MAA MATHFEST

2024 | INDIANAPOLIS, IN

It all starts with Math.

Abstracts of Papers - Presented at MAA MathFest 2024

Contents

Invited Addresses

MAA Earle Raymond Hedrick Lecture Series

Lillian B. Pierce, *Duke University*

Lecture Series: Invisible Cities: *On Ideas in Number Theory and Analysis*

Often in mathematics, we set our sights on a particular theorem. If we are successful, we then present to our audience an array of methods we have assembled to get the better of the problem at hand. In this pair of lectures, we will do something different: we will set our sights on a particular idea, and then follow it as it shape-shifts in the mathematical literature. Can we spot it in all its disguises? By studying its mutability can we better recognize its essential utility? This approach will send us on an unusual path, scuttling across decades of mathematics, and from analysis to number theory, and back again.

Note: Lecture 1 and Lecture 2 will be independent. Both lectures will be welcoming to researchers and students interested in all areas of mathematics

Lecture I - Superorthogonality
Thursday, August 8, 11:00 am - 11:50 am

How do we check if two vectors are orthogonal? We compute their dot product, which by definition takes two vectors as inputs. How do we check if two functions are orthogonal? We compute their inner product, which by definition takes two functions as inputs. Why only two? What would it mean for 4 functions to be “orthogonal”? Or 8 functions? Or 7 functions? Let’s call this superorthogonality. What can we deduce about collections of functions that are superorthogonal? We will explore how accidental encounters with papers spanning 90 years led to a systematic investigation of these questions, and a way to see that previously “unrelated” theorems share a very interesting structure deep under their surface.

Lecture II - Moments
Friday, August 9, 10:00 am - 10:50 am

Many problems in number theory can be phrased as counting problems. How many solutions are there to this Diophantine equation? How many values of this polynomial are perfect squares? How many of these exponential sums are large? Depending on the context, sometimes we hope to show a particular “counting function” is small, and for other problems we hope to show a “counting function" is “large.” We will give a taste of several, quite different, counting problems, and in each case we will show how ideas using “moments" can help us count.

AMS-MAA Joint Invited Address

Diana Thomas, *United States Military Academy West Point*

The Calculus of Metabolic Disease

Thursday, August 8, 2:00 pm - 2:50 pm

Risk of metabolic disease such as type 2 diabetes can be characterized by properties of a glucose concentration curves generated after consuming a provided meal. This curve is referred to as the post-prandial glycemic response curve. Investigators in the field of obesity, nutrition, and diabetes have typically collapsed the post-prandial curve to a single value using either the area under the curve (AUC) or the incremental area under the curve (iAUC), which is the area between the curve and fasting glucose concentrations. In this presentation, I will show that calculus-based curve properties beyond AUC, such as the number of critical points, optimal values, inflection points, maximum rate of incline or decline, can 1) discriminate between healthy and at-risk populations and 2) predict onset of type 2 diabetes in previously non-diabetic patients. As key part of this presentation I will be sharing the data science research journey behind working with clinical investigators, pre-processing messy human subject data, asking the right questions that can transform human health, and developing end-user tools to clinically deploy mathematical models.

MAA Invited Address

Sofiat Olaosebikan, *University of Glasgow*

Matchings Under Preferences: The Student Project Allocation Problem and Beyond

Thursday, August 8, 1:00 pm - 1:50 pm

Matchings under preferences have been a subject of profound interest in the fields of computer science, economics, and operations research, due to its relevance in various real-world applications. The evolution of research in this domain can be traced back to the 1962 seminal paper by David Gale and Llyod Shapley. Their work laid the foundation for the Nobel Prize in Economic Sciences awarded in 2012 to Alvin Roth and Llyod Shapley, acknowledging their pioneering contributions to the theory of stable allocations and the practice of market design.

Matching problems arise when we need to find an allocation between a set A of agents and another set B of agents, e.g., allocating pupils to schools, junior doctors to hospitals, teachers to regions, and pairing donor kidneys with transplant patients. This talk will provide an overview of the key aspects of matching problems, including one-sided and two-sided markets. In particular, the talk will focus on a problem variant under the two-sided market umbrella, namely the Student Project Allocation problem. This model is based on the allocation of students to projects offered by lecturers, where students and lecturers may have preferences over the possible outcome. Beyond assigning students to projects in university departments, application of SPA can be seen in wireless networks where the goal is to allocate users to channels at base stations.

Ben Orlin, *Saint Paul College*

Math for English Majors
Friday, August 9, 1:00 pm - 1:50 pm

In this talk, my stick-figure illustrations and I shall tackle one of the oldest, most profound, and least coherent questions in the history of mathematical inquiry: "This stuff we're learning... when am I going to use it?" Our goal is to unmask this question, like a Scooby Doo villain, to reveal the true question beneath: "This stuff we're learning... what even IS it?" A semi-novel answer is proposed: at the high school and early undergraduate level, "this stuff" is a highly peculiar language. It employs just a handful of workhorse verbs, a nearly infinite variety of custom-built pronouns, and a single, monotonous sentence structure. This language, in which mere paraphrase is one of the highest forms of literature, shares a name with the sprawling set of abstractions it is designed to discuss and illuminate. That name, of course, is "math."

William Dunham, *Bryn Mawr College*

Bryn Mawr Matriculation Exams from Days of Yore
Friday, August 9, 9:00 am - 9:50 am

From its founding in 1885, Bryn Mawr College aspired to the highest academic standards and thus sought to admit women of exceptional promise. In those days before the SAT, the College developed its own “matriculation exam” to identify sufficiently talented students.
While grazing through the Bryn Mawr archives, I found copies of these exams from the decades around 1900. In my talk, I’ll share some favorite mathematical questions and a few non-mathematical ones. Modern students (and I’ll include myself here) might be unnerved by what was expected of applicants in olden times.

MAA James R.C. Leitzel Lecture

Alicia Prieto Langarica, *Youngstown State University*

Move Outta the Way! Re-indigenizing Our Teaching Practices
Friday, August 9, 11:00 am - 11:50 am

This talk will be given as a collection of different stories, about life, growing up, about learning and about teaching. Although seemly very different stories, they are all connected and aim to exemplify how we as a community think about teaching and ideas on how we may consider changing the status quo. I do not have the answers, but hope that this talk will get us thinking deeper about the process of learning and what we can do as instructors to facilitate this learning.

AWM-MAA Etta Zuber Falconer Lecture

Deanna Needell, *University of California, Los Angeles*

Towards Fairer-ness in Machine Learning
Thursday, August 8, 9:00 am - 9:50 am

In this talk, we will address several areas of recent work centered around the themes of transparency and fairness in machine learning as well as highlight the challenges in this area. We will discuss recent results involving linear algebraic tools for learning, such as methods in non-negative matrix factorization that include tailored approaches for fairness. We will showcase our derived theoretical guarantees as well as practical applications of those approaches. These methods allow for natural transparency and human interpretability while still offering strong performance. Then, we will discuss new challenges and directions in fairness including an example in large-scale optimization that allows for population subgroups to have better predictors than when treated within the population as a whole. Throughout the talk, we will include example applications from collaborations with community partners, using machine learning to help organizations with fairness and justice goals.

Chan Stanek Ross Lecture for Students

Kobi Abayomi, *Seton Hall University and Gumbel Demand Acceleration*

What a DJ knows: Song Demand Prediction from Sound Data
Saturday, August 10, 1:00 pm - 1:50 pm

Predicting conditional and likely demand behavior for on-demand media -- and the best audience segmentation -- is of unique value to media rights holders. This information -- the who, what, where and when a rights holder can schedule a marketing or release campaign around -- drives business strategy. In this work we demonstrate how a particular -- but common -- representation of these induced affinity curves fit as almost natural inputs to high precision, predictive models on the media content alone. Directly: we demonstrate a way of predicting how much -- in granularity over time -- people will enjoy a song from how it sounds alone.

Christine Darden Lecture

Melanie Matchett Wood, *Harvard University*

Central Limit Theorems for Matrices and Modular Arithmetic

The Central Limit Theorem is an example of the ubiquitous, yet still surprising, phenomenon in probability that many independent random inputs often combine to give a universal output,

insensitive to the input distributions. It is the mathematical reason that the bell curve, or normal distribution, appears so often. We will explore how this phenomenon plays out when investigating the behavior of matrices, especially in modular arithmetic. We will explain how analogs of the bell curve appear for the behavior of matrices, as universal distributions involving the Riemann zeta function. (This talk includes joint work with Hoi Nguyen.)

Martin Gardner Lecture

David Richeson, *Dickinson College*

A Romance of Many (and Fractional) Dimensions
Saturday, August 10, 2:00 pm - 2:50 pm

Dimension might seem like an intuitive idea. We are all familiar with zero-dimensional points, one-dimensional curves, two-dimensional surfaces, and three-dimensional solids. Yet dimension is a slippery idea that took mathematicians many years to understand. We will use pictures, animations, and analogies to describe our three dimensions and help us visualize a fourth dimension. We will discuss the history of dimension, the public's and artistic community's infatuation with the fourth dimension, time as an extra dimension, the meaning of non-integer dimensions, and the unexpected properties of high-dimensional spaces.

NAM David Harold Blackwell Lecture

Jacqueline Leonard, *University of Wyoming (Emerita)*

Facilitating Computational Thinking in Out-of-School Programs
Saturday, August 10, 11:00 am - 11:50 am

This presentation compares the results of two cohorts during a four-year study, known as The Bessie Coleman Project (BCP). Participants in the treatment group (N=58) engaged in a week-long face-to-face summer camp (Year 2, 2019). Participants in the comparison group (N=235) engaged in an online program that met once a week for five weeks (Year 4, 2021). Computer-aided design (CAD), 3D printing, flight simulation, and drones were used as interventions in the treatment group. Only CAD was used with the comparison group. The results of the study show that students in both groups engaged in computational thinking processes (e.g., abstraction, automation, and analysis) and Computational Thinking Self-Efficacy (CTSE) increased among participants in the treatment group but not the comparison group. We conclude CAD and 3D printing facilitated the development of CT processes and problem-solving skills and engagement in all treatment variables increased CTSE.

Student Activity Speaker

David Taylor, *Roanoke College*

Mathematics + Magic = Mathemagic: Creating Illusions with Undergraduate Mathematics Topics
Friday, August 9, 2:00 pm - 2:50 pm

The word "magic" can evoke a variety of different thoughts in one's mind. Magician Garrett Thomas believes that "magic is not a supernatural power over the material world" and rather that it is "the real experience of a unique type of moment: a moment that clearly happened yet is not possible." Tricks, effects, and illusions are all just that – clever misdirection, entrancing patter, and hidden methods that challenge an audience's notion of reality. "What was once the 'magic' that shaped the material world has evolved into mathematics, science, psychology, and other fields that are no longer called magic, just truth."

In this student activity session, we explore this idea by focusing on several mathematical topics, from calculus to abstract algebra and beyond, using calculators and cards to take a mathematical topic – alongside learning some basic misdirection and story-writing – to create illusions, or what Thomas would say, "artistic truth." To quote Picasso's "the lie that helps us reveal the truth," we'll explore how magic truly isn't about fooling someone, but rather encouraging someone to think more deeply about that moment and the world around us.

Please feel free, if you have a favorite design or style, to bring a new deck of playing cards to the session, but all participants will receive a new deck of cards so everyone can explore and learn together. And, because this session *is* about magic, please don't be surprised or angered if it ends with an unexplained illusion – after all, my biggest desire is for everyone to leave the session itself wanting to – think deeply about ourselves, each other, and the world.

Invited Paper Sessions

MAA Invited Paper Session

AWM-MAA Invited Paper Session (aligned with the Falconer Lecture)
Iterative and Sketching Approaches for Linear Systems and Beyond
Part A: *Thursday, August 8, 3:30 pm - 6:00 pm*
Part B: *Friday, August 9, 8:00 am - 10:00 am*

Iterative and sketching approaches play crucial roles in solving linear, convex, and even non-convex systems, offering different strategies for handling various types of problems. Iterative methods involve repeatedly refining an initial guess for the solution until it converges, and often act on small amounts of data at a time, making them amenable to large-scale and/or sparse problems. Sketching approaches, often inspired by techniques from signal processing, provide a more efficient way to approximate solutions in situations where the system is overdetermined or ill-conditioned. They reduce the computational burden by sampling or sketching the input data, thus making it feasible to solve systems that would be computationally infeasible using traditional methods. Both approaches offer valuable tools in the realm of linear system solvers and beyond, allowing for flexibility in choosing the most suitable method depending on the problem's characteristics and computational resources available. Work on these methods, their applications, their theoretical underpinnings, and their connections to machine learning are welcome.

Organizer:
Deanna Needell, *University of California, Los Angeles*

Part A: *Thursday, August 8, 3:30 pm - 6:00 pm*

A Multiplicative Algorithm for Curvature Corrected Semi non-negative Matrix Factorization of Manifold-valued Data
3:30 pm - 3:50 pm
Joyce Chew, *University of California, Los Angeles*

Manifold-valued data frequently arise from scientific fields such as the imaging sciences, and low-rank approximations of such data are useful for tasks such as compression and data analysis. However, algorithms for computing these approximations need to account for the geometry of the underlying manifold. In this talk, I will first introduce a general framework for curvature-corrected low rank factorizations of manifold-valued data. Using this framework, we develop a scheme for curvature corrected semi-nonnegative matrix factorization of manifold-valued data. In particular, to address computational expense, we present a multiplicative algorithm for computing such factorizations. As a case study, we apply our method to data collected via diffusion tensor magnetic resonance imaging, which take on values on the manifold of 3 x 3 symmetric positive definite matrices.

Randomized Kaczmarz Method for Linear Discriminant Analysis
4:00 pm - 4:20 pm

Jocelyn Chi, *Rice University*

We present randomized Kaczmarz method for linear discriminant analysis (rkLDA), an iterative randomized approach to binary-class Gaussian model linear discriminant analysis (LDA) for very large data. We harness a least squares formulation and mobilize the stochastic gradient descent framework to obtain a randomized classifier with performance that can achieve comparable accuracy to that of full data LDA. We present analysis for the expected change in the LDA predictions if one employs the rkLDA solution in lieu of the full-data least squares solution that accounts for both the Gaussian modeling assumptions on the data and algorithmic randomness. Our analysis shows how the expected change depends on quantities inherent in the data such as the scaled condition number and Frobenius norm of the input data, how well the linear model fits the data, and choices from the randomized algorithm. Our experiments demonstrate that rkLDA can offer a viable alternative to full data LDA on a range of step-sizes and numbers of iterations.

Variable Projection Methods for Large-scale Separable Nonlinear Inverse Problems
4:30 pm - 4:50 pm
Malena Español, *Arizona State University*

Variable projection methods are among the classical and efficient methods to solve separable nonlinear least squares problems. In this talk, I will introduce the variable projection methods to solve large-scale inverse problems and a convergence analysis when inexact inner solvers are used.

Tensor Completion for Low CP-Rank Tensors via Random Sampling
5:00 pm - 5:20 pm
Santhosh Karnik, *Michigan State University*

We propose two provably accurate algorithms for low CP-rank tensor completion - one using adaptive sampling and one using nonadaptive sampling. Both of our algorithms combine matrix completion techniques for a small number of slices along with Jennrich's algorithm to learn the factors corresponding to the first two modes, and then solve systems of linear equations to learn the factors corresponding to the remaining modes. For an order-d, CP-rank r tensor of size $n \times \cdots \times n$ that satisfies mild assumptions, our adaptive sampling algorithm recovers the CP-decomposition with high probability while using at most $O(nr\log r + dnr)$ samples, and our nonadaptive sampling algorithm recovers the CP-decomposition with high probability while using at most $O(dnr^2\log n + nr\log^2 n)$ samples. Both of our algorithms run in polynomial time. Numerical experiments demonstrate that our algorithms work both on noisy synthetic data as well as real world data. This is joint work with Cullen Haselby, Mark Iwen, and Rongrong Wang.

Stochastic Iterative Methods for Online Rank Aggregation from Pairwise Comparisons
5:30 pm - 5:50 pm
Lara Kassab, *University of California, Los Angeles*

In this talk, we consider large-scale ranking problems where one is given a set of pairwise comparisons and the underlying ranking explained by those comparisons is desired. We show that stochastic gradient descent approaches, particularly the Kaczmarz method, can be leveraged to offer convergence to a solution that reveals the underlying ranking while requiring low-memory operations. We introduce several variations of this approach that offer a tradeoff in speed and convergence when the pairwise comparisons are noisy. We prove theoretical results for convergence almost surely and study several regimes including those with full, partial, and noisy observations. Our empirical results give insights into the number of observations required as well as how much noise in those measurements can be tolerated.

Part B: *Friday, August 9, 8:00 am - 10:00 am*

Randomized Gauss-Seidel and Column-Slice-Action Methods for Tensor Problems
8:00 am - 8:20 am
Alona Kryshchenko, *California State University Channel Islands*

Solving large-scale systems of linear equations and linear regressions is a critical challenge in various fields, including machine learning, medical imaging, sensor networks, and statistical analysis. Traditional methods like Kaczmarz, Gauss-Seidel, and Jacobi are effective for matrix-based data but fall short when dealing with modern, complex, multi-modal tensor data, which represents measurements across different dimensions such as spatial-temporal dimensions in video or word-document dimensions in text. This complexity necessitates transforming tensor data into matrices before analysis, a process that overlooks the inherent structure of the data and often leads to inadequate results. The development of analytic methods for tensor data lags significantly behind that for matrices, posing a challenge for computations even though their matrix counterparts are manageable. The talk introduces the Randomized Gauss-Seidel method, designed to solve linear systems involving tensors while preserving their natural structure, addressing the gap in efficient methods for handling high-order tensor data.

Iterative Approaches for Tensor Linear Systems
8:30 am - 8:50 am
Anna Ma, *University of California, Irvine*
In applications involving inverse problems, large-scale data is a common challenge. In this presentation, we introduce an iterative method for approximating the solution of large-scale multi-linear systems, represented in the form A*X=B under the tensor t-product. Unlike previously proposed randomized iterative strategies, such as the tensor randomized Kaczmarz method (row slice sketching) or the tensor Gauss-Seidel method (column slice sketching), which are natural extensions of their matrix counterparts, our approach delves into a distinct scenario utilizing frontal slice sketching. In particular, we explore a context where frontal slices, such as video frames, arrive sequentially over time, and access to only one frontal slice at any given moment is available. This talk will present our novel approach, shedding light on its applicability and potential benefits in approximating solutions to large-scale multi-linear systems. This is joint work with Yin-Ting Liao (UCI) and Hengrui Luo (Rice University).

Kaczmarz based Iterative Hard Thresholding Techniques for Low-Rank Tensor Recovery
9:00 am - 9:20 am
Shambhavi Suryanarayanan, *Princeton University*

Hybrid methods that leverage the Kaczmarz and Iterative Hard Thresholding (IHT) algorithms have been shown to be particularly effective in tackling sparse vector recovery problems. In this talk, I will discuss our recent work, in which we developed Kaczmarz based IHT techniques to recover low-rank tensors from a few linear measurements. I will also present some theoretical convergence guarantees followed by empirical results that highlight the effectiveness of these methods against different classes of measurement operators.

