, Community Policing, and the Broken Window theory were brought in a Linear Algebra classroom to provide an opportunity for social discourse and applicability of abstract mathematical concepts.

Author:

Filippo Posta, *Estrella Mountain Community College*

Math in Social Context: A Seminar for Senior Math Majors

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

Every department at Hamilton College has to provide a means for its majors to satisfy a Social, Structural and Institutional Hierarchies requirement. One approach we use is to integrate DEI issues into our introductory statistics course, but another is a stand-alone seminar for math majors that covers topics such as math education as a civil right, cultural and social attitudes of 'computation' versus mathematics, the use of quantitative tools to detect partisan gerrymandering and the abuse of 'big data' algorithms.

Author:

Sally Cockburn, *Hamilton College*

Empowering Students for Social Justice through Math, Liberal Arts, and EML

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

Engineering in the context of social justice faces complex problems compounded by the fact that the subjects being addressed are human beings. Research suggests that engineering students receive insufficient training in socio-technical design or in humanitarian engineering. The EML (Entrepreneurially Minded Learning) framework's focus on creating value has the potential of bringing the best practices for teaching socially responsible engineers. The problem of introducing social justice into the classroom produced ample approaches, materials, and research, including critical pedagogy, a "model of lived empowerment", socially responsible engineering, sustainability, social entrepreneurship, and mathematics for social justice. However, missing is a holistic approach to creating courses and curricula that combine mathematics and

liberal arts to encourage engineering students to adopt humanities and social science approaches to helping solve societal problems. This article intends to fill this gap by presenting a model for close-knit collaboration across STEM and liberal arts disciplines. We provide an outline of our course, discuss our methods and modalities of course delivery, summarize data collected from student surveys and direct observations, and explore how a service learning opportunity and EML helped equip students with tools for making positive societal change. Finally, we offer recommendations and insights for instructors to build their own courses upon this foundation.

Authors:

Leszek Gawarecki, *Kettering University*
Babak Elahi, *Kettering University*

A Model of Inclusive Instruction: Students at the Center
4:00 p.m. - 4:15 p.m.

Many mathematics faculty across the nation are embracing new teaching methods and implementing various classroom structures to support the increasingly diverse population of students in their classrooms. However, the lack of diverse representation within the faculty population and limited in-depth DEI (diversity, equity, inclusion) training can stimy even the best efforts to improve the learning experiences for diverse students. In this presentation we will detail several student-centered strategies that can be incorporated into classrooms to address these concerns. Positioning students as leaders in the classroom, eliciting student feedback throughout the semester, modifying course structures and policies, and reimagining the curriculum in collaboration with students are the focus of this presentation. The approaches shared in this presentation are based on the strategies utilized in a multicultural, first-generation, and traditionally underrepresented mathematics program.

Authors:

Rebecca Machen, *University of Colorado Boulder*
Nancy Kress, *University of Colorado Boulder*

Math for the People: A Textbook for Teaching Quantitative Reasoning Through Social Justice
4:20 p.m. – 4:35 p.m.

Math for the People is a collaboratively written open educational resource designed to replace a classic textbook for a first year quantitative reasoning course. The text encourages students to explore how mathematics can be used to understand social justice concepts like generational wealth inequity, climate change, and racially-biased policing from a solutions-oriented perspective. Rather than learning a series of mathematical concepts, followed by applications of those concepts, Math for the People seeks to invert that structure, beginning with a problem that students are interested in and discovering the mathematics which can help to understand and even solve that problem. We will discuss the current state of the project and the status of the first edition, launching in Summer 2022. We will also talk about opportunities to review the first edition or author more modules for the second edition.

Authors:

Mark Branson, *Stevenson University*
Whitney George, *University of Wisconsin La Crosse*

Mappering Mecklenburg County: Exploring Census Data for Potential Communities of Interest
4:40 p.m. - 4:55 p.m.

Electoral districting remains a politically contentious topic within the United States. The current redistricting process has raised questions about justice and fairness in electoral maps. One difficulty in

many states is the requirement to identify and maintain 'communities of interest.' This presentation explores the use of the mapper algorithm as a method for identifying clusters of similarities in demographic and economic data. Using data from the American Community Survey, we present results found in Mecklenburg County, North Carolina, map them geographically, and then discuss the potential implications for communities of interest.

Authors:
Anthony Kolshom, *Portland State University*
Courtney Thatcher, *University of Puget Sound*

Math Circles: Talks about Mathematical Joy, Inspirations, Data-Driven Lessons Learned

Part A: *Friday, August 5, 1:00 p.m. - 2:55 p.m., Conf. Room 410*
Part B: *Saturday, August 6, 9:00 a.m. - 11:40 a.m., Conf. Room 410*

The Math Circle community has been working hard over the last several years to maintain enthusiasm for mathematics in a variety of mathematical outreach and enrichment settings – bringing joy and fun for a bit of time when many have felt disconnected. Presenters in this themed session will share the ideas that worked well, that connected, and that brought moments of joy. These ideas don't need to be your own work, presenters can talk about who inspired their idea and discuss how they have adapted other Math Circles leaders' ideas to inspire their own. Presenters are also encouraged to share strategies used to successfully engage with virtual audiences, support the needs of diverse learners, improve outreach, along with any other (qualitative or quantitative) data-driven ideas that improve engagement experiences.

Organizers:
John Peca-Medlin, *University of Arizona*
Brandy Wiegers, *Central Washington University*
Christina Durón, *University of Arizona*
Lauren Rose, *Bard College*
Alessandra Pantano, *University of California, Irvine*

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

Part A: *Friday, August 5, Conf. Room 410*

Joyful Virtual Math Circles via Game Theory
1:00 p.m. - 1:15 p.m.
In the spring of 2022, the Math Renaissance middle-school Math Circle met virtually for eight 90-minute sessions to study Applied Mathematics. Student reaction quickly steered this course into an in-depth study of game theory and decision theory. Using 9 classic problems, students explored how math can model human behavior, some limitations of such modelling, and how we can use math to gain insight on real-world problems and, frankly, on ourselves. In this talk, I will describe these classic problems, the math involved, student reactions, our use of technology, and the joyful conversation that inspired me to offer this course in the first place.

Author:
Rodi Steinig, *Math Renaissance*

A Beast-Academy Inspired Math Circle
1:20 p.m. - 1:35 p.m.

I will partly advertise the "beast academy" math books, which have truly brought me joy and inspiration throughout the pandemic. In fact, my kids and I enjoy them so much that I've started using some of the questions from those books as inspiration for Chicago Math Teachers' circle sessions. In particular, I will describe a session we ran (virtually) in April 2021, based loosely on a question from "Professor Grok" (a six legged monster in those books – did I mention they are in graphic novel format? I told you they bring joy!) The question is pretty simple, asking you to arrange some coins to make a number of lines, but it can lead to very rich discussions.

Author:
Peter Tingley, *Loyola University Chicago*

Math CEO's Training Framework: The Best-Kept Secret behind the Success a Math Circle for Underserved Students
1:40 p.m. - 1:55 p.m.

UCI Math CEO has been proving afterschool math enrichment to low-income, Latinx, middle school students since Fall 2014. College students serve as mentors of adolescents: they facilitate math circle activities and represent tangible models of success in college pursuits and in STEM. They also provide emotional support and positive feedback to youths. Because college mentors ultimately form the link between program curriculum and program impact, behind the success of Math CEO is a very intentional training program of the college mentors on concepts of culturally relevant math pedagogy. During weekly coaching sessions, our mentors practice the math activities they will be investigating with the students, and learn how to create a caring learning environment which is joyful, engaging and mathematically stimulating. This talk will focus on Math CEO's training framework, which is central to our program's efforts to establish and diligently maintain an informal and positive climate where youth can develop academically, socially and emotionally.

Authors:
Alessandra Pantano, *University of California, Irvine*
Andres Forero, *University of California, Irvine*

Math Circles through an Equity Lens
2:00 p.m. - 2:15 p.m.

Philadelphia is frequently considered the "poorest big city" in the United States with more than a quarter of children living below the poverty line. This is a multi-faceted problem, and many of these children don't have equitable access to academic resources. From 2017 - 2020, I explored Math Circles as an opportunity to close the equity gap by offering these learning experiences to students in Kensington, a historically under resourced neighborhood in Philadelphia. Formats explored were invitation to existing Math Circles outside the student's neighborhood, offering Math Circles as a weekend program at a community center, and finally gaining permission to offer Math Circles during the school day in a public elementary school. This talk explores what obstacles and opportunities in each setting and suggests open questions to explore.

Author:
Rebeca Lufi, *Rowan University*

The UCI Math Circle: Building an Online Community of Young Math Researchers
2:20 p.m. - 2:35 p.m.
At the beginning of the 2020-2021 academic school year, the UCI Math Circle (UCIMC) completely redesigned its program to be suitable for a virtual environment. Since our students were not able to spend time in-person with friends as they had in past years, we pivoted our pedagogical goals from teaching specific mathematical concepts to building an online mathematical community that would bring solace and stability during the pandemic. Major changes that were made include, we asked our mentors each academic quarter to volunteer every week so that they would have time to build bonds with participants, we implemented the Julia Robinson Math Festival's digital apps into our curriculum and we created a "mentor training" session where we trained the mentors on how to use an inquiry-based approach to guide their students. Using comparison data between the virtual and in-person math circle, in this talk we detail how the virtual UCIMC was a resounding success: the geographical reach of UCIMC expanded, our attendance increased, and we better retained female UCIMC students. This talk is based on the paper The UCI Math Circle: Building an online community of young math researchers, which appeared in the Journal of Math Circles.

Authors:

John Treuer, *Texas A&M University*
Alessandra Pantano, *University of California, Irvine*
Yasmeen Baki, *University of California, Irvine*

When to Hold 'Em
2:40 p.m. - 2:55 p.m.
We will describe a math circle session related to the article "When to hold 'em," recently published in Mathematics Magazine. In this session participants explore strategies for a simplified poker game, with the goal of answering questions like: when should I hold 'em? When should I fold 'em? When should I bet all my money? This leads to some conclusions that we at least find very satisfying – such as the necessity of occasionally bluffing to do well. It is a session that has brought us joy, and we believe has brought joy to the various groups who have experienced it. We hope it brings you joy as well!

Authors:

Kaity Parsons, *Loyola University Chicago*
Peter Tingley, *Loyola University Chicago*
Emma Zajdela, *Northwestern University*

Part B: *Saturday, August 6, Conf. Room 410*

The Meaning of the Mean, the Standard of the Deviations
9:00 a.m. - 9:15 a.m.
Ask any group of students: Given a set of numbers, how could you represent the numbers using a single value? Everyone tells you it's the mean. But when you ask them why, they can't explain it. And if you ask them to think about it a little more, they realize that the mean is almost never used in the real world to represent a set of data. So why do we use the mean? I describe an activity I've used in both math circles and in college classes that help students understand the meaning of the mean, and why the standard deviation is the standard of the deviations.

Author:

Jeff Suzuki, *Brooklyn College*

The Unsuspecting Parent Math Circle

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

We have now run two different 8-week-long math circles for the parents of children in grades K-5, who signed their kids up for a session of Crazy 8's Math Club by the Bedtime Math Foundation. The parents (mostly private school or homeschooling moms, but some dads too) did not intend to sign themselves up for a math circle, but while their children were doing Crazy 8's activities, the parents did math circle activities we selected from the Julia Robinson Mathematics Festival, Berkeley Math Circle and other sources. We will share some of the outcomes we saw for the parents, as well as the logistics of making it happen.

Author:

Chrissy Safranski, *Franciscan University of Steubenville*
Valerie Plaus, *Franciscan University of Steubenville*

The World of SONA

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

Sona diagrams are an extremely accessible and joyus form of artistic mathematics. We start by reminding everyone of this great way (from ancient African Art) to think about greatest common divisors but this is only the beginning. We explore all sorts of SONA LIKE setups including but not limited to SONA with barriers, competitive SONA, and cooperative SONA. As C.S. Lewis once said "All joy reminds. It is never a possession, always a desire for something longer ago or further away or still 'about to be'."

Author:

Edward Keppelmann, *University of Nevada Reno*

Joy through Justice: Inspiring Change through Meaningful Activities

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

Our Math Teachers' Circle 4 Social Justice (MTC4SJ) is entering our third year and continues to see increased engagement as teachers seek ways to make their curriculum more meaningful to their students. Our unique MTC model seeks to inspire teachers through social justice math activities and empower teachers by positioning them as leaders in guiding sessions and developing lessons. This talk will share specific workshop lessons, teacher feedback, and resources all towards engaging teachers in meaningful mathematics.

Authors:

Kyle Evans, *Trinity College*
Megan Staples, *University of Connecticut*

Fun with Rubik's Cubes

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

Rubik's cubes are always a big hit at math circles and festivals. Participants pick up cubes and play with them, and many are able to solve up to the first layer on their own. This exploration helps to develop spatial awareness and intuition about how the cube moves. Step-by-step guidance at varying levels can accommodate a diversity of participants and lead to a deeper understanding of the problem-solving process. Related low-floor activities include Rubik's cube mosaics and a mystery Rubik's cube puzzle. We will demonstrate strategies used to engage participants online and turn the frustration of solving a highly challenging puzzle into a joyful community-based learning experience.