Robust, Randomized Preconditioning for Kernel Ridge Regression
9:30 am - 9:50 am
Robert Webber, *California Institute of Technology*

This talk discusses two randomized preconditioning techniques for robustly solving kernel ridge regression (KRR) problems with a medium to large number of data points (10^4 <= N <= 10^7). The first method, RPCholesky preconditioning, is capable of accurately solving the full-data KRR problem in O(N^2) arithmetic operations, assuming sufficiently rapid polynomial decay of the kernel matrix eigenvalues. The second method, KRILL preconditioning, offers an accurate solution to a restricted version of the KRR problem involving k << N selected data centers at a cost of O((N + k^2) k log k) operations. The proposed methods efficiently solve a broad range of KRR problems and overcome the failure modes of previous KRR preconditioners, making them ideal for practical applications.

AMS-MAA Invited Paper Session (aligned with the AMS-MAA Joint Lecture)
AI Ethics in Mathematics Departments: Navigating the Future of Research and Education
Saturday, August 10, 2:30 pm - 6:00 pm

While ethics often get taught in required philosophy courses designed to meet general educational criteria, there are unique ethical concerns within data science programs that should specifically be addressed within mathematics departments. For example, how can we best teach our students to be aware of ethical issues in modeling, black box machine learning algorithms, and data sources that may lead to predictions that amplify disparities. Outside of curricular development, there are also ethical issues surrounding AI and machine learning that arise in mathematical research. For example, understanding where modelers, journal article editors and reviewers, and commercial driven entities responsibility lie and what steps can be taken to immunize against future ethical issues are being deeply investigated and highly debated. This session will highlight how these ethical concerns are being addressed by mathematics departments both inside and outside of the classroom.

Organizers:
Diana Thomas, *United States Military Academy West Point*
Nicholas Clark, *United States Military Academy West Point*

Ethical Reasoning in the Algorithmic Age: Shaping Data Science and Mathematics Education
2:30 pm - 2:50 pm
Nicholas Clark, *United States Military Academy West Point*

In the algorithmic age, the convergence of data science and mathematics education must recognize the power of AI. Similarly, instructors in these three domains must recognize the importance of ethical practice in each. Ethical AI is not just an interdisciplinary venture, but a foundational one. This talk will discuss the essential nature of ethical reasoning -rather than "ethics" - in higher education with specific attention to courses and programs in, and supported by, departments of Mathematics. We will explore the construct of "integration, not concatenation", to demonstrate how instructors can deepen student engagement with data science, mathematics, and AI when ethical dimensions of practice in each are integrated into a course. Rather than making room in a course or curriculum for new ethics material ("concatenation"), integration involves the instructor or course developer recognizing opportunities in existing courses to capitalize on elements of ethical reasoning that can achieve this deeper engagement with key aspects of the topic or domain at hand. A focus on ethical reasoning also helps promote coherence in instruction - over time for the same course, or over courses throughout a curriculum - which

is less likely when topical or instructor-specific interests are featured to promote ethics-oriented curriculum objectives like "teaching social justice" or focusing on case analyses of current, specific, examples of illegal or unethical acts in the real world. Coherence of outcomes within a course, or across courses or time, is critically important for valid educational research as well as claims about achieving educational objectives. This talk will make the argument that ethical reasoning can provide this coherence to equipping students in departments of mathematics to be not just skilled, but also ethical, practitioners for a data-driven world.

Incorporating Ethical Reasoning in Calculus I
3:00 pm - 3:20 pm
Juliana Bukoski, *Georgetown College*
Cathy Erbes, *Hiram College*

As a fundamental course for STEM careers, Calculus I is an ideal place to introduce students to the ethical practice of mathematics. However, it can feel impossible to add extra material to an already-packed syllabus. In the summer of 2023, as part of the Framing Mathematics as a Foundation for Ethical STEM NSF grant, we developed a series of problems which integrate ethical reasoning and Calculus I topics. We then piloted the materials in our respective Calculus I classes in the following fall and spring. In this talk, we will share a sample of the problems as well as our challenges and successes in implementing them.

Development of a Capstone Course in Quantitative Ethics
3:30 pm - 3:50 pm
Delante Moore, *United States Military Academy*

The emergence of data science and its intersection with mathematics presents new ethical challenges in research and application. In response, the development of the course "MA490: Ethics in Math, Data Science, and Engineering" was initiated as part of the accreditation process for a new Applied Statistics and Data Science major. This talk, outlines the rationale, curriculum development, and objectives of MA490. The course is designed to embed ethical considerations into the mathematics and data science education framework, preparing students to address ethical dilemmas in their future careers. By leveraging case studies and theoretical discussions, MA490 aims to promote critical thinking about the societal impacts of mathematical and data science work. The presentation will detail the process of integrating ethics into the curriculum, including challenges encountered and strategies for effective teaching. Attendees will gain insights into the importance of ethics in the mathematical sciences and the potential of courses like MA490 to shape responsible practices in the field.

Avoiding future harms: Towards Teaching Ethics in a Computational Mathematics Program
4:00 pm - 4:20 pm
Rachel Roca, *Michigan State University*

As we live in an increasingly data-driven world, the mathematics community must grapple with the incorporation of data science and computing into mathematics education. Mathematics graduates have and will continue to contribute to the building of new machine learning models that have the potential to radically impact our world by promoting social good or reinforcing societal inequities. It is thus vital that we help shape our students' data science identities to value justice and ethics so that we achieve the former, and not the latter. This talk explores ethics education in Michigan State University's department of Computational Mathematics, Science, and Engineering (CMSE) through both student and faculty interviews. From these interviews, we'll discuss challenges and opportunities for implementing ethics

within classrooms. The varied interview responses iterate the need to explicitly engage with ethics in classrooms for students to develop into ethical data scientists and mathematicians.

Incorporating Ethics Throughout the Data Science Curriculum
4:30 pm - 4:50 pm
Mike Powell, PhD, *United States Military Academy*

The critical skills comprising a comprehensive data science education are numerous. Some skills are the focus of individual courses, while others pop up throughout the curriculum. As we began assessing our data science program against ABET student outcomes, we saw a lack of coordinated training in ethics. In this session, we will share our approach to integrating and assessing ethics-focused training across our data science program.

AI Ethics in Research: A Journal Editor's Perspective
5:00 pm - 5:20 pm
Nikhil Dhurandhar, PhD, *Innovation*
Paul W. Horn, *Distinguished Professor*
Helen Devitt Jones, *Texas Tech University*

I am an editor-in-chief for a journal ranked in the top quartile of Endocrinology & Metabolism and Nutrition & Dietetics journals worldwide. In my role, I increasingly handle manuscripts with novel applications of AI and machine learning in medicine. Because of algorithm complexity and a lag in common evaluation methods (like CONSORT), our role as editors and associate editors are challenged to find appropriate reviewers and specific issues to identify that may lead to bias and ethical concerns downstream. The increase in AI submissions is also met with a changing publishing landscape that encourages a fast review process and publications that may garner widespread attention. In this talk, I will lay out the challenges, some potential solutions, and questions for mathematics departments to entertain within their educational programs.

AI and Ethics in Research
5:30 pm - 5:50 pm
David B. Allison, PhD, *Indiana University School of Public Health-Bloomington*

With increases in availability of big data and complex mathematical methods accessible to non-AI trained scientists through push and play software, the potential for errors and misapplication of modeling is high. In this presentation, I review several of these issues and concerns in biomedical research that were identified after publication. Several recommendations to mitigate such errors prior to publication through peer review and appropriate collaborations with content matter experts will be made.

MAA Invited Paper Session (aligned with an MAA Invited Address)
Matching and Labelings in Graphs
Friday, August 9, 8:00 am - 10:30 am

Matchings and labelings are essential concepts in graph theory, which helps us understand the structure and properties of graphs. A matching in a graph consists of set of non-adjacent edges and it comes in various forms such as maximum matchings, perfect matchings, and stable

matchings. This area of research has found applications in resource allocation, scheduling, and optimization problems across diverse domains. Meanwhile, labelings involves assigning labels or weights to vertices or edges of a graph, and it has applications in algorithm design, network optimization, and data representation. By strategically assigning labels, we can optimize data or uncover hidden graph properties. In this session, we will review recent works in the area of matchings and labelings.

Organizers:
Sofiat Olaosebikan, *University of Glasgow*
Christine Kelley, *University of Nebraska-Lincoln*

Matching Permutations of Graphs
8:00 am - 8:20 am
David Galvin, *University of Notre Dame*

The {\it matching permutation} $\pi(G)$ of a graph G is obtained by writing the terms of the matching sequence $(m_i)_{i=1}^{\vu(G)}$ in non-decreasing order and reading off π from the indices (going from right to left). Here m_i is the number of matchings in G of size i and $\vu$ is the size of the largest matching, so $\pi(k)$ is the index of the kth smallest element of the matching sequence.

The matching permutation was introduced in 1987 by Alavi, Malde, Schwenk and Erd\H{o}s. They observed that since the matching sequence is always unimodal, at most 2^{m-1} of the $m!$ possible permutations of $\{\1, \ldots, m}$ can be realized as matching permutations as we run over all graphs with $\vu=m$. (This is in very sharp contrast to the situation when ``matching'' is replaced with ``independent set'', where all $m!$ permutations can be realized.)

They asked the question: is this bound of 2^{m-1} tight, or is it perhaps the case that there are only $o(2^m)$ matching permutations on $\{\1, \ldots, m}$? In joint work with Ball, Hyry and Weingartner we settle this question. I'll give our answer and mention some open questions.

Fair Stable Matchings: A Survey
8:30 am - 8:50 am
Christine T. Cheng, *University of Wisconsin-Milwaukee*

Two-sided matchings with preferences model many real-life problems like school choice, placements of medical residents and refugee settlements. The goal is to create a stable matching, and a standard method for deriving one is through the Gale and Shapley's Deferred Acceptance (DA) algorithm. Most instances have several stable matchings; some even have an exponential number of them. Unfortunately, it is well known that the DA algorithm can only output two types of stable matchings — one that is the "best" for the first set of agents and simultaneously "worst" for the second set of agents and another one that is the opposite. Thus, a natural question is how to find fair stable matchings. This talk will survey various notions of fairness and the computational complexity of the associated stable matchings.

0-Difference Distance Magic Oriented Graphs
9:00 am - 9:20 am
Alison Marr, *Southwestern University*

This talk will discuss 0-difference distance magic-oriented graphs (0-DDMOGs) which are vertex labelings of an oriented graph where for each vertex, the sum of the labels of the in-neighbors of that vertex equals the sum of the labels of the out-neighbors of that vertex. Along with the definitions, we will look at basic properties of 0-DDMOGs and specific classes of oriented digraphs where these labelings exist.

Structural Results in the Student-project Allocation Problem
9:30 am - 9:50 am
Sofiat Olaosebikan, *University of Glasgow*

The Student-Project Allocation problem with Lecturer preferences over Students (SPA-S) involves a set of students, projects and lecturers. The goal is to find a stable matching of students to projects in the sense that no student or lecturer would rather be matched to one other than remain with their current assignment, while respecting the project and lecturer capacities. There are two known polynomial-time algorithms for this problem – one finds a stable matching that is best for students while the other finds a stable matching that is best for lecturers. In addition to these two stable matchings, an instance of SPA-S could admit more stable matchings. In this talk, I will show that the set of stable matchings in an instance of SPA-S forms a distributive lattice under a natural dominance relation, with the student-optimal and lecturer-optimal stable matchings representing the maximum and minimum elements of the lattice, respectively.

Characterization of θ-free Matching Covered Graphs
10:00 am - 10:20 am
Rohinee Joshi, *Indian Institute of Technology Bombay*

A nontrivial connected graph is matching covered if each edge belongs to some perfect matching. For most problems pertaining to perfect matchings, one may restrict attention to matching covered graphs; thus, there is extensive literature on them. A cornerstone of this theory is an ear decomposition result due to Lovasz and Plummer, and it leads to a couple of problems that we discuss below.

A subgraph J of a graph G is conformal if $G - V(J)$ has a perfect matching. A graph J is a bisubdivision of a graph H if the former may be obtained from the latter by replacing each edge (in any subset of the edges) with a path of odd length. The aforementioned ear decomposition results of Lovasz and Plummer implies that every matching covered graph G, except K2 and even cycles, has a conformal subgraph J that is either a bisubdivision of θ or of K4. (Here, θ refers to the graph with two vertices joined by three edges.) This immediately leads to two problems: (i) characterize θ-free matching covered graphs (that is, those graphs that do not have a conformal subgraph that is a bisubdivision of θ), and (ii) characterize K4-free matching covered graphs. Kothari and Murty solved the planar case of the second problem; the nonplanar case is still open.

We provide a characterization of θ-free matching covered graphs; thus solving the first problem stated above. Our characterization is closely tied with a theorem due to Edmonds, Lovasz, and Pulleyblank, pertaining to the existence of special types of tight cuts in matching covered graphs.

MAA Invited Paper Session
Celebrating 50 Years of Embodied Mathematics in the Rubik's Cube
Saturday, August 10, 8:00 am - 12:00 pm

The Rubik's cube was invented 50 years ago. It physically embodies powerful mathematical concepts and the puzzle itself has inspired the creation of much new mathematics. The fact that it is a physical realization of group theory offers exciting connections between students and group theory concepts in learning environments. It can both motivate the student as well as offer a tactile engagement with permutation groups that are otherwise only abstract. Since we are celebrating the anniversary, this session attempts to give glimpses on multiple aspects of the cube. We will review its history and major theoretical progress including complexity and the diameter of the groups. But we will also feature discussions of its use in the classroom and what its hand-on aspect means. The goal of this session is to have diverse presentations and attract a broad audience so speakers will be encouraged to introduce concepts that they discuss.

Organizer:
Brett Stevens, *Carleton University*

The Rubik's Cube: A Relationship 'Building Block' in the Mathematics Classroom
8:00 am - 8:20 am
Daniel Van der Vieren, *Aims Community College*

The Rubik's Cube has the power to transform the mathematics classroom, particularly at the middle and high school levels. Although math can be an intimidating subject for many—often times leading students to question the utility in everyday life—the Rubik's Cube offers an intrigue that is matched by few of its kind. As an extension to his 2018 TedXBoulder talk, Dan will provide several activities and problem-solving exercises for students and teachers alike incorporating this iconic puzzle as we celebrate the 50th anniversary of the Rubik's Cube.

Generators, Conjectures, and Invisible Solutions: Exploring the Rubik's Cube with Undergraduates
8:30 am - 8:50 am
Ben Coté, *Western Oregon University*

Puzzles and games are wonderful entry points for undergraduates of all majors and backgrounds to engage in mathematical research. This talk will share some experiences, conjectures, discoveries, and observations from incorporating the Rubik's cube and other puzzles into undergraduate research experiences, courses for majors, and courses for future elementary/middle teachers.

Which Configurations of Rubik's Cubes Are Possible?
9:00 am - 9:20 am
Maria Nogin, *California State University Fresno*
Katherine Nogin, *Northwestern University*
Michelle Nogin, *Clovis North High School*

Our Math Circle participants love playing with Rubik's Cubes and its many variations, sharing algorithms, and creating patterns. They also ask some interesting questions such as whether it is possible

to switch two corners of a cube, rotate just one edge piece, or create a pattern that they thought of. In this presentation, we will show how some basic abstract algebra concepts such as the parity of permutations as well as a certain geometric argument can be used to answer questions like these. We will also share how a Rubik's cube can be used to illustrate permutations in proof-writing and abstract algebra courses.

Opening Moves: Reducing the Average Move-count at the Start of a Popular Solution Approach
9:30 am - 9:50 am
Morley Davidson, *Kent State University*

The opening moves of most hands-on solution approaches can involve so many cases that lookup tables are typically abandoned in favor of 'intuitive' moves, placing the move-count analysis on a shaky foundation. Meanwhile, further subdividing eg. a two-step starting approach, as in the popular 'Cross' and '2x2x2' approaches, typically sacrifices move-count efficiency. In this talk we focus on the latter approach and present a non-traditional four-step construction that has reasonably good average move-counts, due to internal cancellation, while keeping the lookup tables small enough for practical Cube solving.

Hypercubing Heads Home
10:00 am - 10:20 am
Roice Nelson, *GE Aerospace*

Over the past few decades, a mathematically minded group has been uncovering analogues of Rubik's cube in far away abstract places. This group first formed around the hypercubical 3x3x3x3 (or 3^4) Rubik analogue, so we call ourselves hypercubers. In the last few years, Melinda Green pivoted our journey back towards the original. She and other members developed a physical puzzle with a symmetry group isomorphic to the 2^4 hypercube puzzle. This talk will share highlights of our adventures into abstraction and landing back in the physical world. Join us in the fourth dimension and play with a physical hyperpuzzle yourself!

Solving the Cube (for Beginners)
10:30 am - 10:50 am
Art Benjamin, *Harvey Mudd College*

Rubik's Cube Solving Workshop
11:00 am - 12:00 pm
Art Benjamin, *Harvey Mudd College*
Brett Stevens, *Carleton University*

Learn to solve the Rubik's cube in 8 steps. Bring your own cube if you have one.

MAA Invited Paper Session (aligned with the Gardner Lecture)
Mathematics and Art
Friday, August 9, 2:00 pm - 6:00 pm

This invited paper session features some leading figures in the diverse and interdisciplinary field of mathematics and art. Over their careers, these scholars and artists have transformed mathematical concepts into captivating works of art, deepened our understanding of art through

their mathematical insights, created elegant ways of presenting complicated mathematical ideas through art, fostered a sense of community by intertwining mathematics and art, and inspired broad audiences, including those not traditionally drawn to mathematics.

Organizer:
David Richeson, *Dickinson College*

Counting with Sol LeWitt
2:00 pm - 2:20 pm
Robert Bosch, *Oberlin College*

The conceptual artist Sol LeWitt (1928–2007) made several artworks whose titles contain the phrase "three-part variations on three different kinds of cubes." To a mathematician, these pieces suggest a counting problem: How many distinct variations are there? In this talk, we will discuss several examples of LeWitt's combinatorial artwork. In addition, we will prove that the mathematically correct number in LeWitt's "All Three-Part Variations on Three Different Kinds of Cubes" is 57, not 56, the number he obtained. This is joint work with Ilana McNamara, Oberlin College class of 2024.

Geared Mechanisms
2:30 pm - 2:50 pm
Henry Segerman, *Oklahoma State University*

I'll talk about various works of kinetic art based on gears and racks.

Zippered Surfaces and Other Topological Quilts
3:00 pm - 3:20 pm
Sabetta Matsumoto, *Georgia Institute of Technology*

In this talk, I discuss several projects that use sewing to explore topological surfaces. In one, we use zippers as a way to understand Euler's Formula. Likewise, the Klein Quartic can form a compact structure with genus 3 or it can cover a genus 3 triply periodic minimal surface.

Using a Polyhedral Canvas
3:30 pm - 3:50 pm
Carolyn Yackel, *Mercer University*

This talk will focus on three-dimensional art with polyhedra as an inspiring feature. Classes of examples from numerous artists will be included, after which the presenter will focus on examples from her own work to discuss some of the mathematical issues that arise.