Authors:

A. Gwinn Royal, *Ivy Tech Community College of Indiana*

Lauen Rose, *Bard College*

MATCH: Virtual Classroom Visits by Mathematicians
10:40 a.m. - 10:55 a.m
Join us as we share the successes and lessons learned from the first year of the MATCH program. Sponsored by the MAA Tensor SUMMA program and the American Institute of Mathematics, MATCH supported 10 Fellows in conducting a total of 29 virtual classroom visits to 10 different Title I middle schools, where they led Math Circle-style activities and discussed their personal experiences as mathematicians. Fellows included individuals with diverse racial and ethnic identities, representing a variety of institution types and career stages. The schools they visited were also racially and ethnically diverse, with 9 of 10 schools being majority non-white. Based on Fellow interviews and class surveys, all participants expressed enthusiasm toward the program. Now entering its second year, we look forward to implementing modifications with another cohort of Fellows. Based on the pilot year, we believe the MATCH program is a promising model for engaging mathematicians directly with classrooms and has significant potential for increasing students' access to Math Circle-style learning in school.
Authors:
Spencer Bowen, *American Institute of Mathematics*
Javier Haro, *American Institute of Mathematics*
Brianna Donaldson, *American Institute of Mathematics*

Joyfully Reaching More Families with JRMF Actvities
11:00 a.m. - 11:15 a.m.
In March 2020, the Julia Robinson Mathematics Festival pivoted from offering in-person festivals to offering weekly math circles all over the world, and soon began developing engaging apps for them, which often had advantages over physical manipulatives. I worked at JRMF from 6-2020 to 7-2021 and have been a volunteer before and after. Because these activities are freely available, many math circles that have been meeting online also use them, and feedback from users has improved the activities. My students often play around at the website and request activities whose apps enticed them. I will demonstrate some activities and describe the current volunteer-led JRMF Community Math Circle.
Author:
Skona Brittain, *Santa Barbara Math Ellipse*

Using Self-Assessments to Measure Program Success in Math Circles
11:20 a.m. - 11:35 a.m.
UCI Math CEO (Community Educational Outreach) is a university-community partnership designed to support low-income Latinx middle school students near campus through math enrichment activities and mentoring. Continued self-assessments using regular (qualitative and quantitative) surveys and data analysis are an important component of the program to ensure accountability and realignment of program goals to meet the community needs. In addition to showing how this assessment infrastructure has been utilized to measure success of pandemic-related program changes, I will outline a pre-pandemic project designed to measure the impact on participation in the Math CEO program on reading and math proficiency standards.
Authors:
John Peca-Medlin, *University of Arizona*
Alessandra Pantano, *University of California, Irvine*

Activities from MAGPIES, A virtual Math Circle for Girls

11:40 a.m. - 11:55 a.m.

During the pandemic, we started MAGPIES: Math and Girls + Inspiration = Success, a virtual math circle for girls. This allowed girls from the 4th-9th grade an opportunity to enhance and explore their mathematical skills in a safe, inclusive space. We demonstrate some of the lesson plans created, including the development process and feedback from participants.

Authors:

Shea Roccaforte, *University of New Mexico*

Lauen Rose, *Bard College*

Posters

MAA Contributed Poster Session
Friday, August 5, 1:00 p.m. - 3:00 p.m., Franklin Hall A

Given previous years' success with the MAA Contributed Poster Session (CPS), the MAA is pleased to continue with this session at MathFest 2022 in Philadelphia. The MAA will provide corkboards for the posters – you just need to bring your poster.

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

Organizers:
Steven McKay, *Brigham Young University*
John Travis, *Mississippi College*

Preferential and *k*-Zone Parking Functions

Parking functions are vectors that describe the parking preferences of n cars that enter a one-way street containing n parking spots numbered 1 through n. A list of each car's preferences is also compiled into vectors in which we denote as ($a_{1}, \ldots , a_{n}$), such that a_i is the parking preference for car i. The classical parking rule allows cars to enter the street one at a time going to their preferred parking spot and parking, if that space is unoccupied. If it is occupied, they then proceed down the one-way street and park in the first available parking spot. If all cars can park, we say the vector ($a_{1}, \ldots , a_{n}$) is a parking function.\\ In our research, we introduce new variants of parking function rules with backward movement called k-Zone, preferential, and inverse preferential functions. We study the relationship between k-Zone parking functions and k-Naples parking functions and count the number of parking functions under these new parking rules which allow cars that find their preferred spot occupied to back up a certain parameter. One of our main results establishes that the set of non-increasing preference vectors are k-Naples if and only if they are k-Zone. For one of our findings we provide a table of values enumerating these new combinatorial objects in which we discover a unique relationship to the order of the alternating group A_{n+1}, number of Hamiltonian cycles on the complete graph, K_n, and the number of necklaces with n distinct beads for $n!$ bead permutations.\\ This research was conducted at the Mathematical Sciences Research Institute 2021 Undergraduate Program (MSRI-UP). Funding was provided by the National Science Foundation and the Alfred P. Sloan Foundation.

Authors:
Christopher Soto, *Queens College of the City University of New York and Columbia University*
Parneet Gill, *California State University, Fresno*
Pamela Vargas, *Smith College*

Higher Dimensional Origami Constructions

Origami is the art of creating shapes with a piece of paper without tearing or cutting the paper. This can be translated to mathematics by viewing the piece of paper as the complex plane, and a fold represents a line through a point on the plane. In 2012, Buhler, Butler, de Launey, and Graham developed mathematical origami constructions in this way, by starting with an allowed set of angles (directions), and just two starting points called "seed points". When the lines through two points intersect, the intersection is a new point, and a subset of the complex plane, called the origami set, is generated by iterating this process. We extend previously known results about the algebraic and geometric structures of these origami sets to higher

dimensions. In the case where the set obtained is a lattice, we explore the relationship between the set of angles and the generators of the lattice, and determine how introducing a new angle alters the lattice.

Authors:
Sara Chari, *Bates College*
Adriana Salerno, *Bates College*
Deveena Banerjee, *Vanderbilt University*

The Equivalence between the (S, T) - Stabilities of Jungck-Kirk-type Iterative Schemes

In this paper, the of equivalence between the (S,T) - stabilities of Jungck-Mann and Jungck-multistep iterative schemes are proved in a normed linear space settings, and a consequence is the equivalence with the (S,T)- stabilities of Jungck-Ishikawa and Jungck-Noor iterative schemes.

Author:
Hudson Akewe, *Unviersity of Lagos*

Nonlocal Optimization Problems

This talk will explore the intersection of the calculus of variations and nonlocal modeling. The calculus of variations is a very old and beautiful theory investigating optimization problems in infinite-dimensional function spaces. The field played a crucial role in the historical development of mechanics, and has been applied to optimal control theory, boundary value problems in PDEs, and many other fields. As a natural extension of elementary calculus, the topic makes a wonderful introduction to higher level math for undergraduate students. The other central topic, nonlocal modeling, has received a huge amount of attention in recent years following Silling's reformulation of elastic theory in terms of nonlocal operators. Unlike classical derivatives, nonlocal operators can handle discontinuities and capture long-range interactions, making them ideal tools for fields like fracture dynamics and diffusion problems. In this talk, I will introduce a class of nonlocal operator and show how it compares to the classical derivative. Then I establish the existence and uniqueness of minimizers for variational problems involving this operator. Finally, I discuss some numerical experiments involving these problems that suggest further results connecting these new problems to the classical theory.

Author:
Michael Pieper, *University of Nebraska-Lincoln*

On the Asymptotics of Some Strongly Damped Beam Equations with Structural Damping

The Fourier transform, F, on R^N ($N \geq 1$) transforms the Cauchy problem for a strongly damped beam equation with structural damping $u_{tt}(t,x) - \Delta u_t(t,x) + \alpha(\Delta^2)u(t,x) - \Delta u(t,x) = 0$, $\alpha \geq 0$, to an ordinary differential equation in time. We let $u_\alpha(t,x)$ be the solution of the problem given by the Fourier transform. With suitable initial data $u(0,x)$ and $u_t(0,x)$, it is possible to establish the rate of decay of the squared L^2-norm of $u_\alpha(t,x)$ as $t \to \infty$. In the poster we briefly discuss the methods used to obtain the desired asymptotic expansion: the small perturbation method, integral estimates, and the parabolic cylinder function; provide the first few terms of the expansion; and give a method to compute as many terms of the expansion as desired. Finally we discuss the relationship to the special case when $\alpha = 0$, namely, the strongly damped wave equation $u_{tt}(t,x) - \Delta u_t(t,x) - \Delta u(t,x) = 0$, which has been studied extensively by, among others, Ikehata (2014) and Barrera–Volkmer (2019, 2021).

Author:
Joseph Barrera, *Converse University*

Orlicz Function and Some Paranormed Difference C_2-sequence Spaces

In this paper the results of seminorms for Orlicz sequence spaces are extended to generalized Orlicz sequence spaces defined using double sequences. Some paranormed difference C_2-sequence spaces by the norm on bicomplex space and the Orlicz function have been introduced. The topological properties such as symmetric, solidness, completeness and some inclusion relation between these spaces are also

established.

Author:

Sukhdev Singh, *Lovely Professional University*

Artificial Neural Networks Via Back Propagation For the Iris Data

Machine learning and in particular Artificial Neural Networks (ANN) have been used to analyze numerous data sets. An overview of how an ANN works as well as back propagation, steepest descent, and stochastic gradient descent are presented. Furthermore, R-scripts were constructed for two very simple Artificial Neural Networks (ANN) as well as a more complicated Artificial Neural Networks (ANN) using back propagation. The R-scripts were then used to analyze a subset of the famous iris data set which is linearly separable.

Author:

Sunny Lee, *Wentworth Institute of Technology*

Compressive Sensing Reconstruction of Structural Neuronal Network Connectivity and the Balanced Dynamical Regime

Determining the structure of a network is of central importance to understanding its function in both neuroscience and applied mathematics. However, recovering the structural connectivity of neuronal networks remains a fundamental challenge both theoretically and experimentally. While neuronal networks function in certain dynamical regimes, which may influence their connectivity reconstruction, there is widespread experimental evidence of a balanced neuronal operating state in which strong excitatory and inhibitory inputs are dynamically adjusted such that neuronal voltages primarily remain near resting potential. Utilizing the firing dynamics of neurons in such a balanced regime in conjunction with the ubiquitous sparse connectivity structure of neuronal networks, we develop a theoretical framework using compressive sensing theory for efficiently reconstructing network connections by measuring individual neuronal dynamics in response to a relatively small ensemble of random stimuli injected over a short time scale. By tuning the network dynamical regime, we determine that the highest fidelity of reconstructions is achievable in the balanced state. We hypothesize the balanced dynamics observed in vivo may therefore be a result of evolutionary selection for optimal information encoding and expect the methodology developed to be tractable for alternative model networks as well as experimental paradigms.

Author:

Victor Barranca, *Swarthmore College*

Proving Mathematical Conjectures Using Boolean Satisfiability Solvers

The surprising and quite stunning application of Boolean Satisfiability (SAT) Solvers to prove difficult mathematical conjectures will be given, with examples of how conjectures such as the Collatz conjecture can be transformed by a rewriting process into formulas that use propositional logic and can thereby be tested by a computer to see whether these rewriting systems eventually terminate.

Author:

Alexander Atwood, *Suffolk County Community College*

Nets of Tetrahedra

Triangles are the simplest and the most fundamental example of a polygon. The 3-dimensional analogue of a triangle is the tetrahedron. However, tetrahedra are much less studied than triangles and there are a surprisingly large number of simple questions about them that are still not answered. The purpose of this note is to survey some of what is known, especially results with a "distance geometry" or "discrete geometrical" flavor. To talk about some of what has been accomplished and some of these new questions, it will be helpful to have a standard way to denote tetrahedra and ways to draw nets of tetrahedra. A net can be described informally as the polygon obtained when one cuts along a spanning tree of a (convex) polyhedron so that the polyhedron can be opened into a simple plane polygon. When cuts along a spanning

tree results in a self-intersecting plane polygon the result will be called an overlapping net. This leads to an open problem. The paper will discuss the problem and new open question.

Author:

Derege Mussa, *University of Texas at Dallas*

The Extremal Sizes of Arc-Maximal (k, l)-Digraphs

Boesch and McHugh in [J. Combinatorial Theory Ser. B 38 (1985), 1-7] introduced the edge-maximal (k, l)-graphs to study of network subcohesion, and obtained best possible upper size bounds for all edge-maximal (k, l)-graphs. The best possible lower bounds are obtained in [J. Graph Theory 18 (1994), 227-240]. Let k, l > 0 be integers. A strict digraph D is a (k, l)-digraph if for any subdigraph H of D, the number of vertices of H is at least l, then the arc-strong connectivity of H is at most k-1. An arc-maximal (k, l)-digraph D is one such that for any arc from its complement, the induced digraph by adding this arc to D is not a (k, l)-digraph. We will talk about the relationship between the extremal edge-maximal ((k, l)-graphs and the extremal arc-maximal (k, l)-digraphs. Then we will determine the optimal upper and lower bounds of the sizes of an arc-maximal (k, l)-digraphs.

Authors:

Murong Xu, *University of Scranton*
Hong-Jian Lai, *University of Scranton*
Yingzhi Tian, *University of Scranton*
Liqiong Xu, *University of Scranton*

Chromatic Numbers of Abelian Cayley Graphs

We take a modest first step towards a systematic study of chromatic numbers of Cayley graphs on abelian groups. We lose little when we consider these graphs only when they are connected and of finite degree. As in the work of Heuberger and others, in such cases the graph can be represented by an $m \times r$ integer matrix, where we call m the dimension and r the rank. Adding or subtracting rows produces a graph homomorphism to a graph with a matrix of smaller dimension, thereby giving an upper bound on the chromatic number of the original graph. As an application of this method, we give precise numerical conditions that completely determine the chromatic number in all cases with dimension ≤ 3 or rank ≤ 2. For such a graph without loops, we show that it is 4-colorable if and only if it does not contain a 5-clique, and it is 3-colorable if and only if it contains neither a 5-clique nor a diamond lanyard nor a $C\_13(1,5)$, the latter two of which we define herein. Using these methods, we both recover Payan's theorem on chromatic numbers of cubelike graphs as well as generalize Zhu's theorem on chromatic numbers of 6-valent distance graphs.

Author:

Mike Krebs, *California State University Los Angeles*

Odd Prime Labelings of Graphs

A \textit{prime labeling} of a graph of order n is a well-studied labeling in which the vertices are assigned distinct integers 1 to n such that labels on adjacent vertices are relatively prime. An \textit{odd prime labeling} is a variation of this labeling in which the distinct odd integers 1 to $2n-1$ are used with the same relatively prime condition on adjacent labels. In this talk, we will construct odd prime labelings of many different classes of graphs including disjoint unions of cycles, stacked prisms, and particular types of caterpillars. We will also address a conjecture of whether any graph with a prime labeling also has an odd prime labeling.

Authors:

Norman Fox, *Austin Peay State University*
Holly Carter, *Austin Peay State University*

Public Key Cryptography Using Graph Theory
Cryptography is the science of securely transmitting information through the use of math; the most popular algorithms in the field being AES and RSA. RSA, the most popular public key algorithm, relies on prime number factoring as a way to secure its data. The principle I decided to use is the maximum independent set of a graph, where you must find the largest set of non-adjacent vertices. In this algorithm a very large number of graphs containing information used to decode a message is sent over, one is chosen at random and solved. The solution is used to create a key and a message is sent to the original person who will decode it using brute force from a list of answers they have stored. To test this algorithm, I have tried attacks on the key, the individual graphs, and the first message sent with the decoded graph.
Author:
Nicholas Drain, *California Lutheran University*

"Calculus of Probabilities" by A. A. Markov
In 1900, the prolific Russian mathematician A. A. Markov published the first edition of a book, "Calculus of Probabilities" (Исчисление Вероятностей). We have written what appears to be the first known English translation of this book. The book provides a fascinating look at the state of probability in Russia at that time. We will highlight some of its interesting features and compare them to more modern approaches.
Author:
Alan Levine, *Franklin and Marshall College*

Linear Transformations on Vector Spaces: A New OER Textbook
This is a presentation sharing information about a new OER text for Linear Algebra. This text is built out of the notes written for our students and used over the past several years at Butler University. Distinguishing features are the arrangement of topics, the conversational tone, and the many student explorations built into each section. The text works very naturally for a flipped classroom style course. As for the topics, we begin with a discussion of vector spaces, then introduce linear transformations as the special functions preserving these, and then shift to matrices as a convenient tool to study these functions. We still cover the standard topics, just not in the order many texts use. Lastly, there are unicorns, because they amuse us and the students.
Authors:
Amber Russell, *Butler University*
Scott Kaschner, *Butler University*

Highlights of an Introductory Computational Science Course
Computational Science is the place where Mathematics, Science, and Technology meet. Typically, computers are used to simulate or analyze a complex system or process. It is a rapidly growing field of study that does not really belong to a single discipline. Often a researcher has one specialization and learns about the other areas 'on the fly', potentially increasing the time needed to complete a project. At Clarion University we offer an introductory course on computational science tools to help alleviate this issue. First and second year students learn about the various types of technology available and work through small-scale projects that help prepare them for more advanced research. In this presentation we will outline the structure of such a course and discuss the benefits it has on the mathematics curriculum.
Author:
Daniel Shifflet, *Clarion University of Pennsylvania*

The Promise of Quantum Computing
Can a computer built on quantum mechanics properties carry out calculations faster than the "classical" computers that we are using? A quantum computer is different from a regular computer in so many ways. A classical bit has two states zero and one whereas a quantum bit, or a qubit, has many more possibilities that can be thought of as points on a sphere. For a single qubit, the basic operations correspond to 2x2

unitary matrices, and tensor products are used when working with multiple qubits. IBM provides access to powerful quantum computers for the public with a graphical user interface that makes it easy to use and observe the results. We will explore the basic operations that are used in quantum computing as well as the quantum mechanics properties on which quantum computers are built.

Author:

Azar Khosravani, *Columbia College Chicago*

Network Based Trajectory Analysis and Framework Development of Precalculus Curricula

The core goal of this thesis project is to formalize the complex system that exists naturally in a formal classroom environment. The three factors that are considered in this study are the roles of the student, the roles of the teacher, and the respective environments from which these members arise and how these act as determinants of curriculum development and design. At the curricular scale, educational practices should be treated as a complex system composed of various inherently connected concepts and exchanges of ideas and ways of knowing. This synthesis of previous work and ongoing research efforts employs a network theory mediated analysis to investigate the affordances of curriculum and, in particular, its alignment with student learning processes. Via the utilization of various lenses of network theory, connected curriculum design, and modern learning curve theory, this body of research builds on the fact that education is inherently a complex system at various scales and stages of the learning process. Therefore, the task of a proper educator lies in elucidating these connections and helping students make their own connections (or ways of understanding). A network theoretic perspective of the precalculus curriculum (O'Meara & Vaidya, 2021) proves to be helpful in identifying and motivating key features of the subject as they appear in course texts. Of these, hubs and time-series developments of relevant computed metrics have been particularly useful in mapping the alignment between the preset goals of the precalculus course, as identified in previous literature and execution of taxonomic principles. Moreover, the implications of this work seek to assist in the optimization of the complex system synthesizing various feedback-based designs within educator roles, student response, and the interactions between the two as they pertain to various stages of the curriculum development process. Time-series evolution of network metrics highly relevant to the field of education are generated and considered in conjunction with modern connected learning theory and learning curve theory to assist in the genesis of individualized and equitable student assessment. The results of this study not only provide a deeper understanding of how intended and enacted curriculums interact with each other, but also considers to what extent the components of an andragogical system can be refined via the magnitude of their presence in both course materials and feedback provided directly by active participants in the learning environment. Keywords: network theory, curriculum, creativity, complexity science, connectivity, equity.

Authors:

John O'Meara, *Montclair State University*
Vlad Nita, *Montclair State University*
Ashuwin Vaidya, *Montclair State University*

Critical Lessons from Certification Exam Preparation Materials for Mathematics Teachers' Content Knowledge and Professional Learning

For aspiring mathematics teachers whose education or subject area training is not in mathematics, passing subject area certification examinations can be a major hurdle for entry into teaching. The low passage rates, particularly for alternatively certified teachers, likely result in high usage of preparation materials to prepare for certification exams. In this study, we examined the content of preparation materials available for free or minimal cost (<$10) to aspiring teachers preparing for Florida's Subject Area Exam in 6-12 Mathematics (SAE-Math). Our findings showed a significant gap between the mathematical content development as compared to the benchmarks teachers will be expected to teach and a clear emphasis within the materials on rules and procedures instead of conceptual understanding.

Author:

Sam Vancini, *University of Flordia*

A Generalized Susceptible-Infectious Compartmental Model with Potentially Periodic Behavior

Differential equation compartmental models are invaluable tools used to forecast and analyze disease trajectories. Of these models, the subclass dealing only with susceptible and infectious individuals provides a rare and extremely useful example were solutions have a closed-form, as represented by the logistic equation. However, the logistic equation is limited in its capacity to describe disease trajectories, as its solutions must converge to either the disease-free equilibrium or endemic equilibrium, depending on model parameters. Unfortunately, many diseases undergo periodic cycles, and therefore do not converge to any equilibria. So, to address this limitation, we developed a generalized susceptible-infectious compartmental model capable of describing both periodic and non-periodic disease trajectories. To demonstrate the validity of our approach, we apply the model to predict gonorrhea incidence in the United States, and illustrate how model parameters affect the behavior of the system. The significance of our work is that we provide a novel susceptible-infected compartmental model that has exact and closed-form solutions capable of describing periodic behavior, in addition to the traditional behavior expected by classical theory. Because of this, the work provides disease modellers with a simple means to investigate the potential periodic behavior of many diseases, and thereby aid in ongoing initiatives to curtail recurrent outbreaks.

Authors:
Scott Greenhalgh, *Siena College*
Anna Dumas, *Siena College*

Two Terms with Known Prime Divisors Adding to a Power of 2

Let R be a set of n odd primes. Let N be the number of solutions (X, Y, z) to the equation $X + Y = 2^z$, where XY is divisible by every prime in R and by no other primes. We show $N \le 2^{n-2} + 1$, improving previous bounds obtained using known results on S-unit equations. When $n < 66$, we improve this to $N \le 2^{n-2}$, making the bound on N precise when $n \le 3$.

Authors:
Robert Styer, *Villanova University*
Reese Scott, *Villanova University*

The Spoof on Perfect Numbers

A perfect number is a positive integer that is equal to the sum of its proper divisors. Even perfect numbers were completely categorized by Euclid-Euler Theorem, in which searching for even perfect numbers resolves itself in finding Mersenne primes. The existence of an odd perfect number still remains as one of the oldest unsolved problems in number theory. In the late 20th century, mathematicians took a different approach by exploring odd spoof numbers that could be useful in understanding the structure of odd perfect numbers. In this talk, we will describe what spoof numbers are, and how they compare to perfect numbers.

Author:
Catherine McClure, *Molloy College*

The Evolution of Cryptology

We will first present the necessary Number Theory for understanding the backbones of every cryptosystem, which include modular arithmetic and composite factorizations. Starting with simpler introductory methods, I will build up to Public Key and Elliptic Curve Cryptography, and along the way will compare each encryption method's security level to discuss just how reliable these methods are. How does technology fit into this picture? Is it possible that there will come a time that these methods are made obsolete by either some efficient solution to the RSA problem or some leap in computational ability? How might cryptographers respond to such a development?

Author:
Justin Morelli, *Molloy College*

Some Results on $\tau(n)$-factorizations

The theory of $\tau_{(n)}$-factorizations was introduced by Anderson and Frazier in 2006, but their results were not published until 2013; as an example in the theory of generalized factorizations. The idea of a $\tau_{(n)}$-factorization or $\tau_{(n)}$-product is a product of nonzero nonunit integers that are related modulo n. This definition does not preserve the algebraic structures of the integers. This presentation will give a flavor through examples and some results of several algebraic, graph and number theory concepts.

Author:

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

Does the Choice of Preferential Voting Method Matter? An Empirical Study Using Ranked Choice Elections in the United States

In an election that uses preference ballots, there are many different voting methods that can be used to choose the winner of the election. We analyze the extent to which the choice of voting method matters in American ranked choice elections. We compiled a database of over 200 American elections which used preference ballots and, for each election, calculated the winner under the methods of plurality, instant runoff voting, plurality runoff, Condorcet, Bucklin voting, and two versions of Borda count. We find that the choice of voting method matters less frequently than what is suggested by much of the theoretical literature.

Authors:

Lori McCune, *Missouri Western State University*
David McCune, *William Jewell College*

An Inverse Source Problem with Integral Constraint

We consider an inverse time-dependent source problem for a parabolic partial differential equation with Neumann boundary conditions and subject to an integral constraint in a domain of $\mathbb{R}^n$, $n\ge 1$. We show well-posedness and regularity of solutions in H\"{o}lder spaces. We then develop an algorithm that we employed to approximate solutions of the inverse problem using a finite element discretization in space and the backward Euler scheme in time. Due to instability in the reconstruction, Tikhonov regularization is applied. The errors resulting from our experiments show that the proposed scheme is an accurate approach to approximate solutions of this inverse problem.

Author:

Sedar Ngoma, *State University of New York, Geneseo*

Analyzing the Determinants of Covid Spread in Pennsylvania

This research is a correlational study on the determinants of COVID-19 infection spread in Pennsylvania. Data were collected at the zip code level and analyzed using multiple linear regression. The relationships between Covid infection rate and variables such as population, vaccination rate, population density, and proximity to schools were analyzed. The strongest relationship was found to exist between population density and infection rate. We also examine the relationship between both recent and lagged vaccination rates and infection rate.

Authors:

Maria Ramunno, *Neumann University*
Ryan Savitz, *Neumann University*

Quiver Representations: Expolorations with Undergraduates

Directed graphs, often called quivers, have many useful applications ranging from mapping traffic patterns to determining what will show up on ones social media feed. By giving quivers additional structure, and assigning to each vertex a vector space, and to each arrow a matrix, quivers have also provided us with powerful tools to use in representation theory. They also provide an accessible topic for undergraduate research. In particular, students who have taken a linear algebra course alone can begin exploration in this

area and prove results which usually require much more powerful machinery. Previous students have proven part of Gabriel's theorem, an important result in the classification of quiver algebras. This presentation will briefly introduce the topic and highlight the results achieved by the student researchers. This includes an exploration using rank of matrices and another using row and column operations to simultaneously change bases for multiple vector spaces to more easily break down a quiver representation.

Author:

Dan Wackwitz, *University of Wisconsin - Platteville*

Problem and Research Presentations in Senior Capstone

A Senior Capstone course is a culmination of what students have learned over their academic career. Within that, students can demonstrate both what they have previously learned and how they can use that knowledge to delve into a topic new to them. This presentation gives an overview of how student presentations of both of these types are incorporated into a Capstone course.

Author:

Nicole Panza, *Francis Marion University*

Differential Calculus: From Practice to Theory

The authors will present a draft of their open resource book with that same title. This represents not only a new book but a new way of approaching the first semester calculus course. Instead of starting with the theoretical aspects (limits, continuity, etc.), the authors propose that a more historically accurate approach focusing on using differential calculus as a problem solving tool before delving into the theory is actually more pedagogically sound. This is more than just rearranging the order of topics. The authors contend that students will be better served by learning and applying the rules for differential calculus (rules for differences) as opposed to derivative calculus initially. This is consistent with the general approach, as the notion of a derivative was created over 100 years after the invention of differential calculus to address foundational issues caused by infinitesimal differences. Samples from the book will be presented along with a link for a draft of the book.

Authors:

Robert Rogers, *State University of New York at Fredonia*

Eugene Boman, *The Pennsylvania State University, Harrisburg Campus*

Alternative Assessments in Calculus 1: Stepping Away from Exams

The pandemic forced many to reevaluate their teaching styles and assessments. This poster will focus on the assessment component for Calculus 1. It will delve into the transition from standard exams to alternative assessments. In particular, projects which rely on creativity and critical thinking skills will be explored, along with a couple grading schemes. Exam-like components for the course will also be addressed.

Author:

Liz Lane-Harvard, *University of Central Oklahoma*

Remediation and Enrichment through Labs

Saddled by low prerequisite requirements, many STEM-tracked students are entering Calculus 1 and Precalculus-Algebra underprepared. In order to combat these learning gaps, exacerbated by the pandemic, the University of Central Oklahoma's Department of Mathematics and Statistics implemented mandatory drills to support Precalculus-Algebra and Calculus 1 students. This poster will discuss the structure of the drills along with their long-term goals.

Authors:

Britney Hopkins, *University of Central Oklahoma*

Liz Lane-Harvard, *University of Central Oklahoma*

Calculus Instruction for a Blind Student

This poster will describe challenges encountered in teaching calculus to a blind student, assistance provided by Disability Services, successful assessment strategies, a flexible approach to course content, and innovations that have transferred forward to subsequent semesters.

Authors:

Michael Kerckhove, *University of Richmond*

Emily Helft, *Landmark College Institute for Research and Training*

Lily Dickson, *University of Richmond*

Dual Purpose Homework Assignments: Practice and Enlightenment

We will explore how a reflection assignment was implemented as part of homework assignments in Calculus I and II classes. We will discuss how the assignments not only helped the students to understand the material but also helped them become more self-aware of their learning profile.

Author:

Jennifer Gorman, *Lake Superior State University*

Using Systematic Variation to Support Student Writing of Explanations and Justifications in Calculus

Most mathematics instructors are familiar with the experience of assigning a task or an assessment item that asks students to explain or to justify their result, only to be faced with the challenge of navigating poorly organized or painfully opaque written work. In this session we share the results of our initial efforts across several semesters to design activities, guided by principles of Variation Theory, to support students in Calculus and in Introduction to Abstract Mathematics in conceptualizing qualities of effective explanation and effective justification as genres of mathematical writing. The core principle of Variation Theory is to strategically control variation and invariance across examples and nonexamples of a concept to bring into focus critical features that distinguish examples from nonexamples. We constructed sets of contrasting examples intended to draw attention to how effective explanations and justifications employ narrative, personalized, descriptive text to support clarity and to communicate the writer's knowledge, even in situations where a solutions or argument is only partially complete. Our systematic qualitative analysis of students' responses indicate that our activities were effective at bringing some critical features into focus, though the influences of students' prior experiences with timed examinations and other traditional assessment practices created barriers to their adopting features of effective writing into their own explanations or justification.