Enumerating Truchet Tilings and Afghan Squares
4:00 pm - 4:20 pm
Peter Kagey, *Harvey Mudd College*

One technique for knitting or crocheting an afghan involves joining together many squares, each decorated with a pattern. Given a collection of such square patterns—and viewing the afghan as a grid or a covering space of a cylinder or torus—we can count the number of resulting afghans up to arbitrary symmetries of the square and rectangle, along with cyclic shifting of rows and columns. This provides a

unifying framework for understanding a family of counting problems, and generalizes work by Ethier and Lee counting tilings of the torus by tiles of two colors. This is joint work with Bill Keehn of the Prison Mathematics Project.

Constructing Outreach: Participatory Mathematical Craft
4:30 pm - 4:50 pm
Glen Whitney, *Prison Mathematics Project*

Involving many people in the cooperative construction of human-scale geometric sculptures provides a potent tool for overcoming barriers to appreciating mathematics. This presentation will share examples, challenges, and reflections from fifteen years of group building projects.

Double Take: Perspective Illusions That Make You Look Again
5:00 pm - 5:20 pm
Annalisa Crannell, *Franklin & Marshall College*

Perspective art, so it's said, was the art that made paintings seem realistic and lifelike. Yet the same artistic techniques --and by extension, the same geometry -- can create images that astound and confound us. This talk will provide a carnival of such examples, from special effects in the movies, to sculptures that seem to move as we move, to lunar illumination, to "vampire" objects whose mirror images transform them into other beings.

Rainbow Equality from the Fifth Dimension
5:30 pm - 5:50 pm
Frank Farris, *Santa Clara University*

The RGB color model exemplifies how engineering can sometimes dictate human practice. Yes, it's connected to the biology of how most human's eyes receive signals for color, but human perception is far more complicated than these three primary colors. When I go to assign colors to a mathematical object, it's all too easy to put Red, Green, and Blue in charge. Inspired by a result about Venn diagrams for five sets, I break out of the RGB mold and make the case for sets of five primary colors that, with some constraints, can be chosen by the user.

MAA Invited Paper Session
Rethinking Number Theory
Thursday, August 8, 8:00 am - 11:00 am

Rethinking Number Theory is a 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.

Organizers:
Tyler Billingsley, *Rose-Hulman Institute of Technology*
Deewang Bhamidipati, *University of California, Santa Cruz*
Sandra Nair, *Colorado State University*

Twisted Number Field Counting
8:00 am - 8:20 am
Shilpi Mandal, *Emory University*

The archetypal question in number field counting asks that given a number field K, and a numerical invariant inv($L/$��) of finite extensions of K, what is the asymptotic behaviour of the counting function $N(K;X)=\#\{L/K \mid \mathrm{inv}(L/K)<X\}$ as $X\to\infty$?
Alberts proposed a 'twisted' version of Malle's conjecture, which we consider in the case of $G=$��8 (the dihedral group of 16 elements), T a normal subgroup isomorphic to ��4, $K=$��, and M an arbitrary quadratic field. The culmination of our project would be the first non-abelian twisted count in the literature, with the Galois group acting on T by a nontrivial outer automorphism of $D4$. In this talk, I will present the twisted count and give an exposition of our approach, which is based on local-to-global principles in embedding problems. We do the twisted count by counting the number of solutions to a twisted embedding problem. Through the work on our motivating example, we have evidence that the solubility of the corresponding local embedding problems is dictated by values of Legendre symbols with modulus equal to the discriminant of certain extensions.

Low Degree Points on Surfaces
8:30 am - 8:50 am
Freddy Saia, *University of Illinois Chicago*

For an algebraic curve C over a number field F, defined by polynomial equations with coefficients in F, let δ denote the least integer d so that C has infinitely many points with coordinates in degree equal to (or at most) d. This should be interpreted as an arithmetic measure of ``how irrational'' the curve C is. There has been a significant amount of interesting work related to this invariant in the last few decades, while comparatively less is known about analogous arithmetic measures of irrationality in higher dimensions. We will probe the case of surfaces, focusing on specific examples that provide traction in this problem. This is joint work with Luke Askew and Nathan Chen.

An Overview of the Rethinking Number Theory Workshop Experience
9:00 am - 9:20 am
Sandra Nair, *Colorado State University*

Number theory in the twenty-first century has grown to encompass many research avenues. However, it retains a reputation for being unfriendly towards individuals from traditionally underrepresented and minoritized communities. Rethinking Number Theory is a virtual research workshop series that began in the early remote-working days of 2020, in response to the challenges faced by these communities. The goals of the workshop are for participants to learn new math, get to know colleagues, and have a joyful, affirming research experience. An important part of the Rethinking Number Theory workshops is providing the space, opportunity, and conversational prompts to discuss ways in which the mathematical community can be made more inclusive. In this talk, we will describe some of the structural choices that we made to ensure that we could welcome and support all participants. We will also share our reflections on why this workshop is important and what we hope to work on to keep improving it.

People over Mathematics: Setting Up An Effective Research Group
9:30 am - 9:50 am
Eva Goedhart, *Franklin & Marshall College*

In the Rethinking Number Theory Community, the organizers teach us the importance of establishing open communication, trust, and flexibility, allowing for each of us to be ourselves. I will share a little about what I have experienced in my research groups and hope that will inspire some of yours.

Bianchi Modular Forms
10:00 am - 10:20 am
Kalani Thalagoda, *Tulane University*

In this talk, I will introduce techniques to compute Bianchi modular form over imaginary quadratic fields with non-trivial class groups. I will give examples we computed for the imaginary quadratic field $Q(\sqrt{-17})$. This is joint work with Dan Yasaki.

Further Improvements to the Chevalley-Warning Theorems
10:30 am - 10:50 am
Rachel Petrik, *Rose-Hulman Institute of Technology*

Let $\textit{\textbf{f}} = \{f_1, \dots, f_r\}$ with $f_i \in \mathbb{F}_q[x_1, \dots, x_n]$. Let $d_i = \deg(f_i)$ for $1 \leq i \leq r$ and define the degree of $\textit{\textbf{f}}$ to be $d := d_1+ \dots + d_r$. Let $Z(\textit{\textbf{f}}, \mathbb{F}_q^n)$ be the set of zeros of $\textit{\textbf{f}}$ over $\mathbb{F}_q$ and let $N(\textit{\textbf{f}}, \mathbb{F}_q^n) = |Z(\textit{\textbf{f}}, \mathbb{F}_q^n)|$.The Chevalley--Warning Theorem states that if $N(\textit{\textbf{f}}, \mathbb{F}_q^n) \geq 1$, then $N(\textit{\textbf{f}}, \mathbb{F}_q^n) \geq q^{n-d}$. Examples exist showing this lower bound is optimal. In 2011, Heath-Brown showed that all examples meeting this lower bound have the property that the set of zeros forms an affine space of $\mathbb{F}_q^n$ and by excluding these examples improved the lower bound. In this talk, we improve Heath-Brown's lower bound. In addition, we provide results that show some of the improved bounds are optimal for particular values of q, d, and n. This is joint work with David B. Leep.

MAA Invited Paper Session
Coloring and Labeling in Graphs
Saturday, August 10, 3:00 pm - 6:00 pm

The Four Color Theorem is one of the most famous theorems in graph theory, and perhaps one of the most famous theorems in the field of mathematics. One form of the theorem states that the regions of any map can be colored with four or fewer colors so that no two regions sharing a boundary line have the same color. While this was first conjectured to be true in the 19th century, it took over a century for a complete proof to be developed. In that time, the coloring of graphs captured the minds of mathematicians across the globe. Today, coloring plays a much more varied and nuanced role in the study of graph theory. Many different aspects of graphs have been colored using a variety of different rules and restrictions, leading to an incredibly rich and diverse field of study. In some cases, we might replace the colors with “labels” and study the

interplay between labelings and the structural features of graphs. In this session, we take a sampling of the various ways coloring and labeling play a role in modern graph theory research.

Organizer:
Andrew Bowling, *Wabash College*

Coloring with Forbidden Subgraphs
3:00 pm - 3:20 pm
Neal Bushaw, *Virginia Commonwealth University*

What happens when we forbid particular colorings of some fixed graph F, in a large properly edge-colored host graph G? Does G just resemble a graph with all copies of F forbidden (forgetting the coloring altogether)? If we request that G is edge-maximal, do we find traditional F-saturated graphs, or do the details of the coloring lead to different extremal graphs? We'll discuss some of the history of this variant of the classical forbidden subgraph problem, explore the subtleties of the rainbow extremal and saturation numbers, and then mention a few new results on these parameters for some particular classes of graphs.

Prime Labelings of Zero-Divisor Graphs
3:30 pm - 3:50 pm
Brad Fox, *Austin Peay State University*

The *zero-divisor* graph of a commutative ring R, denoted by $\Gamma(R)$, has the set of its non-zero, zero-divisors as the vertices with edges connecting any pairs that multiply to be zero. We investigate these graphs for particular classes of rings to determine the existence of a *prime labeling*, in which we label the vertices with distinct integers 1 to $|V(\Gamma(R))|$ so that any adjacent pairs have relatively prime labels. In this talk, we will develop prime labelings for zero-divisor graphs of some infinite families of rings, as well as show that there are infinitely many where a prime labeling does not exist.

Coprime Labelings of Graphs
4:00 pm - 4:20 pm
Michael Brilleslyper, *Florida Polytechnic University*

A *coprime labeling* of a graph is one where integer labels on vertices connected by an edge must be coprime. Given a set of consecutive integers, we can construct a graph with a maximal number of edges for which the integers form a coprime labeling. We can also construct the graph's complement, the cofactor graph. Isolated vertices in the cofactor graph play a pivotal role in coprime labelings of complete bipartite graphs. For a consecutive set of integer labels, we investigate which complete bipartite graphs admit coprime labelings. Finally, we mention there are consecutive sets of integers that cannot coprime label any complete bipartite graph, the so-called stapled intervals.

Four Coloring Plane Graphs Using a Deterministic Algorithmic Approach
4:30 pm - 4:50 pm
Weiguo Xie, *University of Minnesota Duluth*

The Four Color Theorem states that the regions of any plane graph can be colored with four or fewer colors so that no two regions sharing a boundary line have the same color. Alfred Kempe used the maximal sets of connected regions having at most two colors, now known as *Kempe chains*, in an attempt

to prove the Four Color Theorem. While Kempe's original proof technique was flawed, his approach can be modified and strengthened to create effective deterministic coloring algorithms. We describe several such algorithms and discuss their efficacy on a large variety of graphs.

Using the Combinatorial Nullstellensatz to Find Zp-magic Graphs
5:00 pm - 5:20 pm
Daniel Roberts, *Illinois Wesleyan University*

For the purpose of this talk, define an edge labeling of a graph G to be a function f : E(G) → Zk \ {0} where k is a positive integer. An edge labeling induces a vertex labeling f+ : V (G) → Zk defined by f+(v) = □uv∈E(G) f(u). If f+ is a constant function, then we say that f is a Zk-magic labeling of G. The driving question for this line of research is: for which values of k does there exist a Zk-magic labeling of a given graph G? In this talk, we will see how to apply the Combinatorial Nullstellensatz to show the existence of Zp-magic labelings (p prime) for some graphs.
This is a non-constructive method of showing that such labelings exist.

The Four Color Theorem from a Labeling Perspective
5:30 pm - 5:50 pm
Andrew Bowling, *University of Minnesota Duluth*

The Four Color Theorem has captivated the imaginations of mathemati¬cians for well over a century. Before the Four Color Theorem was proven, Peter Tait formulated a relationship between four-coloring the regions of cubic maps and three-coloring their edges. More recently, Cooroo Egan developed a vertex labeling called a *zonal labeling*, in which the vertices of a plane graph are labeled with the elements 1, 2 of Z_3 such that the sum of labels on the boundary of each region is 0. It has been shown that a cubic map has a three-coloring of its edges if and only if it has a zonal labeling. We dualize the notion of zonal labelings into what we call a *cozonal labeling* and demonstrate how this new perspective offers advantages in studying certain features of four-coloring.

MAA Invited Paper Session
The Mathematics of Post-Quantum Cryptography
Friday, August 9, 3:00 pm - 6:00 pm

Public-key cryptography allows Alice to send Bob a secret message without previously sharing a secret key. In addition to its practical value, public-key cryptography has become a popular way to motive the teaching of concepts in elementary number theory, abstract algebra, and introduction to proof courses, as well as in cryptography courses. Unfortunately, many experts expect quantum computers to make common forms of public-key cryptography obsolete in the near future. Fortunately, there are several systems being evaluated to replace RSA and the other systems we currently use. Many of these systems are either quite manageable to grasp or have simplified versions which can be manageable for both instructors and the general mathematical public.

The modern idea of public-key cryptography is based on "hard problems" --- puzzles which are easy to construct and hard to solve. Hard number theory problems, such as factoring and discrete

logarithms, are involved in the vast majority of encrypted messages on the Internet today. Cryptographers are looking in all corners of mathematics for more hard problems that quantum computers won't be able to defeat. There are five major types of hard problems under consideration: lattice problems, code problems, multivariable polynomial problems, hash function problems, and elliptic curve isogenies. Current research is ongoing to determine how hard these problems really are and how feasible it is to base public-key systems on them. This session will provide introductions to some of the major types of mathematical problems under consideration, including how they work and why we think they might be hard (or not).

Organizers:
Joshua Holden, *Rose-Hulman Institute of Technology*
Chris Christensen, *Northern Kentucky University*

The NIST Post-Quantum Cryptography Standardization Project
3:00 pm - 3:20 pm
Angela Robinson, *National Institute of Standarda and Technology (NIST)*

The National Institute of Standards and Technology (NIST) initiated a public process to select quantum-resistant public key cryptographic algorithms for standardization in response to the substantial development and advancement of quantum computing. NIST issued the public call for submissions to the PQC Standardization Process in December 2016 and, after three rounds of evaluation and analysis, announced the selection of the first algorithms to be standardized: CRYSTALS-KYBER, CRYSTALS-Dilithium, FALCON, and SPHINCS+. In this talk we will discuss the three current NIST PQC endeavors: drafting standards for the four selected algorithms, the remaining algorithms under consideration in the 4th round of evaluation, and additional digital signatures submitted for standardization consideration.

Post-quantum Cryptography, A New Era
3:30 pm - 3:50 pm
Jintai Ding, *Tsinghua University and BIMSA*

Public key cryptosystems (PKC) are the security foundation of modern communication systems, in particular, the Internet. However Shor's algorithm shows that the existing PKC like Diffie-Hellmann key exchange, RSA and ECC can be broken by a quantum computer. To prepare for the coming age of quantum computing, we need to build new public key cryptosystems that could resist quantum computer attacks. In this lecture, we will give an introduction to post-quantum cryptography and its recent developments, in particular, the NIST standardization process and its impact. Then we will present a practical and provably secure key exchange protocol based on the learning with errors problems, which is conceptually simple and has strong provable security properties. This new construction was established in 2011-2012. We will explain that all the existing LWE-based key exchanges are variants of this fundamental design.

On the Decoding Failure Rate of BIKE
4:00 pm - 4:20 pm
Tyler Billingsley, *Rose-Hulman Institute of Technology*

BIKE, a fourth round candidate in the NIST Post-Quantum Cryptography Standardization process, is a code-based cryptosystem whose security relies on the difficulty of the syndrome decoding problem for general binary linear codes. However, the codes used in BIKE are far from general binary linear codes,

and the decoder used has various constraints that can cause it to fail to decode a syndrome. Though the failures occur with conjectured extreme rarity, an adversary who obtains enough of them can recover the secret key. Motivated by this, after introducing BIKE and the main decoding problem, we will discuss some ongoing efforts to better understand the decoding failure rate (DFR) of BIKE. This is joint work with Sarah Arpin, Daniel Hast, Jun Bo Lau, Ray Perlner, and Angela Robinson.

Post-SIDH Isogeny-based Cryptography
4:30 pm - 4:50 pm
David Jao, *University of Waterloo*

Elliptic curves and arithmetic geometry provide fertile ground for mathematicians and researchers seeking to unearth beautiful mathematics amidst the rich interplay between algebraic and geometric structures. In recent years, cryptographers have gained interest in constructing post-quantum cryptosystems based on isogenies between elliptic curves and abelian varieties. One of the oldest such cryptosystems, the Supersingular Isogeny Diffie-Hellman (SIDH) scheme, advanced to the fourth round of the NIST post-quantum cryptography standardization process before being broken in 2022. However, the scheme remains potentially relevant today because various researchers have proposed new cryptosystems based on SIDH as candidates for further study. In this presentation, we survey the mathematics of isogeny-based cryptography, the construction and break of SIDH, and current proposals for post-quantum isogeny-based cryptosystems.

Panel Discussion
5:00 pm - 5:50 pm
Angela Robinson, *National Institute of Standarda and Technology (NIST)*
Jintai Ding, *Tsinghua University and BIMSA*
Tyler Billingsley, *Rose-Hulman Institute of Technology*
David Jao, *University of Waterloo*
Joshua Holden, *Rose-Hulman Institute of Technology*

Moderator:
Chris Christensen, *Northern Kentucky University*

MAA Invited Paper Session
Knot Theory and Not Knot Theory
Saturday, August 10, 8:00 am - 11:00 am

“But what are the applications?” asked an audience member at the end of every math talk ever. For knot theorists, answering this question is easy. Most knotty researchers will respond by mentioning connections coming from the sciences, like modeling molecules or DNA with knots. We may even bring up the uses of knots in medicine, for instance in developing cancer drugs. (And don’t get us started on string theory!) If we wanted to derail the entire Q&A session after the talk, however, we could go on for hours about the connections of knots to visual art, dance, fashion, machine learning, quantum computing, archaeology, and even magic! In this session, we will indulge ourselves in an exploration of connections between knots and, well, everything else. We hope you’ll join us.

Organizers:
Allison Henrich, *Seattle University*
Inga Johnson, *Willamette University*

More (tie) Knots than We Thought
8:00 am - 8:20 am
Mikael Vejdemo-Johansson, *CUNY College of Staten Island*

Right at the turn of the millennium, Thomas Fink and Yong Mao created a description of necktie knots through a formal language, and used this to enumerate all possible tie knots. They found 87 knots, including (remarkably) several not previously known knots. However, these 87 it turns out are not actually all reasonable tie knots: in 2012, instruction videos for novel tie knots - the Trinity and the Eldredge - went viral. These knots emerge from attempts to reverse engineer movie costuming, and break with several of the assumptions that Fink and Mao made to define and describe tie knots.
In a collaboration with several colleagues and students, I worked out a modification of Fink and Mao's formal language that can describe these novel tie knots, and used this to re-examine the question of how many tie knots are possible. This takes us through a theorem by Chomsky and Schützenberger to systems of algebraic equations and generating functions to ultimately show the existence of 266,682 tie knots (up to mirror symmetry) with a reasonable length necktie.
In this talk I will walk you through these results and the formal languages for describing tie knots. If you don't bring your own necktie to follow along, I will have neckties available to borrow at the talk.

Knotting in Proteins
8:30 am - 8:50 am
Helen Wong, *Claremont McKenna College*

A small but significant portion of proteins contain knots, and the knotting is believed to be significant to their biological function. However, very little is known about how those proteins fold into their knotted native states. In this talk, we will discuss a topological method (based on knot polynomials) to characterize the knotting, and how the resulting topological information can be used to develop and test theoretical folding pathways for knotted proteins.

Relationships Between Discrete Knot Invariants and Analytically Defined Quantities
9:00 am - 9:20 am
Max Lipton, *Massachusetts Institute of Technology*

Classical knot theory concerns itself with discrete invariants such as the crossing number, but knots themselves are simple closed curves in R^3 which are best studied with tools from differential geometry like the Frenet frame and curvature. Since there are uncountably many ways to isotope and reparametrize a knot, it is somewhat of a miracle that we can extract said discrete invariants. I will discuss examples of the relationship between the discrete and continuous.

Artistic Knots
9:30 am - 9:50 am
Henry Segerman, *Oklahoma State University*

I'll talk about my work (and some friends' and colleagues' work) in making art, illustrations, and visualizations of knots and related topological objects, in 3D printing and other media.

Knots and Quantum Computing
10:00 am - 10:20 am
Colleen Delaney, *UC Berkeley*

Building quantum computers capable of solving problems outside the reach of classical computers will require the operation of vast numbers of quantum bits with a very small rate of error. Some proposals for realizing large-scale fault-tolerant quantum computers are inspired by topology -- whether by building clean qubits using materials whose physical properties are topologically invariant, or by performing topological error correction on noisy conventional qubits. In this talk we will explain and explore connections between topology and quantum computing by visualizing the knots and links carved out by particle-like objects in certain quantum materials as they travel through space and time. We'll also discuss the topological invariants their physics computes and how knot theory can be applied to classify their "topological phase of matter".

Knots in Life
10:30 am - 10:50 am
Isabel Darcy, *University of Iowa*

Have you ever woken up in the morning and felt like your brain is tied in knots? The protein ubiquitin hydrolase is very abundant in your brain and contains a local 5 crossing knot. DNA can also become knotted. Tangles equations can be used to model these shapes. A tangle consists of strings embedded within a 3-dimensional ball. Thus a knot can be divided into the sum of two tangles. We will discuss applications of knots in biology including solving tangle equations modeling biological reactions.

MAA Invited Paper Session
Topology ∩ Teaching: Knot Theory Research at Primarily Undergraduate Institutions
Thursday, August 8, 8:00 am - 12:00 pm

Knot Theory, a broad subfield of low-dimensional topology, provides an accessible on-ramp for undergraduate students into mathematical research. However, current research in knot theory often requires tools and background beyond a standard undergraduate curriculum. Furthermore, faculty at PUIs must balance their research commitment with a substantial teaching load.

In this session, speakers will discuss a variety of knot theory projects accessible to undergraduate research. Possible topics include:

- Diagrammatic constructions such as crossing changes, link homotopy, satellite surgery
- Algebraic tools such as quandles, polynomial invariants, Milnor's invariants
- Applications of Heegaard Floer homology to knot surgery, cobordism theory
- Applications of knot theory to the natural sciences such as protein folding

In addition to the mathematical content, presenters will discuss successful approaches to creating sustainable research programs, including projects for undergraduate math students. Topics may include (1) building research collaborations with other PUI faculty, (2) scaffolding projects for students at a variety of levels, (3) transitioning from an undergraduate research project to an

undergraduate research program as a faculty member with a substantial teaching load, and (4) how to equitably provide access to these experiences, including securing required funding for researchers. This session will include collaborative brainstorming and workshop components.

Organizers:
Anthony Bosman, *Andrews University*
Christopher W. Davis, *University of Wisconsin-Eau Claire*
Taylor Martin, *Sam Houston State University*
Carolyn Otto, *University of Wisconsin-Eau Claire*
Katherine Vance, *Simpson College*

Undergraduate Research Involving Local Moves on Links
8:00 am - 8:20 am
Anthony Bosman, *Andrews University*

In this talk we highlight a series of undergraduate mentored projects that investigated the role of local moves on links. Two of the projects, led as summer research experiences over two summers, investigated the role of delta-moves on links. In particular, they studied the minimum number of delta-moves needed to unlink a link with pairwise vanishing linking number, as well as the more general problem of determining the number of delta-moves needed to transform one link into another. Another project studied links obtained by strong fusion, giving a complete classification of pretzel links. We use these projects to reflect on broader themes of undergraduate research, such as identifying accessible yet mathematically interesting problems for students with various levels of mathematical maturity to work on.

Knots, Juggling, and Us
8:30 am - 8:50 am
Ana Wright, *Davidson College*

This year I advised an undergraduate student honors thesis by Ivy Keegan Stump in virtual knot theory and juggling. Devadoss and Mugno described a way of mapping juggling patterns with two hands to classical knots. Ivy Keegan's project generalizes this idea to juggling patterns with an arbitrary number of hands (with multiple jugglers) and virtual knots. I also taught a knot theory course where the students explored problems in knot theory and gave final presentations on their choice of topics in knot theory. I will discuss the honors thesis project and my experience with introducing students to knot theory. In particular, I will talk about how students can find their own interests in knot theory.

Undergraduate Research in Virtual Knots & Crossing Weights
9:00 am - 9:20 am
Sarah Seger, *Concordia College*

Virtual knot theory is a generalization of the classical theory that rapidly expands the number of objects of study. For example, there is only one unique classical knot with 4 crossings, but there are over 500 unique virtual knots with 4 crossings! Virtual knot theory is also a relatively new field, first introduced by Louis Kauffman in 1999, meaning there is a lot to explore. We can represent virtual knot diagrams by Gauss codes, opening the opportunity of using programming in student research. From Gauss codes we can extract the "weight" of each crossing. It is well known that for classical knots, every crossing has weight zero, but there also exist nonclassical knots with this property. One student summer research project investigated virtual knots for which all crossings have weight zero, discovered a set of

virtualization moves and showed that all such knots up to 6 crossings are related to classical knots by these moves. A second summer research project enhanced the Generalized Alexander Polynomial with crossing weight information and found that there were virtual knots with 5 crossings where both the Generalized Alexander Polynomial and the Z-Parity Polynomial vanish but their new polynomial did not vanish, proving that it gives new information.

Unexpected Directions
9:30 am - 9:50 am
Margaret Doig, *Creighton University*

I will describe two separate research problems related to knot theory which were influenced by supervising undergraduates: a program to calculate and formulate and prove conjectures about knot genus through grid Floer homology; a program to understand the statistical distribution of knot invariants in the grid diagram model. The first was assisted by an undergraduate computer science major interested in industry who worked as a developer for me for a summer. The second was directly inspired by a line of inquiry another student independently followed in a graph theory project. I will also comment briefly on some other research projects outside of topology which I likely never would have pursued without the unique pressures and freedom of working at an undergraduate institution.

Discussion & Brainstorming Session
Thriving in the intersection: Topology \cap Teaching
10:00 am - 10:50 am

The session organizers will facilitate discussion and brainstorming of different approaches to creating sustainable research programs at PUIs, including projects for undergraduate math students. Topics may include (1) building research collaborations with other PUI faculty, (2) scaffolding projects for students at a variety of levels, (3) transitioning from an undergraduate research ***project*** to an undergraduate research ***program*** as a faculty member with a substantial teaching load, and (4) how to equitably provide access to these experiences, including securing funding for researchers.

Knot Mosaics, Old and New
11:00 am - 11:20 am
Aaron Heap, *SUNY Geneseo*

Knot Mosaic Theory is a relatively young branch of knot theory, introduced by Sam Lomonaco and Louis Kauffman, in which knot diagrams are created as a square matrix with entries chosen from a collection of 11 mosaic tiles that depict segments and crossings of the knot diagram. There have been several results in recent years, attributed in part to undergraduate student researchers, related to space efficiency of knot mosaics and the completion of the table of knot mosaics for all prime knots with crossing number 10 or less. Additionally, new sets of tiles have emerged that improve upon space efficiency. We will explore these results and provide a collection of open question.

Learning the Ropes by Playing Games
11:30 am - 11:50 am
Allison Henrich, *Seattle University*

Getting involved in mathematics research has countless benefits for students. First-time researchers learn how to formulate good questions, play with examples to develop their intuition, read and write technical papers, give professional talks on complex subjects, work cohesively within a group, and more. Studies

have shown that working on a research project early in a student's college experience has positive impacts on students' retention to graduation. Despite the clear benefits, many students lack access to research opportunities until late in their studies. But early entry points into math research are possible! In this talk, we'll learn about the exciting world of knot games! We'll explore published results that were proven by students with little more than a Calculus 1 background. We'll also share open problems and ideas for how faculty and students at all levels can get involved in knot games research.

MAA Invited Paper Session
Trends in Mathematical and Computational Biology
Part A: *Thursday, August 8, 4:00 pm - 6:00 pm*
Part B: *Saturday, August 10, 3:00 pm - 5:00 pm*

Mathematical and computational biology encompasses a diverse range of biological phenomena and quantitative methods for exploring those phenomena. The pace of research at this junction continues to accelerate and substantial advancements in problems from gene regulation, genomics, phylogenetics, RNA folding, evolution, infectious disease dynamics, neuroscience, growth and control of populations, ecological networks, drug resistance modeling, and medical breakthroughs related to cancer therapies have increasingly ensued from utilizing mathematical and computational approaches. Our session on current trends will sample from this diversity of important questions from biology and medicine and their mathematical treatments, with a goal of maximizing the range of topics and research methods presented at the session. Mathematical approaches will include deterministic and stochastic continuous dynamical models, as well as finite dynamical systems and combinatorial and algebraic methods.

Organizers:
Timothy Comar, *Self-Employed*
Anne Yust, *University of Pittsburgh*
Erin Bodine, *Rhodes College*

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

Part A: *Thursday, August 8, 4:00 pm - 6:00 pm*

Towards A Modeling Framework For Pediatric Sickle Cell Pain
4:00 pm - 4:20 pm
Reginald McGee, *College of the Holy Cross*

Sickle cell pain presents in acute episodes in pediatric patients, as opposed to the chronic pain observed in adults. The episodic nature of pain events in pediatric patients necessitates a distinct approach from what has been used to mathematically model pain severity levels in adults. Statistical studies have examined interactions between sleep actigraphy measurements --- like sleep quality and sleep efficiency --- and pain levels in pediatric populations, and we propose a framework for modeling pediatric pain dynamics that incorporates the effects of sleep actigraphy and electronic survey data over varying time windows. We hypothesize that cumulative effects of these measurements will be more important than daily

measurements in both replicating pain severity levels and determining markers of a pain episode. The ability to identify markers preceding the onset of a pain episode will be crucial in improving patient quality of life. We present work in progress towards developing this modeling framework and a parameterization strategy to fit aggregate data for subpopulations of patients defined by age and course of treatment.

A Mathematical Model of the Impacts of Climate Change on the Winter Tick Epizootic in Moose
4:30 pm - 4:50 pm
David Elzinga, *University of Wisconsin-La Crosse*

The winter tick (*Dermacentor albipictus*) is a cervid targeting parasite that poses serious conservation concerns for moose (*Alces alces*) in North America. Described as a greater "enemy" of moose than wolves, bears, and cougars, winter tick parasitism causes moose to excessively groom during nutritionally limited periods, leading to lethal combinations of malnutrition and wound-infections. We construct two mathematical models using ordinary differential equations (ODEs) which are informed by the empirical literature to recreate in silico the seasonal relationships between winter ticks and moose. We then use our mathematical model to forecast the stability of this parasitic relationship as season lengths fluctuate due to climate change. Finally, we test the high-risk conservation hypothesis that limited, seasonal culling can improve moose population stability in the face of these challenges. Our model suggests that delayed first-frosts due to climate change poses a serious threat to maintaining moose populations, but that moderate winter hunting strategies can reduce the threat of extirpation by lowering the tick burden.

Costs and Benefits of Multi-partner Mutualisms: An Integral Projection Modeling Approach
5:00 pm - 5:20 pm
Ali Campbell, *Rice University*

Understanding interspecific mutualisms is a challenge, because they are among the most widespread species interactions with diverse and dynamic consequences. Depending on the environmental contexts the outcome of an interspecific cooperation can range from parasitic to mutualistic. Most studies focus on a pair of species interacting in a mutualism, however often this is a simplification of the reality. These mutualistic interactions become even more complex when put into the context of a multi-species mutualism, where there are multiple partners interacting with the same focal species. The partners can directly impact the focal species through the interactions, and indirectly impact them through interactions with each other. The cactus Cylindriopuntia imbracata forms symbioses with multiple ant species, but each individual plant can interact with only one species at a time. Using a long-term dataset, we show that there are differences in the impacts of different ant partners on various vital rates of the cacti across ontogeny. Our results demonstrate the importance of evaluating a mutualism within a community context and suggest that even slight differences of rewards between mutualist partners can help promote fitness of the cacti.

Modeling the Dynamics of Students' Math Anxiety in the Classroom
5:30 pm - 5:50 pm
Matthew Mizuhara, *The College of New Jersey*

Math anxiety is the stress induced by doing or solving mathematics. It can affect overall performance, sense of belonging, and long-term retention of students in the STEM pipeline. Among the many techniques used to reduce math anxiety, we focus specifically on the role of peer learning (e.g., group work) in the classroom. Together with undergraduate collaborators, we have developed a preliminary computational model to investigate the effect of group work on the evolution of individuals' math anxiety

levels. This so-called bounded confidence model framework has been adapted from other studies on interpersonal dynamics and may provide insights on how group members reduce or increase each other's anxiety levels.

Part B: *Saturday, August 10, 3:00 pm - 5:00 pm*

Agent-Based Modeling of Environmental Disease Transmission in a Multi-Ward Hospital
3:00 pm - 3:20 pm
Cara Sulyok, *Lewis University*
Brittany Stephenson, *Lewis University*

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 the healthy gut microbiota that prevents 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 include contact with endospores on fomites, objects likely to carry infection, and interactions with healthcare workers (HCWs).
In this work, we developed an agent-based model to stochastically simulate how *C. difficile* endospores spread through a hospital and infect patients. Our simulated hospital consists of six different types of wards in which factors including antibiotic prescription rates, patient length of stay, HCW interactions, and other parameters are varied based on ward characteristics. The model tracks the source of the development of a potential *C. difficile* infection (CDI), which allows us to compare mitigation strategies and identify how to best reduce hospital-acquired CDIs.

Studying Pain through Agent-Based Modeling of the Amygdala
3:30 pm - 3:50 pm
Rachael Miller Neilan, *Duequesne University*

Neuropathic pain is the predominant cause of pain for 20% of people and involves brain areas such as the central nucleus of the amygdala (CeA). Within the CeA, neurons expressing protein kinase c-delta (PKC) are pro-nociceptive (i.e., increase pain) while neurons expressing somatostatin (SST) are anti-nociceptive (i.e., decrease pain). In this talk, I will describe our progress towards developing a 3-D agent-based model of PKC and SST neurons in the CeA and the use of this model to explore the pharmacological targeting of these two neural populations in modulating neuropathic pain.
Our agent-based model includes a realistic 3-D spatial representation of the CeA and its subnuclei and a network of directed links that preserves the connectivity properties of PKC and SST neurons. The model is programmed in NetLogo3D and consists of 13,000 neurons (agents) with cell-type specific properties and behaviors estimated from laboratory data. During each model time step, neuron firing rates are updated based on an external stimulus, inhibitory signals are transmitted between neurons via the network, and a measure of pain-related output from the CeA is calculated as the difference in firing rates of pro-nociceptive PKC neurons and anti-nociceptive SST neurons.
Model simulations were performed to explore differences in pain-related output for different spatial distributions of PKC and SST neurons. Furthermore, a sensitivity analysis was conducted to explore the impact of several key parameters on model output. Our results show that the localization of these neuron populations within CeA subnuclei is a key parameter in predicting pain-related output from the CeA and identifying spatial and cell-type pharmacological targets for pain remedies.
This work is joint with several undergraduate students with majors spanning applied math, computer science, and neuroscience. I will highlight their contributions to this project throughout the talk.

Modelling Anti-Vaccine Sentiment as a Cultural Pathogen
4:00 pm - 4:20 pm
Rohan Mehta, *Elmhurst University*

Culturally transmitted traits that have deleterious effects on health-related traits can be regarded as cultural pathogens. A cultural pathogen can produce coupled dynamics with its associated health-related traits, so that understanding the dynamics of a health-related trait benefits from consideration of the dynamics of the associated cultural pathogen. Here, we treat anti-vaccine sentiment as a cultural pathogen, modelling its 'infection' dynamics with the infection dynamics of the associated vaccine-preventable disease. In a coupled susceptible–infected–resistant (SIR) model, consisting of an SIR model for the anti-vaccine sentiment and an interacting SIR model for the infectious disease, we explore the effect of anti-vaccine sentiment on disease dynamics. We find that disease endemism is contingent on the presence of the sentiment, and that presence of sentiment can enable diseases to become endemic when they would otherwise have disappeared. Furthermore, the sentiment dynamics can create situations in which the disease suddenly returns after a long period of dormancy. We study the effect of assortative sentiment-based interactions on the dynamics of sentiment and disease, identifying a tradeoff whereby assortative meeting aids the spread of a disease but hinders the spread of sentiment. Our results can contribute to finding strategies that reduce the impact of a cultural pathogen on disease, illuminating the value of cultural evolutionary modelling in the analysis of disease dynamics.

Occurrences of Reciprocal Sign Epistasis in Single- and Multi-peaked Theoretical Fitness Landscapes
4:30 pm - 4:50 pm
Manda Riehl, *Rose-Hulman Institute of Technology*

Fitness landscapes help model the theory of adaption, and can be used in applications from designing antibiotic cycling regimens to finding speciation events and hopefully in the future to predicting evolution. In this work we will consider genetic fitness landscapes abstractly as acyclic orientations of Boolean lattices. We focus on occurrences of reciprocal sign epistasis (RSE), which appears in the hypercube orientation as a set of four edges oriented in a particular way. We computationally study which combinations of peaks and RSEs are possible, and we determine bounds and limits on occurrences of RSEs in both single-peaked and multi-peaked hypercube orientations.

MAA Invited Paper Session
"When are we going to use this?": Interdisciplinary Projects in Pure Math Courses
Friday, August 9, 8:00 am - 11:30 am

"When will we ever use this?'" is a question faculty often hear in regards to content in pure mathematics courses. Though, as mathematicians, we can appreciate the beauty of mathematics, our students often want more–they rarely get to apply the knowledge they learn to other disciplines and often fall short on seeing its use in future careers. The demarcation between pure and applied mathematics is not nearly as stark as many undergraduate mathematics students are likely to suspect. Fueled by tradition and habit, the mere existence of this division itself has allowed it to become self-perpetuating; applied courses are increasingly taught with a focus on industry and interconnectedness to other disciplines while pure courses are often allowed to become self-contained adventures into some realm of esotericism. This need not be the case!

Every traditional pure mathematics course covers topics and tools that are utilized in other fields of study.

In this session, faculty will present on interdisciplinary projects they have used in pure mathematics courses. Presenters will provide the audience with a summary of the project, the specific course topic(s) the project reinforces, and a description of the cross-curricular application. Presenters will also include the prerequisites and concepts that are required to complete the project, as well as reflections and advice for faculty interested in implementing the project. Audience members should leave inspired to engage students with pure mathematics material in a new way and to promote active learning strategies, which can bolster a course's inclusivity by allowing students a different means of engaging with course material.