Authors:

Duane Graysay, *Syracuse University*

Brian Odiwuor, *Syracuse University*

Hillary Bermudez, *Syracuse University*

Discussing Classroom Culture: A Better Use of Syllabus Day

We all know that syllabus day isn't effective. Instead, I use the first day to have a class discussion of cultural characteristics that influence students as they step into a mathematics classroom that they likely have never named and thought about explicitly. We discuss individualism, perfectionism, and a focus on quantity over quality. These traits prevent students from getting help when they need it and can lead to anxiety and other the negative feelings about mathematics. Here, I will share my experiences leading this discussion as well as feedback from students suggesting this is a way to increase students' sense of belonging, help them change behavior to address anxiety, and build more positive feelings about our class.

Author:

Erin Griesenauer, *Eckerd College*

The Beautility of Math

With support from Great River Learning, we've developed a new interactive digital textbook, along with curricular resources, for a Mathematical Reasoning course, a service course for liberal arts majors. Each of the 30 lessons begins with an essay about how mathematics is both beautiful and useful, given the lesson's applications. The textbook has three units: NUMBER, SHAPE, and DECISION. Each lesson has embedded homework problems designed to encouraging critical thinking, reinforcing and integrating the material across lessons. The implementation of this textbook in a lower level mathematics course for non-mathematics majors, which unavoidably risks being insufficiently difficult, saw significant increases in student evaluation scores for the category, "challenged to learn something new." This poster will showcase the textbook's lessons, illustrate student class work, and summarize improvement data.

Authors:

Jonathan Clark, *University of Tennessee, Knoxville*

Jeneva Clark, *University of Tennessee, Knoxville*

A Look at Materials from the Building College Level Number Sense Project

Our experiences teaching first year college math suggest that many students need more experience with college level number sense: topics that are introduced in middle school, but which need to be used at a high level for college and careers. For example, students who can easily do a middle school problem involving multiplication and division are sometimes stumped when the numbers are "difficult": decimals, scientific notation, numbers expressed in different formats, such as 4.73 million. Cognition research in the 1980s-90s (Harel & Confrey, 1994) established that a key mathematical issue for many struggling students is often proportional reasoning: a complex of ideas involving multiple meanings and methods for multiplication and division, fractions, place value and decimals, measurement, ratios, proportions, and percent. Measurement, especially understanding quantities and units, is foundational for success in both math and science courses. (Dougherty and Simon, 2014) Mental calculation, especially with approximate numbers, is a neglected but important skill. Advanced Number Sense is an online course housed at the free site MyOpenMath.com that provides an alternative to traditional developmental resources. Our materials (i) can be used completely online: problems are randomized and automatically graded (ii) are at an advanced, adult level and check for conceptual understanding (iii) include topics sometimes omitted from math textbooks: concepts of measurement and units, including dimensional analysis, as well as estimation and mental math. Each of the ten modules includes a pre-test, video, text that includes examples with solutions, practice problems and a post-test. Live demonstrations will be available at the session. References Dougherty B., Simon M. (2014) Elkonin and Davydov Curriculum in Mathematics Education. In: Lerman S. (eds) Encyclopedia of Mathematics Education. Springer, Dordrecht. https://doi.org/10.1007/978-94-007-4978-8_56 Harel, G., & Confrey, J. (Eds.). (1994). The Development of Multiplicative Reasoning in the Learning of Mathematics. Albany, NY: State University of New York Press.

Authors:

Susan Addington, *California State University San Bernardino*

Mary Legner, *Riverside City College*

Kelli Wasserman, *California State University San Bernardino*

"Mathematics for Human Flourishing" as a Freshman Seminar

Exploration of hands-on mathematical experiences for a Freshman seminar class using "Mathematics for Human Flourishing".

Author:

Kristen Schemmerhorn, *Concordia University Chicago*

Modeling of Phase Coexistence via Thermodynamic Potentials

"Thermodynamic potentials can be used to study various phase phenomena. They can be used to determine the phase coexistence of a liquid and vapor for a simple van der Waals fluid, which relates the interactions

and size of particles (molecules/atoms) represented by spheres as simple constants a and b, respectively. Phase coexistence at a given temperature for a simple fluid is determined using Newton's method, thermodynamic potentials, and the conditions of phase coexistence. From this information, we can construct a phase diagram of the vapor and liquid densities versus the temperature. The constructed phase diagram shows how the simple van der Waals fluid predicts the occurrence of a critical point (point at which the fluid is no longer simply characterized as a gas or liquid but rather a liquid and gaseous fluid or critical fluid) as opposed to the ideal gas law. This phase diagram can then be further used to study homogeneous (a pure solution or solution containing a single molecule/atoms) and inhomogeneous (mixture or solution containing multiple molecules/atoms or a substrate/wall) nucleation by classical density functional theory in statistical mechanics. 1. B. C. Husowitz, Modeling of Phase Coexistence via Thermodynamic Potentials, Computing in Science & Engineering, vol. 24, no. 1, pp. 72-77, 1 Jan.-Feb. 2022, doi: 10.1109/MCSE.2022.3145921."

Author:
Barry Husowitz, *Wentworth Institute of Technology*

Anomaly Edge Detection in Liquefaction Susceptibility Maps

"This paper described liquefaction and liquefaction susceptibility maps in detail, as well as the fundamentals of raster data as part of a geographic information system and proposes an automatic anomaly edge detection problem on liquefaction susceptibility maps, among other things. The project's goal is to build a tool that, when given a liquefaction susceptibility map in raster format, automatically detects edges and determines whether there are line segments (formed by the edges) in either a vertical or horizontal fashion that could indicate sharp changes in the raster values that cannot be explained by the underlaying geography, and then reports these findings.

Authors:
Semere Gebresilasie, *Wentworth Institute of Technology*
Yihao Li, *Wentworth Institute of Technology*

The Effect of Spaced Recall in the Precalculus Classroom

The retention of fundamental mathematical skills is imperative in order to provide a foundation on which to build new mathematics skills. It has often been observed at the end of an academic year that students did not retain the math skills they learned at the beginning of the year. Educators and cognitive scientists have explored teaching methods, including spaced recall, that may produce learning that endures over time. In a Precalculus course, we used spaced recall in the form of quizzing to determine if this method would improve students' long-term retention in a classroom setting. The goal was to identify an effective classroom strategy that led to student recall of fundamental math concepts through the end of the academic year. The concepts that were considered for the target of long- term retention were 12 concepts identified by the United States Military Academy math department as being fundamental concepts for entering cadets. These 12 fundamental math concepts are taught in quarter one of the Precalculus with Introduction to Calculus course at the United States Military Academy Preparatory School. There exists an expectation that students will be able to remember those fundamental concepts when they are assessed on the post-test exam six months later. Our research suggests that spaced recall in the form of quizzing had a statistically significant positive impact on the retention of the fundamental concepts resulting in higher performance scores on the post-test, and yet these quizzes did not adversely impact performance on current instructional concepts.

Authors:
Diane Lindquist, *United States Military Academy Preparatory School (USMAPS)*
Brenda Sparrow, *United States Military Academy Preparatory School (USMAPS)*
Joseph Lindquist, *United States Military Academy (USMA)*

To Test or Not to Test – How Much of an Impact do Final Exams Have on Final Course Grades?

"As both the overall number of cadets enrolled at the U.S. Coast Guard Academy and the number of Operations Research & Computer Analysis majors has increased over the past few years, the Department of Mathematics faculty's workload has grown. Without the ability to hire additional faculty we've had to reconsider how we teach many courses, including whether to revisit our department's policy of not allowing exemptions from final exams and whether to even administer final exams. There are several reasons for administering a comprehensive final exam at the end of a course, chief among them so students review the course material one last time (thereby increasing retention) and to give students one last opportunity to demonstrate they've mastered the course material…or from the students' perspective, one last opportunity to improve their course average/grade. Either way a final exam is a lot of work for both students (studying) or faculty (writing the exam, helping students prepare for the exam, and grading the exam), but is all that extra work worth it? For years I've noticed that most of my students do about as well on our final exam as their pre-final course average, meaning there was no difference between their pre-final and final course grades. In this study I formally compare two decade's worth of my Differential Equations students' pre-final course averages, final exam scores, and post-final course averages to see how impactful taking the final exam was on their final course grades."

Author:
Eric Johnson, *U.S. Coast Guard Academy*

Conceptual Understanding of Profit, Revenue & Cost in Applied Calculus

Applied Calculus students, who are comprised solely of business majors at our institution, are exposed to in-depth practice with profit, revenue and cost application problems during this course so that they can build a firm foundation on the concept prior to moving on to a managerial economics course where they will be expected to do further analysis on these types of problems. For this study, 28 groups of two to three students each were given a set of problems with two underlying threads: understanding the basic relationship between profit, cost, and revenue, including writing that association as a functional relationship; and, applying that relationship to a real-life math application, utilizing derivative rules. Student work groups recorded their solution process in the Explain Everything app, including their conversation; these recordings were analyzed for problem-solving patterns.

Authors:
Debbie Gochenaur, *Shippensburg University*
Riana Peters, *Shippensburg University*

Integration by Guessing

We illustrate "Integration by Guessing": Guess, differentiate to check the guess, and then adjust to get an exact fit. It is a simple and powerful methodology, useful in many situations. The adjustments are of two kinds: 1. If the guess is off by a factor, divide by the factor. 2. If the derivative of the guess has an extra term, then subtract the integral of the term from the guess (One use is integration by parts). Standard integration techniques, substitution and Integration by Parts, begin with a hidden guess. Recognizing the role of hidden guesses leads to shortcuts that simplify your work, avoiding tedious, distracting calculations.

Author:
Fred Halpern, *Royal Path to Math*

Temet Nosce: Reflections on Mathematical Autobiographies in a General Education Course

Often, students who are looking to "check the box" for their required general education mathematics course have a less-than-affectionate relationship with the topic. Furthermore, with the wrong culminating experience, this relationship can be worsened and turn the student away from math for good. Using the tenet of "Know Thyself," I employ the use of mathematical autobiographies to help students reflect on their own biases coming into the course and, after the duration of the semester, if and how their relationship with mathematics has changed. In addition, students are encouraged to present their autobiographies in whatever medium is most comfortable for them, allowing (for many) creativity to permeate through fear. This talk

will reflect on three semesters of this project and some of the most influential student autobiographies and metamorphoses.

Author:

Colton Sawyer, *Southern New Hampshire University*

Outer Billiard Visualization Algorithms

We study the singularity structure of outer billiards (or dual billiards) on regular polygons, which often gives rise to intricate and beautiful fractal structures. Although this is not a new topic, little (if any) research exists on the efficiency of calculation and visualization of this structure. First, we present a baseline algorithm, primarily for comparison. Then, by leveraging key properties of the outer billiards transformation, several major improvements are made to this algorithm. Compared to the baseline, the improved algorithms run faster, use less memory, and generate higher resolution images. In addition to being beautiful in its own right, this research should help others in the field of polygonal outer billiards by allowing for quick visualization and experimentation.

Authors:

David Brock, *Dallas College*
Byungik Kahng, *University of North Texas at Dallas*

NFTrig

Non-Fungible Tokens are used as a way of verifying and transferring ownership of digital property. Our project seeks to utilize NFT technology in fostering mathematics education via a collectible digital card game of trigonometric functions. Users can collect functions and create new functions by combining two cards together. Cards will display the name of the function, an animated graph of the function, as well as facts such as identities, derivatives, integrals, and Taylor series.

Authors:

Andrew Sward, *Augustana College*
Jordan Thompson, *Augustana College*
Trung Pham, *Augustana College*
Kidus Olana, *Augustana College*

On the Parametric Geometry of Inverse Exponents

Exponents are a straightforward operation (⟦number⟧^exponent). Roots have an alternate script and symbol. Given we know the (3^3=27), we also recognize ($\sqrt[3]{27}$=3). But not so often used is the written exponent for ($\sqrt[3]{27}$); (27^(1/3)=3). There are three elements in the parametric geometry of roots: index; radical; and radicand. √(index&radicand) . We never include the index when writing square roots. Why? Don't know! Anyway, the unused term for square root of 4 is: (√(2&4)=2). Or (4^(1/2)). We also have seldom seen exponents. (n^0=1); (n^1=n) Setting these exponents (0 and 1) as radical index: (√(1&n))=n, and (√(0&n))=(1/0 indeterminate infinity encountered). This paper uses a GeoGebra parametric machine to find the (√(0&n)), losing the (indeterminate infinity encountered) tag.

Author:

Alenxander Garron, *Sandbox Geometry LLC*

Actions of Clifford gates on four, five, and six qubits

The study of Clifford gates is of interest to mathematicians, physicists, and anyone interested in quantum computing. We define the group of Clifford matrices over n qubits; this group consists of a number of 2^n by 2^n matrices, which act on vectors in $C^{(2^n)}$. The action of these matrices on these vectors has many surprising properties. We examine these properties and describe the action of the matrices for n = 4, 5, 6 using graphs, which become progressively more complicated and yet richer as n increases.

Author:

Frederic Latour

Outreach Poster Session
Thursday, August 4, 9:00 a.m. - 10:20 a.m., Franklin Hall A

All community members involved in outreach activities are welcome to present a poster on those activities. These outreach activities can be camps for middle school children, seminars or symposia for undergraduate women, Sonia Kovalevski Days, etc. We want to hear about the good work you are doing encouraging diversity and inclusion in mathematics.