Organizers:
Elizabeth Donovan, *Murray State University*
Lucas Hoots, *Morehead State University*
Lesley Wiglesworth, *Centre College*

Mathematical Dramaturgy: Making Connections between Mathematics and Literature
8:00 am - 8:20 am
Linda McGuire, *Muhlenberg College, Allentown*
Tara Werner, *Northfield Mount Hermon School*

The origins of this work trace back to a senior-year capstone project, where one author served as the research student and the other as the faculty supervisor. This collaboration blossomed into a multi-year pedagogical exploration situated at the intersection of advanced mathematics and world literature.
The project we will describe asks students to activate the quantitative skills acquired in advanced mathematics courses to model situations described in literary works of their choice. This multi-stage assignment is especially effective in undergraduate contexts that rely on detailed narrative frameworks such as proof writing, the calculus sequence, differential equations, linear algebra, combinatorics, abstract algebra, analysis, and geometry. It also requires close reading, understanding dramatic composition, and imaginative textual analysis of events in a narrative. Mathematically speaking, students use content, techniques and skills to create problem and solution sets that reflect events in the stories they are considering. The final product serves as a story-driven tour through some aspect of mathematics in which students act as narrators and guides.
This presentation will describe the genesis of the project, as well as the development of an implementation framework that has been successfully adapted in various mathematical settings. We will detail how this exercise can be compartmentalized into smaller, one-to-two-week modules and adapted to complement the material found in specific upper-division or lower-division mathematics courses.

Non Abelian Family Affairs
8:30 am - 8:50 am
Thomas Gilsdorf, *Central Michigan University*

This topic represents an example of an interaction between the topic of abstract algebra and that of culture. It turns out that in the Warlpiri culture of what is now Australia, the kinship system is mathematically equivalent to the dihedral group of symmetries of the square. In this talk, we discuss how concepts of group theory are connected with the Warlpiri kinship structure and rules. Some particulars of

mathematical activities in which students make use of group theory concepts to connect Warlpiri kinship to the group of symmetries of a square are given.

Double Integrals and the Human Condition
9:00 am - 9:20 am
Garner Cochran, *Berry College*
Doug Pfeffer, *University of Tampa*
Ron Taylor, *Berry College*

This talk discusses our development of an activity to be used in a multivariable calculus course. Specifically, the idea of the center of mass of a planar lamina is related to food insecurity in a town, municipality or other geographic area. The location of the center of mass would then be a place where it might be beneficial to establish a food bank to address this issue. This project is designed to be completed in one to three 50-minute classes depending on how much time is devoted to modeling the density functions and the boundaries of the region. We discuss extensions related to other standard multivariable calculus concepts and to more open ended questions that students can engage with outside of class time as an independent research project.

Using Linear Algebra in Archaeology
9:30 am - 9:50 am
Cynthia Huffman, *Pittsburg State University*
Ximena Catepillan, *Millersville University*

In this presentation, we discuss how linear algebra was used to prove that the bases of the elite indigenous houses in Rapa Nui, also known as Easter Island, are ellipses. We traveled to Rapa Nui with an archaeological team in July 2019, and with the aid of drones and LIDaR (Light Detection and Ranging) obtained archaeological imagery to complete our work. As a result, we have developed activities that can be used in linear algebra and advanced linear algebra courses to demonstrate the application of topics such as determinants, the kernel or null-space of a matrix, row-reduction, and singular value decomposition.

Get in the Game with Linear Algebra!
10:00 am - 10:20 am
Amanda Harsy, *Lewis University*
Michael Smith, *Lewis University*

Sports analytics is an exciting and accessible research area which draws student interest. Among the many mathematically inspired sports ranking systems, the Colley and Massey methods are relatively simple and can easily be introduced to undergraduate students who have taken a linear algebra course. In this talk, we will share activities that can be used to introduce these linear algebra-based sports ranking models and allow students to implement these models. We organize these activities as part of a 50-minute lab module, but the exercises could also be used as part of an in-class lesson or turned into a semester-long research project. Students can complete these modules individually or in small groups and this application would fit well in a first semester linear algebra course or mathematical modeling course. In this talk, we will share implementation strategies and lessons learned while also sharing student feedback on the activities.

A SET-like Game With a Twist
10:30 am - 10:50 am
Lauren Rose, *Bard College*

Quads is a card game similar to SET, with 81 cards, each containing 1-4 objects in one of 4 colors and one of 4 shapes. The goal of the game is to collect "quads", collections of 4 cards that satisfy a particular pattern. Students can use the card deck to explore a variety of topics in combinatorics, linear algebra, abstract algebra and finite geometry. By working with a deck of cards laid out in front of them, learning mathematics becomes a tactile experience that naturally leads to developing intuition about various mathematical structures.
In addition to classroom activities, I have supervised undergraduate research projects motivated around the question "How many cards must you lay out to guarantee there is a quad?" This research has also led to connections with cryptography and coding theory.

Dancing Topologically: Paths, Passes, and Puzzles
11:00 am - 11:20 am
Karl Schaffer, *De Anza College*

Movement tasks in dance can lead to entertaining topological puzzles. Contrariwise, topological concepts can suggest whole body movement activities. The spatial paths of dancers may generate intriguing puzzles about knots and links and combinatoric problem-solving may be involved when dancers join hands or pass objects from hand to hand. Combining pleasant movement activities with mathematical explorations can provide surprising transformations of the math (and dance) classroom and help demonstrate new ideas about integrating scientific and artistic disciplines.

MAA Invited Paper Session
Research and Career Journeys from the Project NExT Beautiful Blues '17
Thursday, August 8, 2:00 pm - 6:00 pm

This session focuses on the mathematical advancements of members of the Blue '17 Project NExT cohort, with particular emphasis on recent research and research involving undergraduate collaborators. As Project NExT welcomes the next cohort of Blue dots this year, this session highlights the research and career accomplishments of members of the most recent Blue dot cohort and the impact that Project NExT has had on their careers. Just as Project NExT includes mathematicians with a wide range of mathematical interests and backgrounds, the research presented in this session will span many topics in pure and applied mathematics and statistics. We hope that audience members will gain an appreciation for a variety of fields of mathematics and be inspired by the accomplishments of these past NExT fellows.

Organizers:
Emily J. Olson, *Millikin University*
Scott Zinzer, *College of DuPage*

Breaking the Ice: Cryosphere Energy Balance Dynamics as Both Faculty and Undergraduate Research
2:00 pm - 2:20 pm
Kaitlin Hill, *St. Mary's University*

As a key component of the climate system actively experiencing change, the cryosphere presents open scientific questions that are also mathematically interesting. Since Project NExT, I have pursued lines of research related to Arctic and permafrost energy balance, including undergraduate researchers where possible. Throughout this journey, I have worked to become a more reflective and supportive mentor in undergraduate research. In this talk, I will discuss recent results in both research and mentoring.

Games, Graphs, and Undergrads: The Game of Cycles
2:30 pm - 2:50 pm
Emily J. Olson, *Millikin University*

The Game of Cycles is a game played by two players on a simple, undirected, connected planar graph, called a board. Players take turns directing edges on a board with an arrow without creating a source or sink. The game continues until a player creates a directed cycle cell or plays the last legal move. In this talk, we present results related to the Game of Cycles and lessons learned while working with undergraduates at a primarily undergraduate institution on mathematical research. We will also discuss the benefits of applying for a grant to compensate the undergraduates, purchase supplies, and fund travel.

Action Graphs for Catalan Sequences
3:00 pm - 3:20 pm
Amelia Tebbe, Indiana University of Kokomo

Catalan numbers are a well-known sequence of integers that appear in a variety of combinatorial settings. Based on work of Alvarez-Bergner-Lopez, we can recursively create directed graphs, called action graphs, that represent the Catalan numbers. In this talk we will introduce action graphs and discuss work with undergraduate students generalizing action graphs to other sequences related to the Catalan numbers. This project was motivated by work in category theory, and yet is accessible to undergraduate students without assuming a background beyond introduction to proofs. We will also briefly touch on my career journey as a neurodivergent mathematician.

Coloring Sphere Graphs with Students
3:30 pm - 3:50 pm
Edgar A. Bering, S*an José State University*

The sphere graph is a combinatorial object encoding all possible 2-spheres in a 3-manifold. The combinatorics of this graph is closely related to the automorphisms of the fundamental group, and is analogous to the more famous curve graph of a surface. Both the curve graph and the sphere graph are usually infinite, even locally, each vertex has infinitely many neighbors. Surprisingly, the curve graph has a finite coloring. In this talk I will discuss joint work with SJSU students Bennet Haffner, Estephanie Ortiz, and Olivia Sanchez establishing an analogous result for the sphere graph—both the mathematics and the journey of establishing a student research program at a new institution.

From Dissertation to Tenure: Numerical, Computational, and Theoretical PDEs
4:00 pm - 4:20 pm
Quinn A. Morris, *Appalachian State University*

In this talk, I'll discuss how a few mild annoyances from my dissertation turned into undergraduate research experiences, graduate research projects, and several publications in the areas of numerical, computational, and theoretical PDEs. We'll not only discuss some of the results (though broadly enough

for a general mathematical audience to understand), but we will also discuss opportunities and challenges I had along the way that might be of use to new faculty.

A Low-complexity Algorithm for Locally Recoverable Error Correcting Codes
4:30 pm - 4:50 pm
Angelynn Alvarez, *Embry-Riddle Aeronautical University*
Sirani M. Perera, *Embry-Riddle Aeronautical University*
Anthony Várilly-Alvarado, *Rice University*
Daniil Gorshkov, *Embry-Riddle Aeronautical University*

We propose a low-complexity algorithm while computing matrix-vector products and also solving a system of linear equations having an r x r generator matrix (coefficient matrix), where matrix elements represent points on a finite field, to obtain locally recoverable error correcting codes using algebraic surfaces.

Rainbow Numbers of Equations
5:00 pm - 5:20 pm
Katie Ansaldi, *Wabash College*

In this talk, I'll describe my recent research in rainbow numbers of equations, which I began after attending the REUF program at AIM in 2018. An exact r-coloring of a set S is a surjective function $c:S \to [R]$. The rainbow number of a set S for a given equation is the smallest r so every exact-r coloring of S contains a rainbow solution to the equation, that is a solution in which every component is a different color. I will describe results on rainbow numbers for linear equations over Z_n. I'll also present work with undergraduate coauthors in which we computed rainbow numbers for the family of equations $x-y=z^k$ over Z_p, where p is prime.

Graphs, Games, and Undergrads: Total Graph Labelings
5:30 pm - 5:50 pm
Ranjan Rohatgi, *Saint Mary's College*

A k-total labeling of a graph is an assignment of k distinct labels to the vertices and edges of a graph so that adjacent vertices, incident edges, and an edge and its incident vertices receive different labels. In this talk, we will discuss two undergraduate research projects related to total labelings of graphs. First, we present results on total difference labelings of graphs, in which the label on an edge is equal to the positive difference between the labels on its incident vertices. Second, we discuss a two-player game in which players take turns labeling vertices and edges of a graph from a fixed set of labels. One player wins if the graph ends totally labeled while the other wins if the graph cannot be totally labeled. Graph labeling problems can be accessible to students, even those early in their academic careers who have had difficult experiences with mathematics in the past. As a student of mine once said about graph theory: "This isn't math. I hate math, but I like this stuff."

Contributed Paper Sessions

Differential Equations Student Activities and Projects, Big and Small
Saturday, August 10, 8:00 am - 10:15 am

This session features talks by those who teach differential equations using modeling with active, student-centered learning techniques. We invite presentations of effective undergraduate and high school activities and projects offered in teaching differential equations with modeling, especially those that focus on creativity and relevance in modeling, data, and use of technology.

Using realistic modeling to motivate student learning of mathematics motivates students to learn the mathematics under study, generates interest in useful applications of mathematics, enhances transferability of materials to cognate disciplines, and adds intrigue and joy to learning. Moreover, students remember the mathematics because of the applications and learning in context.

We seek scholarly accounts in presentations with immediate possibilities and sufficient materials for attendees to pick up and bring into their teaching of differential equations. The presenters must make clear the rudiments of the approach to the model and to the mathematics in which the engagements and nuances of the student experiences are conveyed so the audience can envision how and then act on using the material to enhance learning in the local classroom. Personal aspects are valued for collegial exchange.

Organizers:
Brian Winkel, *Systemic Initiative for Modeling Investigations and Opportunities with Differential Equations (SIMIODE)*
Therese Shelton, *Southwestern University*
Pushpi Paranamana, *St. Mary's College*
Rosemary Farley, *Manhattan College*
Patrice Tiffany, *Manhattan College*

Sponsor:
Systemic Initiative for Modeling Investigations and Opportunities with Differential Equations (SIMIODE) (https://qubeshub.org/community/groups/simiode)

Modeling to Motivate Differential Equations
8:00 am - 8:15 am
Margaret Watts, *Doane University*

Doane University is a small liberal arts college. In 2020, we developed a course called Advanced Applications of Calculus. This course combines some topics from Calculus II and Differential Equations. The student's taking this course are mostly second semester freshman, the majority are engineering majors. As part of this course, the students complete multiple Mini Projects involving modeling. These projects are given to show the students how differential equations is an important topic and has

applications that they will find interesting and useful. The projects are presented first, then the students learn the differential equations content. In this talk, I will present some of the projects used in the class, discuss the timing of the projects, the goals of the projects, and how I implemented them in the class room.

Collect and Use Data for Modeling with Differential Equations
8:20 am - 8:35 am
Brian Winkel, *SIMIODE*

We share data gathering activities from the SIMIODE library of Modeling Scenarios. Students are motivated to learn the mathematics of differential equations so they can model and explain the data they collect from real-world experiences. We demonstrate several opportunities for collecting data from physical classroom experiences to videos and how this data is used in modeling with differential equations.

Visualizing Approximate Solutions to ODEs in a First Semester Undergraduate Differential Equations Course
8:40 am - 8:55 am
Curtis Kunkel, T*he University of Tennessee at Martin*

A student project exploring different types of approximation techniques for solving various differential equations in a first semester undergraduate differential equation course will be discussed. Numerical approximations programmed and computed using Microsoft Excel. Analytic approximations done by hand using Picard Iterates. Visualization of all approximations presented in GeoGebra. (undergraduate student accessible talk)

Verifying the Hanging Chain Model
9:00 am - 9:15 am
Michael Karls, *Ball State University*

The wave equation with variable tension is a classic partial differential equation that can be used to describe the horizontal displacements of a vertical hanging chain with one end fixed and the other end free to move. Using a web camera and Tracker software to record displacement data from a vibrating hanging chain, we verify a modified version of the wave equation with variable tension that accounts for damping.

Team Writing Projects: A Framework, Challenges, and Recommendations
9:20 am - 9:35 am
Sheldon Lee, *Viterbo University*

I will discuss a model for students to work together in teams on modeling projects, usually involving systems of differential equations. We have implemented these projects into our computational modeling course, which our math and engineering students take after their introductory course in differential equations. For the project, each student is assigned to act as “lead writer” for a major portion of their team’s paper. During this process, students work together to form a cohesive final product, using Overleaf and LaTeX to format their work. There are multiple rounds of reviewing and editing which are done within groups, between groups, and by the instructor. The course also satisfies a “writing within the discipline” core curriculum requirement at our University. I will discuss challenges, common pitfalls, and recommendations for implementation.

Implementing Modeling Activities and Project Assignments in Differential Equations Course
9:40 am - 9:55 am
Pushpi Paranamana, *Saint Mary's College*

Incorporating modeling activities into a differential equations course offers numerous benefits, including enhancing student understanding, increasing engagement, and improving both subject knowledge and critical thinking skills. In this talk, I will discuss how I implemented modeling activities and projects in my class and provide insights into my rationale for choosing these activities and my course preparation. Furthermore, I will share reflections on success stories, lessons learned, and potential improvements/variations. Student performance and their enjoyment in investigating the intersection between theoretical knowledge and real-world applications in the realm of differential equations will be explored through a reflection on student feedback.

Simple Physical Models for Earthquakes in Buildings: Data Collection, ODEs and Linear Algebra
10:00 am - 10:15 am
Allan Struthers, *Michigan Technological University*
David Labyak, *Michigan Technological University*
Jason Gregersen, *Michigan Technological University*

This presentation demonstrates simple physical models for the earthquake response of multi-story buildings. Data collected using Bluetooth accelerometers and position tracking (in quality videos) motivates a sequence of ODE models. Animated diagrams of predicted motion (from the ODE models) are compared to physical model video. The ODEs are used to develop a tuned mass damper to reduce earthquake motion which is physically implemented. Short videos using consistent terminology and notation to justify these ODE models are being developed. The linked videos and ancillary materials are intended (minimal instructor prep) as enrichment in various classes. The video demonstrating that the force required to bend the physical model walls is linear in displacement is appropriate for precalculus. The video demonstrating that the stiffness matrix eigenvectors accurately predict the visible vibrational modes of the three-story physical model is appropriate for linear algebra.

Inquiry-Based Learning

Part A: *Thursday, August 8, 9:40 am - 10:55 am*
Part B: *Friday, August 9, 3:00 pm - 6:15 pm*

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. Within this context, IBL methods exhibit great variety. Activities can take place in single class meetings and span entire curricula for students of any age. Students can be guided to re-invent mathematical concepts, to explore definitions and observe patterns, to justify core results, and to take the lead in asking questions. There is a growing body of evidence that IBL methods are effective and important for teaching mathematics and for fostering positive attitudes toward the subject. This session invites scholarly presentations on the use of inquiry-based methods for teaching and learning. We want to make a special invite to IBL-inspired practical activities, introductions to IBL, and speakers sharing what they have learned from their own experiences getting started

with IBL. Also invited are presentations that include successful IBL activities or assignments, that support observations about student outcomes with evidence, or that could help instructors who are new to IBL try new methods. This session is sponsored by the SIGMAA on Inquiry-Based Learning.

Organizers:
Lee Roberson, *University of Colorado-Boulder*
Joe Barrera, *Converse University*
Mel Henriksen, *Wentworth Institute of Technology*
Mami Wentworth, *Wentworth Institute of Technology*
Rebekah Jones, *University of Colorado-Boulder*

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

Part A: *Thursday, August 8, 9:40 am - 10:55 am*

Creating Assessments that Promotes Meaningful Learning within the Calculus Sequence
9:40 am - 9:55 am
Lee Roberson, *University of Colorado-Boulder*

What we want students to take away from assessments and what students actually take away do not always align. To address this issue we will work to understand what meaningful learning is and use this understanding to outline our learning goals for students engaging in homework assignments. Applying this framework, we will take inspiration from the work of Su Dorée, Peter Liljedahl, and others to evaluate assessment items from the Calculus sequence to determine if they align with our goals and explore strategies for creating homework items that promote meaningful learning.

An Inquiry-based Geometry Course for Teacher Education Students
10:00 am - 10:15 am
Jay Jahangiri, *Kent State University*
Victor Oxman, *Western Galilee College, Acre, Isreal*

It has been more than two decades since the introduction of pedagogy of inquiry-based learning and teaching in the classrooms. The idea, as appealing as it sounds in theory, appeared to face resentments, frustrations, and withdrawals by students and instructors faced challenges in their choice of appropriate and stimulating problems. In this presentation, we intend to address these problems and explore new ideas and strategies for inquiry-based learning and teaching. We show how we used “What If Not” strategy coupled with “Dynamic Geometry Software” to introduce and explore open-ended geometry problems in our teacher education classes.

An IBL Approach to Large, Coordinated Courses
10:20 am - 10:35 am
Stan Yoshinobu, *University of Toronto*

In this talk I'll share an approach to implementing "Big Tent" IBL and the four pillars of IBL to a high enrollment, coordinated course at a large public institution. This approach supports new instructors and

teaching assistants, while providing multiple on ramps and flexibility. The approach also focuses on equitable teaching practices and to the extent possible use of grading for growth methods.

Groups en Action
10:40 am - 10:55 am
Brian (BK) Katz, *California State University, Long Beach (CSULB)*
Jessi Lajos, *Utah State University*

Inspired by prior work of Jessi Lajos and team, I wanted to incorporate some embodied cognition in my abstract algebra course to help my students make meaning of the most challenging ideas (and to have some fun). In this session, we will discuss an activity that spanned three class days in which my students acted out algebraic structures, including the properties of groups, generation, cosets, homomorphisms, and quotients. I hope to share the tasks, some student thinking, and my experience ramping up an embodied task in my classroom.

Part B: *Friday, August 9, 3:00 pm - 6:15 pm*

The Math Craft Laboratory – An Inquiry-Based Workshop Series for High School Women
3:00 pm - 3:15 pm
Amanda Niedzialomski, *University of Tennessee at Martin*
Carlin Bush, *University of Tennessee at Martin*
Dana Gatewood, *University of Tennessee at Martin*
Barbara Kunkel, *University of Tennessee at Martin*

With the help of an MAA Tensor Women and Mathematics Grant in 2023, our four-woman team developed a mentorship program and mathematical workshop series for high school women based on inquiry-based learning and small group work. The Math Craft Laboratory encourages students to engage in open-ended mathematical problem solving with a secondary emphasis on visual crafts. The program aims to expose high school women to the playful, creative, experimental side of mathematics; increase their mathematical confidence; provide opportunities for collaboration with other young women interested in mathematics; and encourage them to consider math-related careers. During this talk, we will discuss the structure, tools, and supports that have allowed the program to be successful.

A Sampling of Inquiry Opportunities in a Complex-themed Transition to Advanced Mathematics Course
3:20 pm - 3:35 pm
Bob Sachs, *George Mason University*
Paul Zorn, *St. Olaf College (Retired)*

Multiple inquiry opportunities arise for students in the setting of a complex-themed transition to advanced mathematics course. Some are proofs but others are investigations or guided reinvention. I will highlight a few topics that have spurred a lot of student interest in my course and describe their "meta" value for later coursework.

Turning Routine Exercises Into Activities that Teach Inquiry: Examples from Discrete Mathematics
3:40 pm - 3:55 pm
Suzanne Dorée, *Augsburg University*

How can we create activities that teach inquiry? In my paper ``Turning Routine Exercises into Activities that Teach Inquiry: A Practical Guide'' [PRIMUS 27(2): 179-188, 2017], I discuss three practical techniques: (1) rephrasing exercises as questions, (2) creating activities that inspire students to make conjectures, and (3) asking for counterexamples to reasonable, but false, conjectures. In this talk I will share examples of successful, classroom-tested activities from my discrete mathematics class illustrating these techniques. This talk is intended to help instructors both new to and experienced with IBL.

Why I Don't Grade Presentations (and What I Do Instead)
4:00 pm - 4:15 pm
David Clark, *Grand Valley State University*

Over the years, my approach to student presentations in IBL classes has changed dramatically. When I first started using guided inquiry, I struggled mightily with how to grade presentations in an effective and consistent way. Over time, I've removed requirements, simplified grades, and then removed grades entirely. I'll share the benefits I've seen from gradeless presentations, some of them very unexpected, and also explain how I motivate students and build presentation skills in this context.

The Impact of Instructional Environment, Student Behaviors, and Instructor Behaviors on Calculus I Students' Math Anxiety While Learning via Inquiry-Based Learning
4:20 pm - 4:35 pm
Harman Aryal, *Stockton University*

It has been more than two decades since the introduction of pedagogy of inquiry-based learning and teaching in the classrooms. The idea, as appealing as it sounds in theory, appeared to face resentments, frustrations, and withdrawals by students and instructors faced challenges in their choice of appropriate and stimulating problems. In this presentation, we intend to address these problems and explore new ideas and strategies for inquiry-based learning and teaching. We show how we used "What If Not" strategy coupled with "Dynamic Geometry Software" to introduce and explore open-ended geometry problems in our teacher education classes.

An Inquiry-based Project in a Modern Geometry Classroom
4:40 pm - 4:55 pm
Xiaoxue Li, *Emory & Henry College*

This is an attempt to design an inquiry-based project for a Modern Geometry class for undergraduate mathematics majors and teacher preparation majors. In such a class, one challenge for students is to truly understand the mutual relations of Euclidean geometry and projective geometry, which is a beautiful example of the mathematical style and new way of thinking born from the advances in non-Euclidean geometry in the 19th century. In the project we design, students investigate all exceptional cases of Desargues' Theorem in a Euclidean plane as well as prove the Theorem by Euclidean means. This yields an insight into the relations between Euclidean and projective geometries, two original proofs, and a problem solving strategy for proving geometric statements about collinearity of points in a Euclidean plane. The effects of implementing this project are also discussed.

Computational Inquiry in Undergraduate Math Courses
5:00 pm - 5:15 pm
Matthew Wright, *St. Olaf College*
Matthew Richey, *St. Olaf College*

Computational skills give students agency to explore and discover mathematics on their own, yet the development of such skills is often overlooked. Students benefit from the ability to take an open-ended math question, design and run computational experiments (in a computer algebra system or programming environment), and formulate conjectures based on their observations. In this talk, I will present ideas for equipping students with computational inquiry skills, with examples from the Modern Computational Mathematics course at St. Olaf College. This course helps students develop computational fluency and skills that they can use to gain mathematical insight, discover patterns, ask good questions, and test conjectures. Examples presented in this talk could serve as IBL modules for other courses. Furthermore, computational exploration can make advanced mathematical topics more accessible and provides transferable skills that students can apply to tackle a wide variety of problems.

Team Based Inquiry Learning in Linear Algebra
5:20 pm - 5:35 pm
Sharona Krinsky, *California State University Los Angeles*

In this talk we will learn about the combination of Team Based Learning and Inquiry-Based Learning into an effective pedagogical structure for both Calculus and Linear Algebra. Including both the four principles that underly team-based learning and the four pillars at the foundation of inquiry-based learning, this talk will share best practices and lessons learned in implementing TBIL into a one semester linear algebra class. The ways in which combining these two active learning pedagogical styles enhances deeper learning will be showcased, along with the addition of the use of standards-based grading to further develop students mathematical knowledge and skills.

Encouraging Student Exploration Via Spreadsheets
5:40 pm - 5:55 pm
Kristi Karber, *University of Central Oklahoma*

Spreadsheets are powerful tools to organize and analyze data. In a Quantitative Literacy course, empowering students to utilize spreadsheets enables them to conduct "what-if" analyses without getting bogged down by tedious manual calculations. This talk highlights an inquiry-based activity where students explore how to calculate a weighted average class grade using a spreadsheet. By varying input values, they can observe the effects on the overall grade which fosters an understanding of the mathematical relationships between the various quantities. Moreover, we will discuss how this activity satisfies the three guiding principles: active learning, meaningful applications, and academic success skills. Lastly, the talk will share additional inquiry-based activities that leverage the power of spreadsheets, encouraging students to investigate mathematical concepts through interactive exploration and analysis.

Cultivating an Investigative Mindset in Mathematics for Liberal Arts
6:00 pm - 6:15 pm
Amy DeCelles, *Bethel University*

How to help students who consider themselves “not math people” or “bad at math” experience the joy of discovering mathematical patterns and understanding mathematical concepts? In this presentation, we discuss strategies employed in a general education math class to encourage collaborative mathematical investigation: teaching about a growth mindset, carefully designing in-class activities, and leading classroom discussions about productive collaboration. Specific activities, student feedback, and revision of activities will be discussed.

Research on Undergraduate Mathematics Education
Part A: *Friday, August 9, 8:00 am - 11:15 am*
Part B: *Saturday, August 10, 3:00 pm - 4:55 pm*

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

Organizers:
Brian Katz, *California State University, Long Beach*
Shandy Hauk, *San Francisco State University*
Deborah Moore-Russo, *University of Oklahoma*
Kaitlyn Serbin, *The University of Texas Rio Grande Valley*

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

Part A: *Friday, August 9, 8:00 am - 11:15 am*

The Use of Artificial Intelligence in Undergraduate Mathematics Education
8:00 am - 8:15 am
Cindy Casey, *Gwynedd Mercy University*
Ryan Savitz, *Neumann University*
Fred Savitz, *Neumann University*

The aim of this study is to establish a framework for utilizing artificial intelligence (AI) in undergraduate mathematics instruction. We begin by developing a theoretical framework for the use of AI in the classroom that is firmly grounded in the literature and the use of inquiry based learning. Next we present a structure for implementing the use of AI in the undergraduate mathematics classroom. Finally, we discuss several examples of of the use of AI in the classroom, at levels ranging from foundational mathematics to high level undergraduate mathematics.

Student Perceptions of a Flipped Complex Analysis Class and Complex Variables
8:20 am - 8:35 am
Mehmet Celik, *Texas A&M University -Commerce*
Rebecca Dibbs, *Texas A&M University -Commerce*

Although introductory and proof-based undergraduate courses have been extensively researched, more exploration is needed in the area of complex analysis. There has been limited research conducted on evidence-based teaching in complex analysis. This study aims to investigate how flipped classrooms in a complex analysis proofs class can help improve upper-level math student perceptions and deepen their understanding of content topics. The two main questions of this study include understanding the experience of a complex analysis student in a flipped classroom and evaluating the effectiveness of the flipped classroom model in supporting student learning in complex analysis.

Implementations of Team-Based Inquiry Learning Across Instructional Contexts
8:40 am - 8:55 am
Drew Lewis, *Independent Mathematician*

Team-Based Inquiry Learning (TBIL) is a novel form of active learning developed with a goal of facilitating the adoption of inquiry-based learning techniques in lower division mathematics courses such as Calculus and Linear Algebra. Over the last four years, the TBIL project has trained faculty in TBIL, developed classroom ready activities (freely available at http://tbil.org), and supported faculty as they implemented TBIL in their courses at institutions across the country. In this talk, we report on a study of these implementations of TBIL in Calculus I, Calculus II, and Linear Algebra across a variety of instructional contexts.

The Spies in Our Midst: Using Student Surveys to Measure Instructional Practice
9:00 am - 9:15 am
Sandra Laursen, *University of Colorado Boulder*
Tim Archie, *University of Colorado Boulder*

Students spend more time observing class conditions than any outside observer—what do they see? In education research and evaluation, student surveys are often used to evaluate the impact of teaching interventions, but less often used to learn if the teaching intervention really occurred. We report results from some 1500 student surveys on the use of active and collaborative learning (ACL) approaches in 140 recitation sections of gateway courses of mathematics, physics, and computer science. Student reports aligned with project leaders' expectations of where ACL had been implemented to greater or lesser degree. Student ACL ratings also correlated strongly with their experience of the classroom and self-assessed learning gains. When focused on specific, observable classroom behaviors, student surveys of instructional practice can augment the suite of tools available to characterize teaching and teaching change in response to professional development and departmental change initiatives.

Tackling Incidents of Racism in Active Learning Mathematics Classrooms: Educator and Student Responses to Microaggressions
9:20 am - 9:35 am
Rebecca Machen, *University of Colorado Boulder*

In this session, participants will explore active learning strategies in mathematics classrooms that foster student belonging and promote inclusion within the classroom environment. We will delve into two frameworks that blend theories of Whiteness and inclusive teaching practices into the conversation. Drawing on previous research, we will examine instructor and student reactions to microaggressions. Participants will then engage with additional scenarios to expand their toolkit for addressing such challenges. This session will be structured around active learning, and participants will be asked to engage in conversation throughout the session.

Career Development Among Black Math Majors: Examining Two Exemplary HBCUs' Disciplinary Practices
9:40 am - 9:55 am
Christopher Jett, *Georgia State University*
Morgin Jones Williams, *University of South Carolina Beaufort*

There are national calls for more domestic talent in our nation's math programs and math-intensive career fields, which has precipitated a need for more Black math majors. As it stands, HBCUs are the leading

producers of Black math majors. Because of their exemplary math-related teaching and learning efforts, it seems prudent to examine the practices implemented in their undergraduate math programs that positively impact Black students' career trajectories. The presenters will share overarching findings and implications from two RUME studies with math majors at two distinct HBCUs to help facilitate Black students' career development in the mathematical sciences. Attendees will learn how these two HBCUs support Black math majors across the undergraduate years, observe how two RUME scholars examine mathematics teaching and learning from asset-based perspectives, and leave with ideas to incorporate career development activities for math majors from minoritized groups.

Team-Worthy Tasks in Discrete Mathematics
10:00 am - 10:15 am
Shandy Hauk, *San Francisco State University*
Jesus Gonzalez, *West Valley College*
Tim Hsu, *San José State University*
Mohammed Yahdi, *Hartnell College*
Marion Campisi, *San José State University*
Mary Rayappan, *Hartnell College*

Discrete mathematics is a core course in mathematics and computer science degree programs. Like calculus, it has a history of enormous disparities in outcomes correlated to societal status markers (e.g., gender, ethnicity, income). For calculus, it has taken several generations of scholarly work to reshape structures, policies, and practices to eke out a less inequitable state. No similar reform effort has occurred for discrete mathematics. Yet. This presentation reports on a state-wide effort in California to transform curriculum and instruction in discrete mathematics. Project research examines the use of seven team-worthy lessons (as substitutes for lecture) and related faculty learning about how to use such lessons. Early results indicate increases in students' sense of access to, and engagement in, the intellectual work of discrete mathematics, growth in instructor knowledge of equity-supportive practices, and a reshaping of instructors' views of students' capabilities.

Developing Mathematical Thinking and Problem-Solving Skills to Teach Volume Through Real-Life Scenarios
10:20 am - 10:35 am
Kuan-Chun Chen, *Southern Illinois University Carbondale*
Eunmi Joung, *Utah Valley University*

This session presents a recently published article on developing middle school pre-service teachers' (PST) mathematical problem-solving skills and conceptual understanding of volume through five real-life scenarios. The activities, designed for grades 6-8 and aligned with CCSS, engage learners in determining volumes of cylinders and rectangular prisms using the flu vaccine distribution. The five scenarios progress from simple to more complex problems, challenging PST to fully understand the concepts and promote their geometric reasoning, critical thinking skills, and pedagogical content knowledge, ultimately preparing them to create meaningful lessons for their future students. The real-world example of flu vaccine distribution makes the learning experience more engaging and relevant. This session offers insights for mathematics educators and PST to foster a deeper understanding and appreciation of the practical applications of mathematics in an enjoyable way for students.

Using Contrasting Prompts as an Intervention to Encourage Student Reflection on Mathematical Ideas

10:40 am - 10:55 am
Derek Eckman, *Idaho State University*
Kyeong Hah Roh, *Arizona State University*

Mathematics educators and organizations have promoted the practice of facilitating student-centered mathematical discussions for decades (e.g., NCTM, 2000, 2014; Smith & Stein, 2018). One method to introduce and promote discussion activities is to use contrasting prompts, a technique utilized by some qualitative researchers (e.g., Eckman, 2023; Halani & Roh, 2011; Roh, 2008, 2010; Roh & Lee, 2011; Sellers et al., 2021) to promote student reflection on mathematical ideas. Contrasting prompts consist of two or more similar appearing (but mathematically distinct) statements or representations that students interpret and debate. In this presentation, we discuss the affordances and results of our previous use of contrasting prompts (e.g., set-builder notation, limit, series), the criteria for developing contrasting prompts activities, and the usefulness of these activities as an application of theory-oriented qualitative research results to classroom instruction.

Assessing Textbook Introduction to Series Using the Revised Bloom's Taxonomy
11:00 am - 11:15 am
Nicole Schaal, *Eckerd College*
Erin Griesenauer, *Eckerd College*

The study of series is a major component in Calculus II, but this topic is often very challenging for students. To find more effective ways to teach series, we apply the Revised Bloom's Taxonomy to textbook presentations of series and identify gaps in the presentation. In this process, we offer the novel insight of distinguishing between how an expert would approach the topic and how a student seeing the material for the first time might approach the topic. Identifying gaps in how this topic is presented (from either the expert or the novice perspective) can guide the development of supplemental materials to fill in these gaps and better support student learning.

Part B: *Saturday, August 10, 3:00 pm - 4:55 pm*

Developing an Automated Feedback System in Linear Algebra Through Analysis of Student Exam Responses
3:00 pm - 3:15 pm
Francisco Pizarro, *University of Michigan*
Kenny Deng, *University of Michigan*
Vilma Mesa, *University of Michigan*

The concept of span is crucial in Linear Algebra, and there exists a sizable amount of evidence that it is one of the more difficult concepts to learn. We seek to develop a feedback process that uses students' justifications to identify their reasoning about span. Using Balacheff's (2009) model of conceptions, we analyzed two examples on a section about spanning sets in an open-source, interactive linear algebra textbook (Beezer, 2021) and compared them to the control structures evident in student responses to a final exam question about the span of columns of a matrix. We identified additional control structures students used to answer the question and elucidated common approaches to solve this type of problem, where the most common structure students implemented was the relationship of the shape of the matrix to the target space. This work contributes to improvements to the teaching of linear algebra courses and to the design of open-source interactive textbooks.

The Discourse of a Good Student in Mathematics Syllabi: Student Interpretations of Course Expectations
3:20 pm - 3:35 pm
Abdullah Bo Shgeia, *University of Michigan-Marsal School of Education*
Claire Boeck, *University of Michigan-Marsal School of Education*
Vilma Mesa, *University of Michigan-Marsal School of Education*

Instructors' assumptions about who is a "good" student can create inequitable environments. As part of a larger study in which we analyzed 31 syllabi from Calculus I, Abstract and Linear Algebra courses to identify themes about what it means to be a "good" student in college math courses, we sought to answer the question, "How do college math students interpret syllabi statements regarding course expectations?" We conducted interviews with nine students enrolled in math courses at a public research university to gather their reactions to the statements. The students interpreted statements as emphasizing the student's responsibility, a message with which they were familiar; however, the tone of the message conveyed mattered. Although students recognized the emphasis on their responsibility in syllabi as helpful, they had negative reactions to the wording of some of the statements. Additionally, Calculus I students were less critical of expectations than students in the other courses.

Comparison of Undergraduate Students' Statistical Literacy in Non-Media and Media Contexts
3:40 pm - 3:55 pm
Sam Waters, *University of Northern Colorado*

News media is the primary source of information about social and scientific issues for most adults. The variety of statistical and mathematical products in the news requires inter-related skills to appropriately comprehend and evaluate. The purpose of this convergent mixed-methods study was to investigate how students in an introductory statistics course apply statistical concepts when critiquing statistics in the news media. Responses to a course-wide assessment and individual task-based interviews were used to examine students' thinking using Watson and Callingham's (2003) six-level construct of statistical literacy. In this talk, I will share initial results from the course-wide assessment. Results will include how students performed on different statistical topics and how performance compared on tasks in media versus non-media contexts.