Organizers:
Rachelle Decoste, *Wheaton College*
Candice Price, *Smith College*
Nancy Neudauer, *Pacific University*

GirlsGetMath@Stonehill: Empowering and mentoring high school students
GirlsGetMath@Stonehill is a five-day, non-residential program hosted by Stonehill College. This initiative is a replica of ICERM's GirlsGetMath program, created to give high school students a glimpse of high-level mathematics while showcasing the many exciting opportunities and careers available in STEM. We provide students with a female empowering environment and facilitate connections with other students with similar interests in order to build a peer support system. Students explore a variety of topics such as cryptography, data science, recommendation systems, probability, and topology through hands-on activities, interactive lectures, and daily computer labs. Besides learning about different fields of mathematics, participants tour science labs and interact with faculty and students working on research projects and observe first-hand how other fields use mathematics on a daily basis.
Author:
Leyda Almodóvar Velázquez, *Stonehill College*

Incorporating Math Circle Activities into Course-Based Undergraduate Research Experiences (CUREs) in Statistics
This project weaves together Course-Based Undergraduate Research Experiences (CUREs) with my interests in math circles and other similar outreach activities, within the context of an undergraduate Introduction to Statistical Methods course. The open-ended and collaborative nature of math circle problems engages students in mathematical exploration without the intimidation often associated with research. Adams State University has recently been awarded an NSF Hispanic Serving Institution STEM grant aimed at investigating the effects of livestock grazing within mountain habitats near our institution. Many of our students have deep roots in the area, making this place-based study more immediately engaging to them. Through this grant, CUREs are offered to general education students in biology, chemistry, geosciences, and mathematics, giving them the opportunity to be a part of scientific research in the first two years of their college experience. CUREs and Math Circles have in common the aim of richer student engagement, and my goal with the statistics CURE is to bridge these objectives, increasing STEM retention and making better investigators. Involving students of all ages in fun math problems which encourage them to think creatively without the onus of finding the `right' answer can increase both interest in mathematics and also confidence in one's ability to solve problems. Such interactions show students new and often less contrived instances of the utility of mathematics. In this poster, I describe the details of the Introduction to Statistics CURE at my university and a few math circle problems I adapted for that course with the goal of fostering curiosity and play, both in this course and in others. In particular, we examined lyrics to Beyoncé songs to fingerprint their authorship. We played with mark and recapture examples to more carefully study abundance and biodiversity, with data the students themselves had collected in their biology courses. These examples provide lively introductions to the power of statistics and also show them that the various courses

in their curriculum have a common thread. With greater freedom to play and explore, students feel more engaged and sold on the notion of science being fun rather than merely instrumental and utilitarian.

Author:

Meredith Anderson, *Adams State University*

Girls Talk Math at Worcester Polytechnic Institute

"Girls Talk Math (GTM) is a FREE 2-week day camp for girls and nonbinary rising 9th-12th grade students. Founded in 2016 at the University of North Carolina at Chapel Hill, GTM has been running at UNC for seven years and at the University of Maryland, College Park for five years. In 2022, a third chapter launched at Worcester Polytechnic Institute (WPI) in Massachusetts thanks to funding from the Mathematical Association of America Tensor Women and Mathematics grant and the local Women's Impact Network grant. Campers work in groups to complete challenging problem sets and research the life of a mathematician or scientists from an underrepresented group in STEM. The camp curriculum is developed by undergraduate and graduate student volunteers within an inquiry-based learning framework. Problem sets cover topics in theoretical and applied mathematics and are available to download on GitHub (at https://github.com/girls-talk-math). During camp, each group of students writes a blog post focused on the math topic they learned and writes and records a podcast about the assigned mathematician or scientist. All camper-produced media is available at https://girlstalkmath.com, on iTunes, and SoundCloud. GTM has been volunteer-led since its inception but thanks to increased availability of funding, this summer at WPI for the first time undergraduate and graduate students camp staff were paid for their time. Paid positions included team leaders working directly with campers, a curriculum coordinator, and an operations manager to help plan camp logistics. Additionally, campers will receive a stipend for attending camp along with free daily lunches and snacks. This is meant to help recruit students who would normally work during the summer to help alleviate the burden of committing two weeks of their time to the GTM program."

Author:

Francesca Bernardi, *Worcester Polytechnic Institute*

PRIME: The People Reaching Intuition in Mathematics for Empowerment Program

Youngstown State University (YSU) is located in downtown Youngstown Ohio, a minority majority city with a combined Black and Hispanic population of over 51%. However, the YSU domestic student body is less than 15% non-white. In the College of Science, Technology, Engineering, and Mathematics, diversity is an even bigger problem, with only 10% non-white students. Even worse, the six-year graduation rate of Black students at YSU is 11%. In most of the surrounding Youngstown City high schools, students graduate without the background necessary to succeed in college, and one of the main impediments to success is their lack of mathematical preparation. The People Reaching Intuition in Mathematics for Empowerment Program (PRIME) is an after-school program with the goals to inspire high school students from Youngstown City Schools to pursue education after high school in STEM areas and to give them the confidence, enjoyment, and tools to be able to fulfill the mathematics requirements to get that degree. A successful first run of PRIME was completed during the 2021-2022 academic year, funded by an MAA Tensor-SUMMA grant. This first cohort consisted of twelve East High School 10th-graders, aided by five YSU student mentors and the program directors. The poster presentation will discuss the successes and challenges of our inaugural run, as well as plans for the next session.

Authors:

Alexis Byers, *Youngstown State University*
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Charles Stark, *Youngstown City School Disctrict*

STEM Model-Eliciting Activities for Middle School Students

We present two social justice mathematical modeling activities that Towson University undergraduate students (pre-service teachers) conducted in enrichment sessions with middle school students, supported by the Dolciani Mathematics Enrichment Grant in 2021-22. These activities use mathematical modeling to help students describe impacts of bias and injustice on the world, historically and at present. The first activity explores the misrepresentation that is inherent in map-making, with two-dimensional representations of a 3-D earth. Participants were asked to compare relative sizes of countries' two map projections: the 1569 Mercator and the 2021 TrueSize projections. The second activity explores food deserts, geographic areas where residents have limited access to affordable, healthy food options. Participants used the coding language Scratch to create a program that models residents' travel to grocery stores. The mathematical content involved in these activities include geometry and proportional reasoning.

Authors:

Diana Cheng, *Towson University*
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UT-PLAYS Math

Math teacher shortages are persistent nation-wide, and this shortage is not helped by the difficulty that many prospective math teachers have when attempting to pass the required PRAXIS or NES math licensure exams. In Tennessee, pass rates for these exams are among the lowest for required teacher licensure exams, across all content areas. In this poster, The University of Tennessee, Knoxville shares a grant-funded program called UT-PLAYS Math (Personalized Learning At Your Speed), which aims to address the teacher shortage problem in a creative way. The program's goal is to endorse teachers throughout the state with additional mathematics licenses, including experienced teachers who may have never taught math before. This outreach project is designed to be available and accessible to all interested PK-12 teachers. Our online asynchronous program uses the Microcredential model to prepare teachers for engaging students in mathematics classroom settings, building their pedagogical content knowledge in mathematics, and passing either a PRAXIS or NES math licensure exam. This poster will showcase our program design, highlight our test review tools, and share lessons learned for the first year of operating this outreach program.

Authors:

Jonathan Clark, *The University of Tennessee, Knoxville*
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STEM-CARE (STEM Community for Anti-Racist Education)

STEM-CARE (STEM Community for Anti-Racist Education) is a community of STEM educators at the University of Wisconsin - La Crosse that work with an anti-racist education framework. This framework was inspired by the toolkit, A Pathway to Equitable Math Instruction which is a resource designed to support Black, LatinX, and Multilingual students in mathematics classes in grades 6-8 and was also used in the development of the new mathematics curriculum framework in California. The resources and guidance from this toolkit were modified to be incorporated in all college-level STEM disciplines bringing awareness to anti-racist teaching practices.

Author:

Whitney George, *University of Wisconsin - La Crosse*

JRMF Community Math Circle - A Training Ground for Math Outreach Leaders

The JRMF Community Math Circle is a continuation of the Julia Robinson Math Festival (JRMF) Webinars that ran for 20 months starting in March 2020. A diverse community of math educators facilitated breakout sessions for the JRMF Math Webinars, and a team of 13 of us now organize the JRMF Community Math Circle, working cooperatively with the JRMF team. Our math circle offers students of all ages the opportunity to explore the newest JRMF activities and apps or revisit old favorites. The small-group

breakout rooms create a welcoming environment for students of varying skill levels and backgrounds to explore mathematics through puzzles, games, and hands-on activities. Facilitator trainings are held prior to each event, to provide math educators the opportunity to practice and explore the activity under the guidance of experienced activity coaches. We encourage math educators to use these activities in their classrooms and to start outreach programs of their own.

Authors:

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MAGPIES: Math & Girls + Inspiration = Success, Lessons Learned and Plans for the Future

We report on two years of running MAGPIES: Math & Girls + Inspiration = Success, a virtual math circle for middle school girls. MAGPIES monthly events are facilitated collaboratively by Bard College students and a diverse group of math educators, resulting in an impactful experience for all involved. The breakout rooms create a safe space and a collaborative environment for young girls to explore mathematics through puzzles, games, and hands-on activities. We encourage math educators and outreach leaders to start MAGPIES chapters in their own communities.

Authors:

Lauren Rose, *Bard College*
Felicia Flores, *Bard College*
Kariane Calta, *Vassar College*

Dixie Tensor Scholar Program 2022

Through the MAA Tensor Grant for Women in Mathematics, we developed the Dixie Tensor Scholar program (DTSP) to provide our undergraduate students and students from local high schools with activities aimed at connecting women STEM majors, high school girls, and successful women STEM professionals to exchange ideas through a year-long mentoring program. Also, we organize a one day workshop - Maryam Day for parents and female students from local high schools by increasing awareness of career options, demonstrating the benefits of studying mathematics by providing them with an environment to exchange ideas, strengthen problem-solving skills, and advance their intellectual confidence. In our presentation, we will share our experiences and the success of our DTSP program.

Authors:

Bhuvaneswari Sambandham, *Dixie State University*
Vinodh Chellamuthu, *Dixie State University*
Jie Liu, *Dixie State University*
Clare Banks, *Dixie State University*

Broadening Participation of Underrepresented Minority STEM Faculty in the Professoriate

This AGEP Alliance model provides faculty professional development and career preparation to minority STEM doctoral candidates. To increase the numbers of historically underrepresented faculty in STEM, the target audience is instructors at Historically Black Colleges and Universities (HBCUs) that are in the dissertation stage of their PhD degree. The Alliance's HBCU Instructors Bridge to Academia Program (HI Bridge) consists of research seminars, research advising, faculty mentoring, research presentations, peer collaboration, networking, and alumni follow-up meetings. These activities are designed to support the candidates in completing their PhDs and prepare them for success in their faculty careers. Our work is also designed to identify factors that influence attrition rates of the target audience. We will be presenting the organizational structure of the Alliance team and the progress that has been made with the first cohort of participants.

Authors:
Jana Talley, *Jackson State University*
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Grace Ndip, *Virginia State University*
Willie Rockward, *Morgan State University*
Jeremey Ernst, *Emory Riddle Aeronautical University*

Poster Session for Projects Supported by the NSF Division of Undergraduate Education
Thursday, August 4, 9:00 a.m. - 10:20 a.m., Franklin Hall A

This session will feature principal investigators (PIs) presenting progress and outcomes from various NSF funded projects in the Division of Undergraduate Education. The poster session format will permit ample opportunity for attendees to engage in small group discussions with the PIs and to network with each other.

Organizer:
Doug Ensley, *Shippensburg University*

Advancing Students' Proof Practices in Mathematics through Inquiry, Reinvention, and Engagement
In recent years there has been growing interest in mathematics instruction that actively engages students. There is also extensive literature demonstrating the struggles that students can have in transitioning to advanced mathematics. The ASPIRE in Math project (DUE #1916490) is working to address these needs by creating inquiry-oriented curricular and instructor support materials that aim to 1) support students in transitioning to advanced mathematics and 2) support instructors in transitioning to inquiry-oriented instruction. In this poster, we present the project's current progress on our deliverables. In particular, for each deliverable we 1) provide a description and example(s) that outline its goal and current form; 2) discuss our process for its design and redesign, particularly highlighting the iterative process of the design research methodology we used; and 3) present reflections on the deliverables from students and/or instructors who have participated in a course that implemented our materials. These reflections are used to highlight both how they informed redesigns of our material and the impact our materials have had on students' and instructors' perceptions of inquiry-oriented learning and teaching. Lastly, we hope our poster will serve as an introduction and invitation for any mathematics faculty who are interested in active learning, especially in the context of introductory proof courses.
Authors:
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ASPIRE in Math Project Team

S-STEM: Building Foundations for Success
The S-STEM program at Calvin is aimed at improving retention in STEM via scholarships to cover a critical funding gap, an implementation of classroom interventions and co-curricular supports, and a leveraging of existing university supports including the Calvin LifeWork program and research and internship opportunities. Each year a scholarship cohort of 15 students participate in an extended first-year seminar and benefit from proactive advising and mentoring. They are assigned to special sections of introductory

courses in computer science, chemistry, and mathematics. This is an overview of the program at Calvin including lessons learned during the first three years.

Authors:

Mike Bolt, *Calvin University*

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Herb Fynewever, *Calvin University*

Arlene Hoogewerf, *Hoogewerf*

Vic Norman, *Hoogewerf*

An NSF S-STEM Grant Supporting Community College Transfer Students

The NSF S-STEM program seeks to grow the science capacity of United States citizens by providing scholarships for students majoring in STEM disciplines. The S-STEM program supports students with scholarship money and provides money to allow institutions to implement and study curricular and co-curricular experiences that impact student success. This poster will describe the four types of S-STEM grants and the authors' experience with a $4 million track 3 S-STEM grant, Clear Path. Clear Path provides support to students transferring from a community college to East Stroudsburg University (ESU) and majoring in a STEM discipline. Students at our partner community colleges, were supported in their final year at the community college. In addition to providing scholarships to low-income students, Clear Path strives to increase targeted developmental mechanisms including professional future sense of self, academic self-efficacy, and academic-related help-seeking behaviors through enriched academic advising, peer mentoring, and cohort building activities, including success seminars. Clear Path also includes tutoring in upper-level science classes. Over the last six years, Clear Path has supported 125 scholars, 89 of whom have graduated from ESU with a STEM degree (11 more still progressing). The Clear Path scholars have received $2,608,739.50 in scholarship funds.

Authors:

Olivia Carducci, *East Stroudsburg University*

Michelle Jones-Wilson, *East Stroudsburg University*

Bonnie Green, *East Stroudsburg University*

Teamwork in Tennessee: A SUMMIT-P Project to Enhance Introductory Mathematics Courses

As Tennessee's flagship research institution serving over 30,000 students, UTK joined SUMMIT-P, the National Consortium for Synergistic Undergraduate Mathematics via Multi-institutional Interdisciplinary Teaching Partnerships (DUE-1822451) to collaboratively revise and improve the curriculum for lower division undergraduate mathematics courses. In particular, on the UTK campus, the Phase I project team includes faculty from Mathematics, Anthropology, and Geography. This presentation will share results and products from (1) an improved existing Mathematical Reasoning course, (2) a newly developed Data Science course, (3) a newly developed Data Science minor for undergraduates, and (4) a newly developed interdisciplinary faculty learning community. In Phase II, pending support, we aim to further broaden STEM literacy at UTK by (1) improving new Data Science courses within the Data Science minor, (2) continuing to improve an existing Mathematical Reasoning course, (3) improving the anthropology course, "Big-data Social Sciences," and (4) creating a calculus sequence that better serves engineering students.

Authors:

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Leaders Emerging and Pursuing STEM (LEAPS) an S-STEM Grant at Saint Peter's University

Leaders Emerging and Pursuing STEM (LEAPS) is a track 1 NSF S-STEM grant that will support three cohorts of ten high-achieving, low-income, STEM students while they are students at Saint Peter's

University. LEAPS consists of a suite of student support systems designed to provide scholarships, improve student retention in the STEM majors, and increase successful STEM career or graduation school placement. LEAPS scholars are part of an on-campus community and have the opportunity to build a strong learning cohort with other LEAPS scholars. The workshops, team building activities, and seminars prepare students for graduate school or a STEM profession. The annual scholarships remove an identified barrier by helping make college more affordable. The first cohort of ten LEAPS students have successfully completed their first year. Students have engaged in career preparation, study-skills workshops, team-building activities, research, and mentoring. This summer, we will welcome our second cohort of ten more students into the LEAPS program and will have a week-long summer camp program for all the LEAPS scholars.

Authors:

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Michael Finetti, *Saint Peter's University*

Renovating Calculus with the Partner Disciplines: A SUMMIT-P Project

The National Consortium for Synergistic Undergraduate Mathematics via Multi-institutional Interdisciplinary Teaching Partnerships (SUMMIT-P) has been working since 2016 to revise and improve the lower division undergraduate mathematics curriculum. The key element of these innovations is interdisciplinary partnerships, with partner disciplines directly involved in decisions about curricular needs, building off the research of the MAA's Curriculum Foundations Project. At Augsburg University, mathematicians worked locally with a chemist and economist to renovate the calculus sequence and collaborated with other institutions in the consortium via meetings, workshops and site visits to share insights and materials developed. Three key changes resulted from this work: (1) More consistent use of active, inquiry-based learning to improve procedural fluency, conceptual understanding, and basic problem-solving; (2) More applications in class and revised weekly labs in applied contexts to improve mathematical modeling skills and transference of mathematical knowledge to applied domains; and (3) Redesigned Calculus I and Multivariable Calculus to create a direct pathway (without Calculus II) to allow Chemistry (and other) majors quicker access to Multivariable Calculus.

Authors:

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

This collaborative project (DUE #2111260 and #2111273) will serve the national interest by implementing, assessing, and understanding effective practices in delivering online, teaching-focused professional development (PD) to instructors of undergraduate mathematical sciences. Current PD models limit potential 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, the Mathematical Association of America (MAA) and the University of Colorado Boulder (UCB) 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. Furthermore, we will incorporate explicit efforts to build PD capacity, seeking to have a lasting impact on undergraduate mathematics instruction by training new workshop providers and broadening participation in PD leadership. Our project design is firmly grounded in scholarship on effective

instruction, professional learning, and system change. The investigators from UCB's Ethnography & Evaluation Research (E&ER) group will apply a research-with-evaluation approach to measure impact of online PD, considering both individual instructors' growth and implementation and how these depend on their professional backgrounds and instructional contexts. Ajzen's Theory of Planned Behavior, coupled with a component perspective of Century et.al. to implementing innovations, will provide conceptual frameworks for these measurements. E&ER will also track the growth of PD leaders who take part in project trainings, and will evaluate, research, and disseminate findings on effective evidence-based techniques for online professional development. The project will operate at multiple levels for which the underlying goals include: planning, implementing, and evaluating the workshops to generate new knowledge regarding effective practices for online PD models; creating processes and structures that align community needs with content expertise; implementing a communication plan to reach into underserved areas of the community; emphasizing research-based approaches to instruction, course design, and assessment; and, overall, developing effective models for intensive and extended online workshops. All workshops will emphasize creation of active, inclusive classroom environments under the framework offered by the MAA Instructional Practices Guide (2018), a compendium of research-based approaches to teaching that includes cross-cutting themes on equity, diversity, and inclusion. The project will activate levers for change at two levels: (1) empowering individuals to make research-based changes to their teaching that will enhance student learning, and (2) shaping departmental and disciplinary cultures to support those changes. By hosting over 40 workshops and directly serving some 1000 mathematics instructors, the project will make a lasting impact on participant knowledge, skills, and uptake of research-based instructional strategies in inclusive undergraduate mathematics instruction, which will in turn impact many thousands of students. The additional attention to capacity-building, institutional change, and transfer to other STEM disciplines will exponentially increase the level of impact.

Authors:

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Deirdre Smeltzer, *Mathematical Association of America*

Expanding Pathways to a Data Science Career by Developing a Certification in Data Science and Analytics

Businesses and organizations across all industry sectors are increasingly looking for ways to use data in their decision making. This shift to data-driven decision making is creating a growing workforce demand for Data Science and Analytics professionals. In a 2018 report, the US Bureau of Labor Statistics projected those jobs in data science and analytics will grow 34% by 2026. However, thus far, very few two-year institutions offer data analytics programs that could prepare students for entry-level positions in data science and analytics. The County College of Morris (Randolph, NJ) developed a 16-credit data science certificate that integrates technology such as R, Tableau, Python, and SQL into the curriculum. The curriculum will be informed by an industry advisory committee and implement national recommendations for data science education, including teaching statistics thinking, integrating real data with a context and a purpose, and using project-based learning. The resulting certification will prepare students to enter the workforce as data analytics professionals, or to transfer to four-year programs. Ramapo College is our partner transfer institution. Thus, this project has the potential to increase the capacity and quality of the data science workforce in New Jersey, the project may also provide a model for other institutions that are interested in building new data science programs. This project is funded by the Advanced Technological Education program that focuses on the education of technicians for the advanced-technology fields that drive the nation's economy. Award Abstract # 2000887 Expanding Pathways to a Data Science Career by Developing a Certification in Data Science and Analytics.

Authors:

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Team teaching, integrated Science and Engineering courses, and dedicated mentorship: Preparing for our first cohort of NSF S-STEM scholars

Penn State Abington will welcome a cohort of 12 scholars in the Fall 2022 semester as part of our NSF S-STEM funded program: "Integrating the teaching of Math, Physics, and Engineering courses to improve retention of Engineering students at Penn State Abington." In this program, the scholars will take two integrated courses: Calculus I integrated with Physics: Mechanics during the fall semester of their first year and Physics: Electricity and Magnetism integrated with Electrical Engineering: Circuits and Devices in the fall semester of their second year. In each, the students will have support from two instructors who are team teaching the courses together. The students also take our Cornerstone Engineering Design course as a group as well as an Engineering-themed First Year Seminar course. Other highlights of the program are dedicated peer mentors, dedicated advisers, and exclusive mentoring by faculty, alumni, and industry partners. As our scholars have both high potential and high financial need, we are thrilled to be able to support them financially and academically as they journey through their course work and requirements for their intended Engineering majors.

Author:

Matthew Fury, *Penn State Abington*

Crafting a classroom: Personal and institutional factors that influence early-career mathematics instructors' implementation of active learning techniques

Active learning techniques have been shown to close achievement gaps and can support equity among undergraduates in STEM. Within mathematics, some professional development programs encourage early-career mathematics instructors to adopt active learning techniques within their teaching. While instructors are becoming more aware of the benefits of active learning, there is little research about what influences them to implement it within their own classrooms. This research uses pre-survey data from 201 participants who were newly admitted into a professional development program to study whether and how often early-career mathematics instructors use active learning techniques in their courses. We will present findings about which active learning techniques are already most implemented by early-career mathematics instructors, as well as factors that influence their implementation, such departmental expectations, institution size, and qualitative responses about teaching. This work is supported by NSF award DUE-1821704.

Authors:

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Turning the Tide: Teaching Mathematics in High-Need Schools in Central Pennsylvania

Shippensburg University's Mathematics Department was awarded a $1.4 million grant from the National Science Foundation (Award #2150966) for their initiative to increase the number of high school math teachers in the region. The grant funds scholarships and expands partnerships with Central Pennsylvania's Community College (HACC) and Hagerstown Community College (HCC). From intensive, immersive field experiences of over 400 hours across three years to increased professional development in working with students in high needs schools, the program is working to increase the number of highly trained mathematics teachers for the region.

Authors:

Debbie Gochenaur, *Shippensburg University*
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The Breath of The Earth's Lungs

There is no doubt about the value of forests to human beings, so how to make rational use of and manage forests is very important. In this paper, we deeply explore the maximizing carbon sequestration capacity and developing forest management plans based on carbon sequestration capacity. For Task 1, it shows the most effective way to store carbon dioxide in forests. Firstly, the carbon sequestration capacity of tropical rain forest, temperate forest and northern forest and different kinds of trees are considered in this paper. Obviously, in this case, there are many factors affecting the carbon sequestration capacity of forests and their products. In this paper, the data are preprocessed by multi factor analysis of variance; Then, an optimization model is established to solve the maximum carbon storage capacity as the objective function; Finally, the hybrid genetic algorithm is used to solve the optimization model. For Task 2, it requires that a management plan be established taking into account the value of forests other than carbon sequestration. Firstly, this paper chooses carbon sequestration, species diversity, water conservation capacity and wind and sand fixation capacity to reflect the value of forest. Carbon sequestration has been analyzed in question 1. In this topic, neural network is used to analyze the relationship between deforestation rate and species diversity, water conservation capacity and wind prevention and sand fixation capacity; Then, the carbon sequestration capacity, species diversity, water conservation capacity and wind and sand fixation capacity are normalized and weighted to obtain a comprehensive score, and the neural network algorithm is used to find the deforestation rate when the score is the highest; Finally, under the determined deforestation rate, analyze how the deforested forest produces forest products to maximize carbon sequestration, so as to take into account as many factors as possible. For Task 3, it elaborates that the model in the previous article be applied to the actual forest for analysis. This paper selects Jianfengling tropical rain forest, Changbai Mountain Korean pine broad-leaved mixed forest and Daxinganling coniferous forest for analysis. Firstly, we need to solve how much carbon dioxide the selected forest will store in 100 years, which is similar to problem 1. Taking the maximum carbon storage capacity as the objective function, we use the hybrid genetic algorithm of problem 1 to deal with the problem; then, it is necessary to solve the forest management plan of the selected forest, which is similar to problem 2. The forest management plan is formulated by comprehensively considering carbon sequestration, species diversity, water conservation capacity and wind prevention and sand fixation capacity, which is solved by neural network algorithm; finally, we need to make a transition plan when changing the harvesting interval. This paper uses canonical correlation analysis to quantitatively calculate the impact of harvesting interval on forest management plan, and then make corresponding adjustments compared with the old and new plans. At last, we conduct sensitivity analysis, which shows the robustness of our model. We also summerize the stengths and weaknesses and provide insights to lCM society about then carbon sequestration capacity.

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Preparing Students for Careers in Computer Science and Math, an NSF S-STEM Project at Western Washington University

NSF S-STEM award #1742110 funds the CS/M (Computer Science/Math) Scholars Program at Western Washington University (WWU) . This program, now in its fifth year, provides multi-year scholarships for students majoring in computer science or math. In addition to scholarships, the program involves first-quarter seminar courses, near-peer mentoring, and regular events focused on professional development and exploration of career opportunities. Research is focused on understanding the effect of program activities on students' self-efficacy, identity within the disciplines, and sense of belonging, and also on the impact of early exposure to computer science. The poster will provide an overview of the program including recruitment of students, student demographics, student-to-student mentoring, the involvement of recent WWU alumni as mentors to students, program events, research methodology and results, program evaluation, and impacts of the program beyond the participants. The effect of COVID on the program will also be described.

Authors:
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Elizabeth Litzler, *Center for Evaluation & Research for STEM Equity*

GeT Support: An online professional learning community to support the geometry course for teachers

Our poster describes ongoing work creating and sustaining a learning community for instructors who teach the college geometry classes which are taken by prospective secondary mathematics teachers (GeT courses). Most mathematics departments offer a geometry course required for future secondary teachers, but few faculty members are involved in any one institution, to the point that local communities don't exist for course-specific professional learning. GeT: A Pencil is an inter-institutional community of instructors that overcomes that pervasive lack of community by bringing GeT instructors together to work on problems of practice, which include documenting and improving GeT instruction. Throughout the scope of the project we have asked some of the following questions: (1) Can we detect changes in mathematical knowledge for teaching geometry among undergraduates who take geometry courses for teachers? (2) How can instruction in geometry courses for teachers be characterized, from the perspective of instructors and students? (3) What can a community of instructors of college geometry courses do to increase capacity for teaching high school geometry? (4) How can a community of instructors of college geometry help individual instructors increase capacity for teaching those courses? We have found that our MKT-G instrument detects average increases of .25 standard deviations for students (N=435) during the period they take the course. Furthermore, student surveys of instruction report: (1) more interactive lecture than traditional lecture, (2) more practices of helping students solve their own problems than telling students the answers to difficult questions, (3) more providing definitions and proofs of theorems than having students participate in creating definitions or developing proofs of theorems, and (4) more novel problems than traditional problems. Our instructor participants have collaborated in developing and documenting a consensuated list of Student Learning Outcomes, which we will also share in the poster. Instructors have been very eloquent about the personal benefits of the community, both in terms of their practice (doing things they had not done before) and personal advancement (achieving career milestones with the assistance of work done for the community).