Mathematicians' Values and Norms around Algorithms
4:00 pm - 4:15 pm
Rachel Rupnow, *Northern Illinois University*
Alastair Fletcher, *Northern Illinois University*
Peter Sassman, *Northern Illinois University*

Mathematicians hold values that are realized and supported through different activities. Prior work has highlighted values and norms supporting those values related to proving and defining, such as that mathematicians value "freedom of choice in the use and creation of definitions" and that this value is supported by norms like "mathematicians write definitions purposefully for utility". However, proving and defining are not the only activities mathematicians or students engage in. For instance, algorithmatizing can be viewed as the practice of learning to create, use, and understand systematic sets of procedures. One might argue that algorithmatizing receives more emphasis in K-14 mathematics than proving and defining and remains important in higher-level mathematics. Based on interviews with computational mathematicians, we will address values and norms of the mathematical community supported by working with algorithms and implications of these values and norms for instruction.

Identity Trajectory Case Studies of Entry-Level College Mathematics Faculty
4:20 pm - 4:35 pm
Michael Oehrtman, *Oklahoma State University*
Michael Tallman, *Oklahoma State University*
John Paul Cook, *Oklahoma State University*

We present an analysis of five case studies of faculty identity trajectories through collaborations to improve student learning in entry-level college mathematics courses. We collected data in the context of a statewide project that seeks to effect change in the cultural practices of mathematics instructors by cultivating a "community of practice" (Wenger, Communities of practice: Learning, meaning, and identity, 1998) around inquiry-oriented instruction. Each stage of the project was designed to engage mathematics faculty in negotiating meaning about effective active learning, quantitative modeling, and academic success skills and in creating and sharing artifacts reifying these meanings. In this talk we will summarize and illustrate the ways in which these aspects of identity are unique to the individual, coherent across their professional roles, influence their instructional practices, and evolve through collaborations about teaching and learning undergraduate mathematics.

Successes, Struggles, Surprises and Short-term Goals of Mathematics Graduate Student Instructors Teaching for the First Time
4:40 pm - 4:55 pm
Johan Benedict Cristobal, *University of Nebraska-Lincoln*

As part of a larger study on graduate student instructors' (GSIs') experiences of teaching, I collected and analyzed 24 journal entries across 3 GSIs from a mid-sized R1 university who were first-time instructors of a particular mathematics course. Through multiple cycles of constant comparative inductive analysis, I addressed the question, "What experiences are salient in novice GSIs' written reflections of teaching?" Reflections were organized into the Four S's: successes, struggles, surprises, and short-term goals. Successes point to what experiences may lead to confidence in teaching. Struggles and surprises point to what professional development programs should preemptively address. Short-term goals point to what instructors valorize and attend to for their development. I close with implications of these Four S's for GSI leaders and facilitators. An awareness of these threads may help the transition into the role of teaching content at their specific local and cultural contexts.

Mathematics and Sports
Thursday, August 8, 3:30 pm - 6:05 pm

The expanding availability of play-by-play statistics, video-based spatial data, and other sports data, for a variety of sports, is leading to innovative kinds of research, using techniques from various areas of the mathematical sciences. By modeling the outcome distributions in certain situations, researchers can develop new metrics for player or team performance in various aspects of a sport, comparing actual results to expected values. Such work often has implications for strategic game management and personnel evaluation. Classic areas of study, such as tournament design, ranking methodology, forecasting future performance, insight into rare or record events, and physics-based analysis, also remain of interest. This session will include both presentations of original research and expository talks; topics related to the use of sports

applications in curriculum are welcome. With a broad audience in mind, all talks are requested to be accessible to mathematics majors. Undergraduates and their mentors are particularly encouraged to submit abstracts for consideration.

Over the last decade, the interdisciplinary subfield of sports analytics has matured from an informal pastime to a specialized field of study. Peer reviewed journals include the Journal of Sports Economics (first published in 2000), the Journal of Quantitative Analysis in Sports (2007, now ASA-affiliated) and the Journal of Sports Analytics (2015). The MIT Sloan Sports Analytics Conference annually draws hundreds of industry professionals, along with thousands of attendees, and receives extensive coverage by mainstream media. Smaller events such as the Midwest Sports Analytics Meeting at Central College (IA) and other regional conferences offer broader opportunities for those from academia (including undergraduates) to present their work and to interact with others who have similar research interests. The Sports SIGMAA gives the MAA a community similar to those already established within the ASA and INFORMS. Further, the Sports SIGMAA now has an active journal entitled Mathematics and Sports (2020).

Given the substantial representation of faculty and students from primarily-undergraduate institutions (PUIs) at the national meetings, it is also notable that sports analytics is a very accessible field for undergraduate research. With the availability of rich data sets online and the familiarity of some phenomena being studied, it is possible to involve younger students in associated research, even first-year undergraduates, teaching the relevant content on a just-in-time basis. Indeed there are a growing number of mathematics faculty at PUIs for whom sports analytics is their primary subfield, a trend that seems likely to continue on a small scale. Our experience has been that about one third of our speakers are undergraduate students.

Aside from data-driven analytics, there are many other areas in which interesting mathematics arises in an athletic-related context, or that standard curriculum can be motivated by an example from sports. These may be related to calculus (motion), linear algebra (ranking theory), graph theory (scheduling), combinatorics (best-of-n series), and of course, probability and statistics.

This session has a history in the JMM that goes back decades and has been strong in recent years (typically 20-30 talks and robust attendance). In 2019, the Sports SIGMAA held its first Themed Contributed Paper Session at MathFest with nine talks. There were eight talks and substantial attendance at the 2021 (virtual) JMM session. In the 2023 Themed Contributed Paper Session at Mathfest, 8 talks were presented and there were a minimum of 40 people in attendance for each. With the rising academic profile of related work across multiple disciplines, we believe that this session will continue to add value to national conferences for years to come.

Organizers:
Filippo Posta, *Phoenix College*
Amanda Harsy, *Lewis University*

Sponsor:
SIGMAA on Mathematics and Sports (SIGMAA Sports)

A Comparison of Consistency of Olympic Figure Skating Scores Using Two Different Scoring Systems
3:30 pm - 3:45 pm
Grace Stulman, *Towson University*
Diana Cheng, *Towson University*
John Gonzalez, *United States Department of Defense*

This project analyzes the internal consistency of figure skating scores earned at the Winter Olympic Games (WOG). In 2002, there was a judging scandal related to the pairs & ice dance events at the WOG conducted under the 6.0 judging system. Subsequently, the International Skating Union developed a new system in hopes of improving the consistency of judges' ratings and reducing biases that were present. We compared the consistency of scores in WOG across years where different judging systems were used. The results of these analyses can be used to inform skaters' training and the development of scoring regulations in international figure skating.

Student Modeling Projects in Sports
3:50 pm - 4:05 pm
Therese Shelton, *Southwestern University*

We will give an overview of some undergraduate student modeling projects we have supervised, including field independent pitching, baseball team ranking using the chess ranking Elo, basketball shot selection, Markovian ties in volleyball, and more. Most of these are data driven.

Counterattack Data in Women's NCAA D-1 Volleyball
4:10 pm - 4:25 pm
Caleb Adams, *Radford University*

In this talk, the speaker will present results of statistical analyses reflecting the offensive counterattack following an opponent's out-of-system attack from teams in the Atlantic Coast Conference (NCAA Division I Women's Volleyball). Data stems from video of in-conference matches including data from two of the best teams in the country in 2024. The evolution of the metric used will be discussed as well as how data is gathered and analyzed. Examined is the type of attack defended, the quality of the counterattack, and the effectiveness of the counterattack. A final analysis determining if there is a correlation between effective counterattacking and match outcome and the comparison of results between high-level teams and teams that finished at the bottom of the conference is also presented.

Using the Gini Index to Investigate Talent Inequity in College Football
4:30 pm - 4:45 pm
Reza Abbasian, *Texas Lutheran University*
John Sieben, *Texas Lutheran University*

Corrado Gini in his 1912 paper Variability and Mutability proposed the index of distribution of wealth that has become known as the Gini Index. As proposed the Gini Index measures the equality or inequalities in the distribution of a country's wealth across the entire population of the country. It can also be used for measuring the equitable distribution of any resource across a population. In this talk we explore an application of Gini index to recruiting top talent in college football. Specifically, we use data on the star-rated high school athletes recruited by top college teams, form the distribution of talent across

the collection of universities competing for that talent and by calculating Gini index highlight the inequity of football talent among various Division I college football teams. Our hope in conducting this work is to demonstrate use of basic knowledge of probability and statistics in modeling athletic events.

The Effect of Carbon Plated Shoe Technology on Elite Marathon Times
4:50 pm - 5:05 pm
Ryan Savitz, *Neumann University*
Jared Ward, *Brigham Young University*
Andrew Bjorkelo, *Neumann University*
Bo Waggoner, *University of Colorado*

This paper examines the effect of carbon plated "super shoes" on the performance of elite male marathoners. In order to quantify the effect of these shoes on elite athletes, we analyzed data on the number of athletes who ran a marathon in under 2:08:00 each year from 1985 through 2021. A multiple linear regression model was constructed that controlled for the non-"super shoe" related upward time trend in the number of sub-2:08 times, utilizing a Cochrane-Orcutt transformation to correct for autocorrelation. This model shows that this new shoe technology is responsible for an additional roughly 24 additional sub-2:08 times per year. Estimated from this, we find a shoe-related time reduction of 1 minute and 31 seconds, or a 1.174% decrease in time. We also discuss the progression marathon times from 2022-present and how multiple super shoe effects may be tied into these new trends.

A Markov Chain Analysis of the Basketball Game Lightning
5:10 pm - 5:25 pm
Michael Loper, *University of Wisconsin - River Falls*
Andrew Flatz, *University of Wisconsin - River Falls*
Lezlie Weyer, *University of Wisconsin - River Falls*

Lightning (also called Knockout, Elimination, and other names) is a basketball drill that is often played as minigame on the playground. The game is played with two basketballs and a line of players that cycles. If a player makes a basket before the player in front of them, they eliminate the player in front of them. The objective is to be the last player remaining. In this game, players often disagree on what the order of players should be. In this undergraduate research project, we used an absorbing Markov chain to analyze where in the line is the optimal place to start if a player wants to maximize their probability of winning the game. We will also discuss trends in the data and the expected length of a game.

Skateboarding in Four-Dimensions
5:30 pm – 5:45 pm
Thomas Li, *River Hill High School*

Skateboarding is a sport popular among young people, but its connection to math is yet to be explored. As an avid skateboarder and a student who loves math, I always wonder whether there is an elegant way to model and understand those flips and spins. My introduction to Quaternions, a 4-dimensional vector system, leads me to an exciting journey connecting skateboarding and math. In this talk, I would like to share how skateboarding tricks can be represented, modeled, and understood using the Quaternions systems. I will use computer simulation to show how tricks like "spin," "flip," or "shuvit" can be illustrated beautifully using Quaternions and how simple and difficult tricks differentiate from each other in terms of representation. Time-permitting, I will also show some ongoing work of using sensors to collect motion data from skateboarding to engage youth in learning math in an entertaining way.

Statistical Analysis of Traveling on Expected Goals in US Men Professional Soccer
5:50 pm – 6:05 pm
Filippo Posta, *Phoenix College*

We collected data from the past 3 seasons of the MLS and USL Championship soccer leagues with the goal of studying the impact of traveling. We were particularly interested to find out about any statistically significant differences between the two leagues due to the gap in resources accompanied by an equally demanding cross-country schedule. We also studied any traveling imbalance between team schedules within each league and how it could impact performance on the field. All analysis is done using publicly available data and statistical inference techniques. We present our findings, potential applications, and extensions.

Teaching and Learning of Differential Equations

Thursday, August 8, 2:30 pm - 6:05 pm

This session features talks by math faculty teaching ordinary and partial differential equations. The goal is to provide a platform where math faculty can share ideas on using differential equations as undergraduate research projects, present evidence-based research on the teaching and learning of differential equations, share experiences, and best practices in using software and technology to support the teaching of differential equations, report on pedagogical strategies and techniques that increase student engagement and success in differential equations, and/or introduce new or unconventional ways of teaching traditional concepts in differential equations. Presenters are encouraged to submit articles based on their presentation for consideration in CODEE journal (www.codee.org), an open-access, peer-reviewed journal devoted to the teaching and learning of differential equations.

Organizers:
Scott Strong, *Colorado School of Mines*
Johannah Crandall, *Spokane Falls Community College*
Maila Hallare, *United States Air Force Academy*
Chris Oehrlein, *Oklahoma City Community College*
Viktoria Savatorova, *Central Connecticut State University*
Beverly West, *Cornell University*

The Factoring Method That Will Change Your Life!
2:30 pm - 2:45 pm
Peyam Tabrizian, *Brown University*

In this talk, I will present a very elegant method for solving constant coefficient 2nd order ODE such y” - 5y’ + 6y = 0 by factoring out operators instead of using auxiliary equations. The advantage of this technique that it is much more direct and does not require any guesswork whatsoever. Moreover, it generalizes easily to inhomogeneous ODE and can even be used to solve some PDE such as the wave equation.

Innovations in Solving Ordinary Differential Equations
2:50 pm - 3:05 pm
Hamid Semiyari, *American University*

This presentation explores innovative approaches to solving ordinary differential equations (ODEs), including both linear and nonlinear cases. Building on the work of Parker and Sochacki from James Madison University, who adapted the Picard method for solving initial value problems (IVPs), we extended their technique to address boundary value problems (BVPs). Unlike traditional methods that struggle with nonlinear problems, our approach effectively handles both linear and nonlinear challenges. Additionally, it provides solutions to DEs in the form of a Taylor series of the exact solution, contrasting with the single-point solutions typical of most existing methods. Initially, we relied on symbolic software like Maple, but transitioning to MATLAB and R significantly improved our computation speed.

This session provides a platform for mathematics educators to discuss undergraduate projects, teaching strategies, and the effective use of software for teaching differential equations.

Piecing Together a Direction Field
3:10 pm - 3:25 pm
Nicole Panza, *Francis Marion University*

Direction fields tell us a lot about how the solutions to differential equations behave. However, they can be tedious and often misleading if not enough time and effort are put into creating them. In this activity, students worked on creating one collective direction field by piecing together their individual points, discussing overall solutions, and comparing the solution we created as a class to the one created by technology. This gave students a tactile and first-hand way of experiencing direction fields to make the pictures that technology gives us more relatable.

Dynamic Mentoring with Mathematical Modeling
3:30 pm - 3:45 pm
Sherli Koshy-Chenthittayil, *Touro University Nevada*
Monica Morales Hernandez, *Adelphi University*

In this session, I will present how one can use mathematical biology research projects to help students understand ODEs and their applications. Using different research projects and open-source software like COPASI (a biochemical modeling program), NetLogo (agent-based modeling) to investigate dynamics of biologically relevant ODE systems. Through the projects, the students (high school, undergraduate and medical school) learnt about ODEs, parallel computing, translation of ODEs to agent-based models, and optimization techniques. The students were able to create high quality research presentations and contribute to manuscripts, enhance computer programming skills, and become proficient in the software. Students shared that the project experience helped develop confidence, reduce math anxiety, and enhanced networking skills. From this session, faculty will be able to design similar mathematical modeling projects for student engagement as well as improve existing mentoring skills.

Modeling Newtonian Cooling: Parameter Estimation and Data Fitting with ODEs
3:50 pm - 4:05 pm
Viktoria Savatorova, *Central Connecticut State University*
David Stolarz, *Central Connecticut State University*
Jayson Arichavala, *Central Connecticut State University*

We explore the application of ordinary differential equations (ODEs) in modeling Newtonian cooling phenomena within an attic crawl space. The primary objective was to estimate the outside ambient temperature that can be tolerated without the risk of water in pipes within the attic crawl space freezing. Our study began by formulating the problem with appropriate assumptions, resulting in a first-order linear differential equation that captures the cooling process. The obtained mathematical model has two parameters characterizing the exchange of heat with the interior and exterior, respectively. These parameters are unknown and need to be defined by fitting the model to empirical temperature data collected from the crawl space and two distinct ambient temperatures. To address varying temperature dynamics, we used a continuous model during time intervals where ambient temperatures exhibited linearity and a discrete model otherwise.

An Interdisciplinary Undergraduate Research Project: Mathematical Analysis and Optimal Control on Unemployment Model
4:10 pm - 4:25 pm
Jeong-Mi Yoon, *University of Houston-Downtown*

In this presentation I will introduce my experience as a faculty advisor in the mathematics senior project titled in “Mathematical Analysis and Optimal Control on Unemployment Model” at the spring of 2024.

I started the project with a system of three nonlinear differential equations representing the relation between employment, unemployment and vacancy populations developed by S.E. Munoli and S.B. Gani (2016). The system was explored by the linearization and stability analysis techniques analytically, and also by using mathematics software Maple and MATLAB numerically. Through this research, student learned how to run programs and interpret behaviors of solution of the system, and how to optimize results using the Pontryagin’s Minimal Principle. By completing this project, student got valuable research experiences in social sciences.

Epidemiologic Modeling with Human Interaction and Disease Informed Neural Networks Technology to Engage Next Generation DE Students
4:30 pm - 4:45 pm
Carmen Caiseda, *Inter American University of Puerto RIco*
Alonso Ogueda-Oliva, *George Mason University*
Jeremis Morales-Morales, *Inter American University of Puerto Rico*
Padmanabhan Seshaiyer, *George Mason University*

In this work we share an epidemiologic compartmental model with human interaction and the use of Disease Informed Neural Network to engage students in mathematical modeling. The project is a result of a cross-discipinary collaborative research experience for students that includes mathematics, epidemiology, sociology, and technology resources as an instructional toolkit. A multi-level mentoring team of undergraduate and graduate students, as well as senior and junior faculty members helped boost the transfer of knowledge and further development of the model. We will also share literate programming model that uses available web-based resources, such as Jupyter Notebook, where the DE instruction drives the coding to obtain a real-time output as solutions to the mathematical model.

Through this approach we aim to equip our next generation of students with advanced thinking skills and technology motivated by modeling for social good in a rich Mathematical, Biological and Social context.

Self-Assessment and Score Negotiation on Problem Sets in an Intro ODE Course
4:50 pm - 5:05 pm
Chris Oehrlein, *Oklahoma City Community College*

Part of assessment reform in mathematics and science is the Ungrading movement. Ungrading is a term with many interpretations and applications in alternative assessment. A simple way for professors to step into Ungrading is by allowing students to self-assess and negotiate scores, progress, etc. with them. One professor has been using this concept on problem sets in the Introduction to Ordinary Differential Equations course for a few semesters. He will report on missteps, the evolution of his process, perceptions (his own, his students', his colleagues', and his administrators'), and possible expansion to other aspects of the course.

Differential Equations is More Than a Calculus Refinement Course
5:10 pm - 5:25 pm
Cesar Martínez-Garza, *Penn State - Berks College*

Sophomore-level ODEs for non-Mathematics majors is often treated as a "Calculus refinement" course. The difficulty of assessments is typically gauged by difficult integrals or "tricky" algebraic equations, rather than the ODEs themselves. Nowadays, I commit heresies, like allowing students to leave solutions in integral form, for example. I seek to expose the students to the inherent "structural beauty" of differential equations, rather than distract them with integrals requiring quadruple IBP. I weave the Wronskian, homogeneous/non-homogeneous solutions, and Variation of Parameters beginning with first order equations. To complement this qualitative approach, I take students to a computer lab where we use Mathematica to explore more complicated cases, including nonlinear equations. In this talk, I will share some examples of unifying concepts as well as some computer lab assignments that students have found particularly elucidating.