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Promoting Success in Undergraduate Mathematics Through Graduate Teaching Assistant Training: The Unique Contributions of the Peer TA Coach Role

Promoting Success in Undergraduate Mathematics through Graduate Teaching Assistant Training (PSUM-GTT) employs a multi-component approach to teacher training, including a weekly teaching and learning workshop with a focus on equity and inclusion, a Critical Issues in STEM Education seminar series, one-to-one peer mentoring, support from a peer TA coach, and outreach experiences to observe and experience the local K-12 classroom and pipeline. This poster focuses on the experiences of TA Coaches in the training program designed and refined at the University of Colorado Denver starting in 2015, with support from the NSF (award 1539602). In 2019, the program was introduced at Auburn University and the University of Memphis with NSF funding (awards 1821454, 1821460, 1821619). The TA Coach role was initially developed to provide in-class support for GTAs new to facilitating active learning strategies in the classroom. Similar to the paired teaching approach to help new faculty adopt active learning strategies (Strubbe et al., 2019), it is a unique element of the training program that can facilitate and support

conversations amongst faculty, peer mentors and mentees. Upon adaptation across partner institutions, the TA Coach role has been defined with flexibility to best suit the needs and goals of each department and their GTA trainees. This poster summarizes the roles of the TA Coaches across the three universities and explores their perceptions of the unique benefits that the TA coach role provides to the GTAs they assist and their own professional and instructional experiences. References: Strubbe, L. E., Stang, J., Holland, T., Sherman, S. B., & Code, W. J. (2019). Faculty Adoption of Active Learning Strategies via Paired Teaching. Journal of College Science Teaching, 49(1), 31-47.

Authors:
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OPTIMUM Interactions: Fostering Student-Centered Online Tutoring Practices

Access to free, high-quality, institutionally provided tutoring services can be critical to the success of university students. When the pandemic forced university tutoring operations to close or move online in Spring 2020, many chose to move operations online. We observed that online interactions were drastically different than what we were used to seeing in person, and we recognized that training for tutors had to evolve. The Fall 2021 semester saw the return of in-person tutoring at many institutions, however, online options remained in place at many institutions to serve students who may not be able to participate in-person. This created more equitable access to a critical student support. We will share an overview of the Online Practices for Tutoring In Mathematics Using Meaningful (OPTIMUM) Interactions (NSF Due #2201747) training materials we developed in response to the need for a more student-focused online tutoring experience. We collected data on tutor-student interactions at two research-focused institutions. Although we are still analyzing the data, early indications are that these interactions have improved significantly from Spring 2020. We will share how training has evolved, and how that has translated into better online tutoring experiences for students.

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Deborah Moore-Russo, *University of Oklahoma*

The Value of COMMIT-ing to Teaching with Inquiry: Examining A Network of Communities Focused on Transforming Mathematics Instruction

The 21st century workforce is in need of highly qualified STEM professionals. It is projected that STEM jobs will grow 8% over the next ten years (Seitz, 2021). However, mathematics courses at institutions of higher education (IHEs) often act as "gatekeeper courses," leaving many students with minimal access to or interest in pursuing STEM careers. One strategy for increasing success, including for students from historically under-represented groups, has been to use evidence-based teaching methods, such as active learning (Freeman et al, 2014; Theobald et al, 2020). Despite research that supports this approach, traditional lecture-style teaching is still the predominant method of instruction in many college mathematics courses (Jaworski & Gellert, 2011; Laursen et al., 2019; Nolan, 2006, 2010). Using networks and communities of practices to initiate, promote, and sustain change is one method shown to overcome these barriers to instructional change (Austin, 2011; Gehrke & Kezar, 2017.) The COMMIT (COMmunities for Mathematics Inquiry in Teaching) Network, funded through NSF-IUSE grant XXXX, provides a flexible structure to support regional communities of practice, called COMMITs, in their mission to influence instructional change, address faculty isolation, and ultimately, improve student learning outcomes. The

COMMIT Network consists of a dozen regional COMMITS, that collectively span over half of the United States, with over 800 educators actively involved. Each regional COMMIT brings high quality professional development to their local members, focused on infusing active learning, equity, and inquiry into college mathematics classrooms. In this poster session, we will present findings from years 1 and 2 of the grant, examining the research questions: 1) To what extent does the COMMIT Network create value for the regional COMMITS? 2) What aspects of the COMMIT model are most valuable to individual faculty participants, COMMIT leaders, and the broader network? Utilizing Wenger et al.'s value framework (Wenger et al., 2011), we examine the multiple layers of value identified by both faculty members and leaders as we seek to understand how the COMMIT Network can best support the sustained and systemic implementation of evidence-based teaching practices in IHEs. References available upon request.

Authors:

Paula Jakopovic, *University of Nebraska at Omaha*
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Christine von Renesse, *Westfield University*
Nina White, *University of Michigan*

Fostering STEM Retention Interest and Retention by Integrating Innovative Research in Teaching

It is often difficult to maintain student engagement in statistics coursework. Flipped classroom approaches have gain popularity for providing lecture content outside of class and active learning approaches during class time. However, documentation for the development of statistics flipped classroom coursework materials is sparse. Moreover, cross-university collaborations are rare in this subject area. Therefore, we will present products and processes we employed to create course content and outcomes measures for a cross-university flipped classroom biostatistics course. We will adopt the same biostatistics textbook and cover the same topics at both Fisk University and Tennessee State University. The research team has explored biological datasets and adopted a dataset generated from a field experiment which was designed to test the effects of crop variety (four varieties) and planting density (three densities) on mung bean growth, physiology and yield using a randomized block design with three blocks. A course project is designed to include commonly used statistical methods such as descriptive statistics, t-test, ANOVA and regression to analyze this dataset. Regarding outcomes, we created a comprehensive quiz as the primary outcomes measure, but included STEM career and interest measures to detect changes in student attitudes. We also created record keeping forms to help assure course content is delivered as intended. A pilot year is concluding and we will present an initial review of the results.

Authors:

Qingxia Li, *Fisk University*
Thomas Gross, *Western Kentucky University*
Dafeng Hui, *Tennessee State University*

Math Teacher Candidates have an Opendoor to the Outside Classroom

As part of the Broadening Engagement in Mathematics Participation and Readiness Education Project (BE-MathPREP), this project provides a learning community and professional development aimed at improving pedagogical approaches and content knowledge that incorporates sharing best practices with math teacher candidates and the Math Teachers' Circle of Hawaiʻi (MaTCH). In particular, we focus on our first summer MaTCH workshop through this grant with culture-based located at the tidal islands of Keʻehi (Kahakaʻaulana, Mokuoʻeo, and Mokauea) region were home to our Aliʻi. Up to the mid-1900, it was a high food-producing region until western development and a change in social structure practically destroyed the culturally significant Hawaiian fisheries in this area and the knowledge that comes with the practice. With its rich history and its proximity to the Honolulu urban area, these tidal islands, off the south shore of Oʻahu, are an ideal outdoor classroom. Teacher candidates have multiple opportunities to work through mathematics from the learner's perspective and utilize that to inform their teaching practice. The teacher

candidates will also engage in analyzing pedagogical aspects of the mathematical experiences as well as through other activities such as professional readings, collaborative discussions, and examination of curricula materials. This presentation will share the lesson plans and teaching portfolios that are created by the teacher candidates.

Authors:
Veny Liu, *University of Hawaii West Oahu*
Laurie James, *University of Hawaii West Oahu*
Felicia Dirige, *University of Hawaii West Oahu*

Undergraduate Service Learning Experiences with Data: Mathematics in the Community

In this project, the research team seeks to investigate the potential for a service learning model to enhance student engagement with and learning of foundational quantitative literacy competencies relating to data literacy and visualization. The overarching long-term goal of the project team is to increase interest, participation, and persistence in the STEM disciplines and retention at the university by transforming how undergraduate students engage with and learn mathematics in a first-year general education (GenEd) course. To address this goal, the team will design, implement, and assess a new GenEd course, STAT 1100: Data Literacy and Visualization—a service learning course in which students analyze and create visualizations of data in order to answer authentic questions from non-profit community partners.

Authors:
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Becky Brusky, *University of Nebraska at Omaha*
Mahbubul Majumder, *University of Nebraska at Omaha*
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Julie Dierberger, *University of Nebraska at Omaha*

SUMMIT-P: Using Faculty Learning Communities in Mathematics and Partner Disciplines at Lee University

In conjunction with the Committee on Curriculum Renewal Across the First Two Years (CRAFTY) of the Mathematical Association of America (MAA) and SUMMIT-P, faculty at Lee University have been working to revise and improve the lower division undergraduate mathematics curriculum in Introduction to Statistics, Concepts of Math I and II (for education majors) and Algebra for Calculus courses. Through the interdisciplinary faculty learning communities (FLCs) that were created, partner discipline colleagues have been directly involved in decisions about curricular changes, with FLCs using fishbowl discussions, wish lists, and site visits. In this poster session we share information about our FLCs and outcomes of the six-year SUMMIT-P project at Lee University.

Authors:
Caroline Maher-Boulis, *Lee University*
Bryan Poole, *Lee University*
John Hearn, *Lee University*

Collaborative Research: Extending Inquiry-Oriented Linear Algebra (IOLA-X)

The Inquiry-Oriented Linear Algebra (IOLA-X) project aims to serve the national interest by improving student learning in linear algebra. It aligns with national calls to engage students in learning through inquiry. To this end, it helps students learn mathematics by engaging in mathematical discussions, developing and testing conjectures, and explaining and justifying their thinking. The project has four main goals: (i) create four new units that integrate with existing Inquiry-Oriented Linear Algebra materials; (ii) create instructional support materials for the four new units; (iii) build knowledge through empirical research about student reasoning and effective inquiry-oriented instructional practices in linear algebra; and (iv) foster inquiry-oriented instructional practices in undergraduate mathematics. To accomplish its goals, the

project introduces the Design Research Spiral comprised of five phases: Task Design based on Realistic Mathematics Education (Freudenthal, 1991), Paired Teaching Experiments (Steffe & Thompson, 2000), Classroom Teaching Experiments (Cobb, 2000), Online Working Groups (Fortune & Keene, 2021), and Website Development. The project extends the current Inquiry-Oriented Linear Algebra materials, providing supports for instructors adopting an inquiry-oriented approach to teaching linear algebra. This project works to benefit society by improving undergraduate mathematics instruction and extending the use of inquiry-oriented teaching. By extending the current curriculum products and instructor support materials to comprise an entire introductory linear algebra course, we provide a more comprehensive set of supports for instructors who want to adopt an inquiry-oriented approach to teaching linear algebra. By working to impact new instructors and settings, we have the potential to increase the impact of active learning and inquiry-oriented teaching to both a larger number of students and institutions.

Authors:

Matt Mauntel, *Florida State University*
Megan Wawro, *Virginia Tech*
Michelle Zandieh, *Arizona State University*
Christine Andrews-Larson, *Florida State University*
David Plaxco, *Clayton State University*

SLU- SUMMIT-P Making Math Education More Effective for Business Students

The projects of the SUMMIT-P consortium looked at making mathematics education more effective for partner disciplines, a longstanding issue in STEM education. SLU's project looked at math and business. The project led to four subprojects that should be sustainable after the grant concludes. Two of the subprojects primarily reside within the math department. Each of the subprojects produced a deliverable: The business calculus subproject produced an online book along with supporting materials that are available under an open-source library. We have anecdotal evidence that it increases student engagement. We are working on a study of that feature. It has been adopted at two other schools. The college algebra subproject produced a series of worksheets that can be used to walk students through progressively more robust modeling exercises. The visualization subproject has produced a series of applets that are used by the business faculty in their courses. The prerequisite skills remediation subproject produced a skills test for managerial accounting along with remediation material organized on a website. The process should be reproducible with other disciplines.

Author:

Mike May, *Saint Louis University*

High Leverage Teaching Practices for the Proof-Based Undergraduate Mathematics Classroom

Professional organizations have called for undergraduate mathematics courses to become less lecture-focused. However, transitioning to more active approaches is pedagogically challenging. In the Orchestrating Discussions Around Proof (ODAP) project, we used a design-based research approach to test and refine instructional practices that may support rich student engagement in proof. We found that many teaching practices from the K-12 setting could be adapted to the proof-based classroom, although implementation often relied on navigating between formal and informal mathematics and making sense of abstract referent objects. Products from ODAP include three abstract algebra lesson guides and a set of structured instructional practices that may help facilitate more active learning. Ultimately, we hope such practices may support more positive classroom experiences for mathematics majors and future high school teachers who take proof courses.

Authors:

Kathleen Melhuish, *Texas State University*
Paul Dawkins, *Texas State University*
Holly Zolt, *Texas State University*
Anthony Tucci, *Texas State University*

SUMMIT-P Partnership in Action: Promoting Engineering Applications in Calculus and Differential Equations Courses Via Team-Teaching

Norfolk State University is currently the only HBCU member of the SUMMIT-P Consortium. Providing support to our partner discipline, engineering department, we have structured our program to include hands-on engineering applications, team-teaching, active learning strategies, and effective presentation formats. The engineering applications, developed in-house jointly by engineering and math faculty, are inspired by faculty research and/or upper-level engineering concepts.

Authors:
Shahrooz Moosavizadeh, *Norfolk State University*
Maila Hallare, *Norfolk State University*
Makarand Deo, *Norfolk State University*

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

This project aims to transform instructional practices in college algebra to improve students' mathematical reasoning. This work is accomplished via a partnership between the University of Colorado Denver and three Hispanic serving institutions: Metropolitan State University of Denver, Santa Fe Community College, and Texas State University. The project's institutional partners have a range of size and focus, and serve large populations of students of color and first-generation-in-college students. The project addresses a significant problem in U.S. undergraduate mathematics education: the overemphasis on finding the right answer. Specifically, it intends to decrease the emphasis on answer finding, and increase the emphasis on mathematical reasoning in high enrollment lower division mathematics courses. The project will accomplish these goals by developing and refining "Techtivities" for college algebra students. Techtivities are free, interactive, online problems based on video scenarios, such as the movement of a Ferris wheel. They engage students in creating multiple graphs to represent numerical relationships between objects in the scenario. The project helps instructors use these Techtivities effectively through both an instructor professional development program and instructor Communities of Transformation. By transforming instructional practices in gatekeeper introductory college math courses, we seek to increase student persistence in STEM majors and help the U.S. prepare an increasingly diverse population for STEM professions.

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

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. Student surveys of engineering students reveal greater

retention of knowledge about differential equation content. Engineer faculty surveys note a change in attitudes relative to the engagement of the mathematics faculty.

Authors:
Rebecca Segal, *Virginia Commonwealth University*
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Second Report on NSF grant: Math-Stat Modeling Across the Curriculum

To raise awareness of quantitative applications across disciplines, three years ago Texas Lutheran University requested and was awarded a grant from The National Science Foundation, IUSE program (award # 1905246) for a project titled "Mathematical and Statistical Modeling Across the Curriculum (M2AC): Empowering Non-STEM Students to Appreciate and Use Quantitative Modeling." This project intends to increase the use of mathematical and statistical modeling projects across disciplines in non-STEM fields such as the social sciences, applied studies and humanities where, at the undergraduate level, quantitative methods and tools are often not emphasized. In the past two years, the PI's and collaborating faculty and students from participating disciplines have developed and archived over forty discipline-specific mathematical and statistical modeling modules which are peer-reviewed and archived at: https://www.tlumathcsis.org/. Faculty involved in this study are using these modules in their classes. To assess the efficacy of our approach we are utilizing pre and post surveys as well as "control" student groups to gauge impact. Currently we are in the final year of a three-year study. In this poster presentation, we will provide a brief description of the goals of the grant, work accomplished to date, and the instruments used to measure a change in the attitude of participating students toward quantitative analysis. We will also present a sample of our modules to demonstrate the breadth of applications and a summary of our findings.

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

PVAMU SUMS Scholars: Results from the Mathematics Component

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 pursue a post-undergraduate degree or enter the workforce in the aforementioned fields. In this poster, we will focus on the work done specifically regarding the mathematics component of the SUMS program. In particular, we will look at recruiting efforts (specifically mathematics majors) as well as the performance of the SUMS cohorts in their shared Calculus I course. Efforts to assist and mentor the SUMS students in their Calculus I course will be discussed as well as comparisons between the SUMS students and their non-SUMS peers. We will also look at data regarding the performance of the SUMS Scholars based on their performance in Calculus I.

Authors:
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Alphonso Keaton, *Prairie View A&M University*
E. Gloria C. Regisford, *Prairie View A&M University*

An Open Source Collection of Multivariable Calculus Problems

In an effort to make college more affordable to students, many faculty are adopting free open educational resources (OERs) to replace expensive textbooks and publisher provided homework systems. Initially

funded through an NSF-DUE grant and currently supported by a Pennsylvania Grant for Open and Affordable Learning, this project aims to create and disseminate, in WeBWorK, a bank of OER mathematics exercises designed for accessible and equitable education. Furthermore, this resource fills a gap in the WeBWorK open problem library by emphasizing both graphical problems (some using CalcPlot3D) and modern applications to environmental engineering, computer vision, and structural engineering. In this poster we will introduce some of these problems and discuss the design considerations.

Author:

Monica VanDieren, *Robert Morris 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, *TEXAS A&M UNIVERSITY-CORPUS CHRISTI*
Larissa Schroeder, *University of Nebraska at Omaha*

PosterFest 2022: Scholarship by Early Career Mathematicians

Thursday, August 4, 1:00 p.m. - 2:20 p.m., Franklin Hall A

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

Modifying certain terms of determinate moment sequences

In this work, we study the connections between representing measures of a determinate Stieltjes moment sequence and its perturbed form.

Author:

Saroj Aryal, *Georgian Court University*

Plasticity among neurons in the visual cortex during development: a mathematical modeling approach

The transmission of signals among cells in the brain underlies all sensory processing and behavior. The strength and structure of this transmission are plastic, changing with the activity of the cells, with the bulk

of this plasticity occurring early in development and setting up the complex network structure observed in adults. In particular, cells in the visual cortex (V1) of mammals develop a property called orientation preference, where the cells respond preferentially to a specific angle of visual input. This orientation preference is formed during development through the plasticity of incoming synapses from the midbrain to V1. While plasticity rules for synaptic changes between a class of neurons called excitatory (E) cells have been fairly well characterized, rules dictating the synaptic changes among another class of neurons called inhibitory (I) cells are still being researched. This work uses a biologically-motivated mathematical model to investigate the role of different descriptions of plasticity of I-cell synapses in the formation of orientation preferences of cells in the V1. In particular, we aim to characterize how various models of synaptic plasticity between I cells may interact with the plasticity among E cells to determine the resulting orientation preference of V1 cells.

Author:

Jennifer Crodelle, *Middlebury College*

Trinity Women's Basketball Analytics

In 2021-22 I created a new Intro to Sports Analytics course and also worked with independent study students collecting and analyzing data for our women's basketball team. This poster displays our analysis and findings of the team and player performance using key ideas in basketball analytics. In addition, this poster and project can serve as a model for authentic student experiences with data and meaningful partnerships between academics and athletics.

Author:

Kyle Evans, *Trinity College*

Inductive Shifting Proof for the Erd\" os-Ko-Rado Theorem on Sets and Vector Spaces

Given a finite set $[n]$, one can consider various collections (called families) of intersecting subsets with fixed size k. The original Erd\" os-Ko-Rado (EKR) Theorem gave the tight upper bound on the size of such a family. It was proven through a ``shifting technique'' as well as induction on n. The base case $n=2k$ used a simple partitioning argument. The EKR Theorem has since been generalized to families of t-intersecting sets. We discuss how this can be done with a similar argument to the $t=1$ case. Another extension of the EKR Theorem applies to a finite vector space V and families of ``t-intersecting subspaces'', meaning the dimension of an intersection between any two subspaces is at least t. We give an alternative proof of the $t=1$ case using an adjusted form of the same inductive argument described for sets. Finally, we were able to replicate many aspects of the proof for general t. We illustrate these and note the remaining difficulty in finalizing the argument for this stronger result.

Author:

Daniel Gotshall, *Villanova University*

Scratching Beneath The Surface: How A Coding Task Bolsters Mathematical Thinking and Student Leadership

Teachers are constantly looking for ways to foster engagement, develop reasoning skills, and bolster perseverance in student math thinking. Capitalizing on student interest in video games, we developed a meaningful math task utilizing the Scratch coding platform to meet these goals. A heterogenous group of fifth graders with varying levels of experience with Scratch, were given 45 minutes for four days to develop a kindergarten appropriate math game. The task occurred outside of the core math instruction during a flexible content block. With the students driving the creation, the teacher served as a facilitator rather than a traditional instructor. This opened opportunities for peer collaboration, feedback, and leadership. At the end of the week, all students actively created an individual math game even making use of any available free time. All students used available tutorials, peer expertise, and the engineering design process to plan and improve their games even when faced with setbacks and coding obstacles. An unintended but welcomed

side effect of the project allowed for new leaders to emerge and shifted power dynamics which strengthened the classroom's culture of learning.

Authors:
Rachel Kovel, Towson University
Wendy Gibson, Towson University

Higher Rank Graph C*-algebras With Trivial K-Theory

Given a graph of rank k, Λ, it was established by A. Kumjian and D. Pask that we may obtain a C^*-algebra, $C^*(\Lambda)$. Then, D. G. Evans demonstrated that there exists a spectral sequence induced by the adjacency matrices $M_1,\dots,M_k$ of the graph Λ that converges to the K-theory of $C^*(\Lambda)$. In practice, this spectral sequence is difficult to use for K-theory computations. This talk will show that under certain graphical conditions the spectral sequence becomes very easy to work with and guarantees that $C^*(\Lambda)$ has trivial K-theory.

Author:
S Joseph Lippert, *University of Montana*

The Relationship of the Cross Cap Number and Jones Polynomial of Links

In knot theory one of the first invariants we first learn about is the genus of a link, which involves looking at oriented spanning surfaces. For cross cap number we investigate the analog of genus but on non orientable spanning surfaces of our link. In particular the cross cap number is the minimal first betti number of all non orientable spanning surfaces of a link. In 2014 Kalfagianni and Lee showed that we can bound the cross cap number of non torus alternating links using the penultimate coefficients of the Jone's Polynomial. We will talk about both of these invariants and how we are able to relate them for alternating links. Further, we investigate what happens when we try to generalize to non alternating links, where it fails and where it we expect it to still hold.

Author:
Robert McConkey, *Michigan State University*

Analyzing the Impact of Active Learning in General Education Mathematics Courses

We present results of a study that explores the overall perceptions and attitudes of students in three general education mathematics courses with varying levels of active learning-based teaching methods. Win, Lose, or Draw is a team-based learning course taught using group work, discovery learning, and a final project. Storytelling with Data is a project-based learning course taught using a flipped classroom structure. Finally, Introduction to Mathematical Thinking is taught using a more traditional, lecture-based method. In our study, we collected survey data each semester between 2019 and 2022 from the three general education mathematics courses listed above on two occasions throughout a semester: pre-course and post-course. We present an analysis of survey data across courses, which explores the disposition and mindset of students, their mathematical confidence and anxiety, and perceptions on pedagogical methods used for the teaching of mathematics. We also explored how these perceptions and dispositions changed throughout a single course by comparing pre and post surveys.

Authors:
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Brittany Stephenson, *Lewis University*
Amanda Harsy, *Lewis University*
Michael Smith, *Lewis University*

Distance cospectrality in digraphs

A digraph consists of a set of vertices and a set of directed edges called arcs. The distance matrix of a digraph is the matrix whose entires are the distances from one vertex to another. Two non-isomorphic

digraphs are distance cospectral if their distance matrices have the same multiset of eigenvalues. In this work, the number of digraphs with a distance cospectral mate is found for 6 and fewer vertices and it is shown that almost all digraphs have a cospectral mate. Using generalized cycle decompositions, constructions are described which produces pairs of distance cospectral digraphs from a digraph containing twin vertices with certain structural properties.

Author:

Carolyn Reinhart, *Swarthmore College*

Extending ggplot2 statistical geometries

Ggplot2, the implementation of the grammar of graphics in the R statistical programming language, is a popular open source project. Because it provides an API that lets creators separates data visualization concerns --- including declaration of data, variable representations by visual channels, determination of coordinate systems, selection of geometric shapes taking on the aesthetic representation --- users have great freedom in the creation and customization of charts. Ggplot2 comes with a large number of geometric shapes that can represent variables in data sets. Some of these are available shapes are drawn after statistical transformation, such as boxplots, linear regressions, or histograms. But many statistical concepts do not have easy-to-use geometries for representing statistical summaries. This project will develop an extension package "ggxmean" (https://github.com/EvaMaeRey/ggxmean) to create new "geoms" useful for easily visualizing additional statistical concepts.

Author:

Evangeline Reynolds, *West Point*
Morgan Brown, *West Point*

The isoperimetric problem on the number line with log-concave density

We examine the isoperimetric problem on the number line with a prescribed density function that is symmetric, radially increasing, and satisfies a log-concavity requirement. Under these conditions, we find that isoperimetric solutions can be identified for an arbitrary (finite) number of regions, and that these solutions have a well-understood and regular structure.

Author:

John Ross, *Southwestern University*

Deborah and Franklin Tepper Haimo Awards

Thursday, August 4, 3:00 p.m. - 4:20 p.m., Salon G & H

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 Jennifer Quinn, University of Washington, Tacoma.

People Over Math: Using Restorative Practices to Build Research Communities
Having collaborated with over 110 undergraduate students on mathematical research, I have seen these students flourish -- their work has resulted in over 30 research publications and more than 25 writing contributions to the profession. In this talk, I detail the specifics that make our research communities so fruitful. (Spoiler alert: it was not the math!) In particular, I share ways in which we implement restorative practices in our collaborations to build honest and sincere relationships that focus on individual responsibility and shared accountability. These practices are the foundation on which we build communities that value and center people over mathematics, which in turn, greatly advance our mathematical work.
Speaker:
Pamela Harris, *Williams College*

The "Aha! moment" and Real World Applications of Mathematics
I do my best to include an "Aha! moment" in each lecture. The revealing of a surprising connection between topics or including a real world application not only provides for an entertaining lecture but also helps students remember the lesson well after they leave the classroom. These connections can include showing that seemingly theoretical topics can have practical applications. However concrete examples of real world applications in traditional mathematics courses are rare. As a result many students graduate asking the question "What else can I do with a mathematics degree besides teach?". This talk will provide some surprising connections as well as real world applications of mathematics which will help students see how powerful mathematics can be.
Speaker:
Darren A. Narayan, *Rochester Institute of Technology*

A Vision for a Culturally Responsive Pedagogy for the Undergraduate Mathematics Classroom
Education researchers, mathematics education researchers, and mathematicians working in the scholarship of teaching and learning have provided many different tools that undergraduate mathematics faculty can draw on to support the most marginalized students in their classrooms. Often these students are Black, Latinx, Pacific Islander, Native American, or come from low income communities. While many of these practices are designed to benefit these underserved students, they often benefit all our students. In this presentation I will share why I feel it is important that college mathematics educators incorporate culturally responsive teaching practices and will share my thoughts and experiences on what this might look like.
Speaker:
Robin Wilson, *California State Polytechnic University, Pomona*

Alder Award Session

Friday, August 5, 3:00 p.m. – 4:20 p.m., Salon G & H

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 Jennifer Quinn, University of Washington, Tacoma.

Changing My Own Mindset (and Some Applications)

Teaching is hard. Blaming students is easy. In this talk I will discuss what happened when I stopped complaining about students and started trusting them. This attitude has changed what I do in my classroom - assessment techniques, activities, and what I value. In a time when I both feel a need for radical change and am just so tired, I'll try to offer some concrete things I've tried, both big and small. This talk is a tribute to everyone I've ever had the privilege of talking about teaching with, including my students: I've learned something from all of you!

Speaker:
Lauren Keough, *Grand Valley State University*

The Real World is Not a Textbook Problem: Embracing Uncomfortable Projects

Too often, students think learning math is a sequence of step-by-step procedures to solve problems that have only one solution classified as right or wrong. After years of cultivating this mindset, students come to believe that every problem is like this. But when students begin their careers, they will discover that real-world problems are almost never arranged so neatly, with clearly defined terms and constraints, and only one solution. These encounters with multifaceted problems can be very uncomfortable. Providing opportunities for our students to grapple with messy uncomfortable real-world projects before they graduate is essential. Through these experiences, students can build their creativity, enhance their lateral thinking, and discover their potential is unlimited.

Speaker:
Vinodh Kumar Chellamuthu, *Utah Tech University*

Modeling Our World with Mathematics: Incorporating Math Modeling into a General Education Curriculum

In recent years, we have been increasing the number of "non-traditional" mathematics courses offered in our general education curriculum at Lewis University. Most recently we added a 100-level mathematical modeling course that counts for both mathematics and civic engagement credit. In this newly developed course, we introduce students to the process of model construction in a variety of applications and demonstrate the role assumptions play in model outcomes and data visualizations. The emphasis is on improving students' quantitative literacy skills and providing firsthand experience with how mathematics can help us understand applications and make informed decisions. Topics have included data visualization dos and don'ts, voting strategies, gerrymandering, racial profiling, minimum wage, tax brackets, disease models, and predator/prey

models. In this talk, I will share lessons I learned in the development and initial implementation of this course.

Speaker:
Brittany Stevenson, *Lewis University*