Engaging Students with "Lab" Assignments in an ODEs Course
5:30 pm - 5:45 pm
Jay George, *Penn State Erie*

An introductory differential equations course is ripe with opportunities for students to make connections between analytical, numerical, and graphical representation of solutions. Occasional activities that go beyond typical homework exercises can strengthen such connections and deepen students' conceptual understanding.

In this talk, I will present several brief "lab" assignments I use in a sophomore-level differential equations course to promote student engagement with key concepts, technology, and graphical representation of solutions.

Historical Approaches to First Order Linear Differential Equations
5:50 pm - 6:05 pm
Adam Parker, *Wittenberg University*

We will present three historical approaches to solving first order linear differential equations - one each due to Leibniz, Johann Bernoulli, and Euler. Leibniz utilized his intuition to guess at the form of a solution. Bernoulli solved them using variation of parameters. Euler then developed our modern integrating factor technique. Depending on your approach to teaching ordinary differential equations, one of these methods may be more appropriate and helpful to your students.

Advances in Algebraic Topology
Part A: *Friday, August 9, 1:00 pm - 3:55 pm*
Part B: *Saturday, August 10, 3:00 pm - 4:15 pm*

The subject of algebraic topology spans a wide range of topics, from category theory to the use of machine learning to study large data sets. Although the foundations of this field focused on using tools from algebra to study problems in topological settings, this subject is now relevant to a broad collection of pure and applied mathematics, including homotopy theory, topological data analysis, homotopy type theory, and category theory. Thanks to this intersection with many other branches of mathematics, talks in this subject may be of interest to mathematicians working in topology more broadly, as well as geometry, algebra, number theory, and algebraic geometry. In addition, this session is intended for speakers from both theoretical and applied perspectives on algebraic topology, and thus pertains to a wide audience. Talks in this session will present original research results, and we welcome a wide audience of mathematicians interested in algebraic topology.

Organizers:
Chloe Lewis, *University of Wisconsin-Eau Claire*
Sarah Klanderman, *Marian University*
Amelia Tebbe, *Indiana University Kokomo*

Part A: *Friday, August 9, 1:00 pm - 3:55 pm*

Removing Isolated Zeroes by Homotopy
1:00 pm - 1:15 pm
Adam Coffman, *Purdue Fort Wayne*
Jiří Lebl, *Oklahoma State University*

Suppose that the inverse image of the zero vector by a continuous map f from R^n to R^q has an isolated point P. The existence of a continuous map g which approximates f but is nonvanishing near P is equivalent to a topological property we call ``locally inessential," generalizing the notion of index zero for vector fields, the q=n case. For dimensions n, q where the (n-1)-fundamental group of the (q-1)-sphere is trivial, every isolated zero is locally inessential. We consider the problem of constructing such an approximation g and a continuous homotopy from f to g through locally nonvanishing maps. The existence of a smooth homotopy, given a smooth map f, is stated as an open question.

Diagram-Equivariant Homotopy Theory
1:20 pm - 1:35 pm
Hannah Housden, *Vanderbilt University*

The notion of group action on a topological space can be generalized to the notion of an action by a category. This talk will explore the basic notions and discuss what happens in the case of a category with two objects with one non-identity morphism. As it turns out, there are highly nontrivial homotopical structures here, despite the category being very simple.

Steenrod Operations on Polyhedral Products
1:40 pm - 1:55 pm
Sanjana Agarwal, *Indiana University, Bloomington*
Jelena Grbić, *University of Southampton*
Michele Intermont, *Kalamazoo College*
Milica Jovanović, *University of Belgrade*
Evgeniya Lagoda, *Freie Universität Berlin*
Sarah Whitehouse, *University of Sheffield*

Given a simplicial complex K on m vertices and m topological pairs ((X1, A1), . . . , (Xm, Am)), the polyhedral product is a way to construct a new topological space by "pasting these n-pairs of spaces along the combinatorics of K". One example of this is the moment-angle complex which you get when (Xi,Ai) = (D2,S1). It comes equipped with a m-torus action and is a topological analogue of projective toric varieties studied in algebraic geometry. For an arbitrary simplicial complex K, the moment-angle complex can be identified as the complement of a complex coordinate subspace arrangement, linking polyhedral products to combinatorics and commutative algebra.

A natural question to ask is if one understands the cohomology and steenrod operations on the spaces (Xi,Ai), what can one say about the cohomology and the steenrod operations on a polyhedral product. In this talk we present what is understood about this problem, including our work in this direction.

Derivatives in Homotopy Theory
2:00 pm - 2:15 pm
Duncan Clark, *Milwaukee School of Engineering*

Functor calculus is a modern subfield of topology initially developed by Tom Goodwillie as a means to understand complicated functors arising in topology (like K-theory) by studying simpler, polynomial-like approximations. In particular, any suitably nice functor has associated to it a sequence of ``derivatives"---spectra with actions by the symmetric groups---that largely determine the structure of these approximations. In this talk, we'll investigate the derivatives of the identity functor. and describe the algebraic properties this sequence of derivatives possesses.

Fiber of the Cyclotomic Trace for the Sphere Spectrum and Tate-Poitou Duality
2:20 pm -2:35 pm
Myungsin Cho, *Indiana University*

Algebraic K-theory is an invariant of a ring, originated in Grothendieck’s K-group. Topologically, this takes account vector bundles over a fixed topological space. However, its applications extend far beyond topology, manifesting mysteriously in various fields like algebraic geometry, number theory, and differential topology. Specifically, understanding the algebraic K-theory of integers and the sphere spectrum has been recognized as a central challenge in algebra and geometry. Although these two are not yet completely known, various relationships and interplay between them has been studied through cyclotomic trace. Moreover, K(1)-localization allows us to understand algebraic K-theory of the integer using the l-adic ́etale cohomology. In this talk, I will exhibit the connection between the integer and the sphere spectrum within the framework of K(1)-local algebraic K-theory and Tate-Poitou duality from the ́etale cohomology.

Transfer Systems for Rank Two Elementary Abelian Groups
2:40 pm - 2:55 pm

Christy Hazel, *Grinnell College*
Linus Bao, *University of Oxford*
Tia Karkos, *Colorado State University*
Alice Kessler, *Iowa State University*
Austin Nicolas, *Grinnell College*
Kyle Ormsby, *Reed College*
Jeremie Park, *University of California -Davis*
Cait Schleff, *University of Louisville*
Scotty Tilton, *University of California - San Diego*

Transfer systems are combinatorial objects of interest due to their exciting connections to equivariant homotopy theory. Using transfer systems, we are able to translate complicated questions about equivariant commutativity into questions about subposets of a lattice. In this talk, we'll define transfer systems, discuss their connections to equivariant homotopy theory, and then highlight some recent results about transfer systems for rank two elementary abelian groups. This joint work with L. Bao, T. Karkos, A. Kessler, A. Nicolas, K. Ormsby, J. Park, C. Schleff, and S. Tilton was part of the 2023 eCHT Summer REU.

Uniquely Compatible Transfer Systems
3:00 pm - 3:15 pm
Kristen Mazur, *Elon University*
Angélica Osorno, *Reed College*
Constanze Roitzheim, *University of Kent*
Rekha Santhanam, *Indian Institute of Technology Bombay*
Danika Van Niel, *Michigan State University*
Valentina Zapata Castro, *University of Virginia*

Transfer systems are combinatorial objects that encode information about equivariant operations. More precisely, a transfer system encodes the transfers (or wrong-way maps) carried by algebras over certain equivariant operads. Thus, transfer systems allow us to use combinatorial tools to study equivariant homotopy theory. Compatible pairs of transfer systems, which are pairs of transfer systems satisfying certain conditions, correspond to multiplicative structures compatible with an underlying additive structure. In particular, compatible pairs are closely related to bi-incomplete Tambara functors. In this talk we introduce transfer systems, compatible pairs, and discuss when a transfer system is only compatible with at most two other transfer systems. The work discussed in this talk began as a collaboration through the Women in Topology IV workshop and is joint with Angélica M. Osorno, Constanze Roitzheim, Rekha Santhanam, Danika Van Niel, and Valentina Zapata Castro.

Localizations of Tambara Functors
3:20 pm - 3:35 pm
Ben Spitz, *University of California, Los Angeles*
Hiroyuki Nakaoka, *Nagoya University*
Jason Schuchardt, *University of California, Los Angeles*

Tambara functors generalize commutative rings "in an equivariant direction". However, the algebraic tools we have for working with Tambara functors are much more limited than those available in traditional commutative algebra. In this talk I will discuss recent progress in developing a theory of localizations of Tambara functors at prime ideals.

Octonionic Quadratic Equations
3:40 pm - 3:55 pm
Kalpa Thudewaththage, *Widener University*

There are four normed division algebras over R, namely real numbers, complex numbers, quaternions, and octonions. Lack of commutativity and associativity make it difficult to investigate algebraic and geometric properties of octonions. It does not make sense to ask whether the equation x^2+1=0 is solvable, without specifying the field in which we want the solutions to be lie on. The equation x^2+1=0 has no solutions in R but there are complex numbers which do satisfy this equation. In this work, we extend the same idea to the octonions, which is an eight dimensional normed division algebra and solved octonionic quadratic equation of the form x^2+bx+c=0, where b,c are octonions. Finally, we represent the left spectrum of 2×2 octonionic Hermitian matrix as a set of solutions to a corresponding octonionic quadratic equation and give full classification to its left eigenvalues. Further, we introduced a python package called “pyoctonion" to solve any given octonionic quadratic equations.

Part B: *Saturday, August 10, 3:00 pm - 4:15 pm*

Künneth Formulae in Persistent Homology
3:00 pm - 3:15 pm
Hitesh Gakhar, *Michigan State University*
Jose Perea, *Northeastern University*

The classical Künneth formula in homological algebra provides a relationship between the homology of a product space and that of its factors. In this talk, we will showcase similar results for persistent homology, a tool used in Topological Data Analysis. In particular, we will provide relationships between persistent homology of two different notions of product filtrations and that of their factor filtered spaces, along with an application to topological time series analysis.

Topological Versus Biochemical Features: Comparative Performance in Protein Stability Predictions
3:20 pm - 3:35 pm
Amish Mishra, *Taylor University*
Francis Motta, *Florida Atlantic University*

In this talk, we demonstrate the efficacy of topological features in predicting the stability of hundreds of synthetic proteins, comparing against models trained on biochemical features as determined by subject-matter experts (SME). Our models, based on topological features of the protein structures, achieved 92%-99% of the performance of SME-based models in terms of the average precision score. Additionally, we extract insights from information-rich plots that uncover high correlations between topological features and SME features, indicating that topological information sufficiently captures biochemical interactions to train effective models. Utilizing a data-driven approach, our pipeline employed Cover-Tree Differencing via Entropy Reduction (CDER) on all persistence diagrams for each protein design topology. This strategy for feature engineering discriminated between stable and unstable protein designs based on the homological information as captured in their persistence diagrams.

Asymptotic Dimension and Geometric Decompositions in Dimensions 3 and 4
3:40 pm - 3:55 pm
Pablo Suarez-Serrato, *National Autonomous University of Mexico*

Haydee Contreras Peruyero, *Centro de Ciencias Matemáticas - National Autonomous University of Mexico*

We show that the fundamental groups of smooth 4-manifolds that admit geometric decompositions in the sense of Thurston have asymptotic dimension at most four, and equal to 4 when aspherical. We also show that closed 3-manifold groups have asymptotic dimension at most 3. Our proof method yields that the asymptotic dimension of closed 3-dimensional Alexandrov spaces is at most 3. We thus obtain that the Novikov conjecture holds for closed 4-manifolds with such a geometric decomposition and closed 3-dimensional Alexandrov spaces. Consequences of these results include a vanishing result for the Yamabe invariant of certain 0-surgered geometric 4-manifolds and the existence of zero in the spectrum of aspherical smooth 4-manifolds with a geometric decomposition.

Bicategories for TQFTs with Defects with Structure
4:00 pm - 4:15 pm
Ik Jae Lee, *Rowan University*
David Yetter, *Kansas State University*

We provide a description of adequate categorical data to give a Turaev-Viro type state-sum construct of invariants of 3-manifolds with a system of defects, generalizing the Dijkgraaf-Witten type invariants of our earlier work. We term the defects in our construction defects-with-structure because algebraic data associated to them is in general richer than a module category over the spherical fusion category from which the theory is constructed when no defect is present.

Teaching Flops: Learning and Adapting When Teaching Goes Astray

Part A: *Thursday, August 8, 2:00 pm - 3:15 pm*
Part B: *Saturday, August 10, 9:30 am - 11:45 am*

In this session, we want to facilitate conversation about times when teaching doesn't go as expected and the lessons we can learn from them. We believe these discussions are important for us to have, in order to learn, adapt, and improve our teaching. Certainly, teaching math is hard. We have all had times when our best laid lesson plans didn't go as expected. Let's reflect on these times and share our experiences so that we can all become better teachers.

This session will provide a space to explore the limitations of teaching strategies and to think about which factors influence the success of our courses. This will provide a necessary counterbalance to the survivorship bias built into the scholarship of mathematics education. In order to learn and improve our teaching, we must look not just at times our techniques have worked but be honest and open about the times things didn't go as intended.

Organizers:
Russ Goodman, *Central College (IA)*
Erin Griesenauer, *Eckerd College (FL)*
Allen Harbaugh-Schattenkirk, *Longwood University (VA)*

Part A: *Thursday, August 8, 2:00 pm - 3:15 pm*

Control Your Changes
2:00 pm - 2:15 pm
Kenny Barrese, *Brescia University*

In the Fall of 2019 I taught Differential Calculus, something I had done many times before. However, this semester I taught it for the first time at a new institution and taught it using inquiry-based methods for the first time. What could go wrong? Quite a lot, it turns out. Why did it go wrong? That I cannot tell you, but I will tell you what I learned from the experience and how I have reduced the likelihood of having such a bad experience in the future.

Ostrich-like Behavior of Students in Math for Liberal Arts
2:20 pm – 2:35 pm
Mariah Birgen, *Wartburg College*

"My first course development strategy is that every course must have a soul. Courses that lack this seem to students to be some type of Frankenstein's Monster. However, over the years I have discovered that this is not the only requirement.

I teach Mathematics of Democracy which often violates rule two, which is, don't teach a course that answers questions that the students don't want to ask. The course answers questions on Multicandidate Elections, Weighted Voting, Apportionment, Gerrymandering, and Finance. It is the last of which that often violates rule two. It turns out that loans are something that students are familiar with, but do not want to ask questions about. This ostrich-like behavior has only increased with students with Pandemic-era students. This talk will explore the limitations of how much a teacher can stretch the students towards things they would rather ignore and will introduce possible new directions, including civic engagement, that the curriculum could take."

Reflections on Implementing and Improving a Mastery-Based Grading System for Mathematics Courses
2:40 pm - 2:55 pm
Felicia Tabing, *University of Southern California*

Motivated by the idea that a mastery-based grading system is supposed to encourage learning and take the pressure off high-stakes assessments, I implemented a mastery-based grading system for most of the mathematics courses I teach. Each term, I consider feedback and make changes to the grading system to hopefully improve it. I will discuss issues I encountered and did not anticipate due to specific aspects of the design of the grading system and syllabus, and what I have done to remedy these issues (even though this did not always fix the problem, and a new one would often come up!)

Navigating the Roller Coaster of Standards-based Grading in College Algebra
3:00 pm - 3:15 pm
Randa Kress, *Idaho State University*
Derek Eckman, *Idaho State University*
Jason Reed, *Idaho State University*

In this presentation, we describe our one-year journey to implement standards-based grading in our coordinated College Algebra and co-requisite College Algebra courses. In particular, we address the roadblocks we encountered in our initial implementation during the fall semester (both from a teaching

and logistics perspective), our current attempts to mitigate these issues in the spring, and our plans for additional refinement of the system as we move forward into the next academic year. Our presentation will provide insights into how departments wishing to adopt standards-based grading beyond the individual instructor level might approach this endeavor and the possible roadblocks they might encounter.

Part B: *Saturday, August 10, 9:30 am - 11:45 am*

A First Attempt at an Alternative Grading Scheme
9:30 am - 9:45 am
Molly Lynch, *Hollins University*

In this talk, I outline my first attempt at trying mastery-based grading in my calculus 1 class. I explain my motivation for using this grading scheme as well as how I structured my grade book. I highlight some of the pillars of alternative grading schemes and reflect on why my implementation did not succeed. I end by talking about adjustments I have made and further changes I plan to incorporate in the future.

I Wish You Hadn't Done That: An Examination of Student Cheating
9:50 am - 10:05 am
John Prather, *Ohio University's Eastern Campus*

A recent flop that I had was that prior to the pandemic, I never had any particular problems with cheating. Teaching in an online environment, however, I was confronted with the reality that, in an un-proctored environment, more students will cheat than I would have guessed. Then my own curiosity got the better of me, and I started to wonder exactly how students cheat. In this talk, without being too negative, I will discuss how students cheat and how instructors can tell even in un-proctored situations, particularly in lower-level math courses.

My Failed Attempt to Engage Students in Groups: What Went Wrong and What Changed Now
10:10 am - 10:25 am
Sharmila Sivalingam, *Maryville University of St. Louis*

"One such scenario is when the presenter decided to participate in a program and implemented some changes in an introductory mathematics course. Two such changes were to rotate student groups and use relaxation techniques at the beginning of the class. However, the semester became stressful and the students were divided, which was not the expected result. It was a failed and discouraging attempt. However, a careful reflection on what went wrong and how it could be done differently helped the presenter to create a plan for the future. In this session the presenter will discuss about background for implementing the new changes, what went wrong, why it was not successful, limiting factors and what strategies are considered and employed after the first attempt."

Why Won't My Students Collaborate? The Failure of Partner Homework
10:30 am - 10:45 am
Kristi Meyer, *Wisconsin Lutheran College*

On paper, partner homework sounds like a great idea: get students talking about the problems assigned, have them work together to catch mistakes and correct misunderstandings, and then submit one combined homework assignment (thus making for a lighter grading load!). I even give my students the opportunity to evaluate their partners to head off the potential issue of one student doing all the work. But despite my best efforts, partner homework hasn't been the success I'd like it to be. In this talk, I'll detail how I

implement partner homework in my classes, explain what's gone wrong along the way, and consider if there are tweaks that can save this system or whether it should be abandoned in favor of something else.

(Un)Cooperative Learning
10:50 am – 11:05 am
Rachel Frankel,
University of Cincinnati, Blue Ash College

Join me as I share my candid experience with cooperative learning in a college algebra course. Despite a thorough reading of the literature on cooperative learning and meticulously planning everything including diverse group compositions, unexpected twists like high absenteeism were a problem. Lengthy worksheets added to the challenge, leaving us short on time and long on frustration. Further, as I tried to foster teamwork, some students worked solo and most groups relied on a single student's efforts. In this presentation, we'll explore what went wrong and aim to learn from these missteps.

Intensive Coaching for At-Risk Calculus Students
11:10 am - 11:25 am
Mel Henriksen, *Wentworth Institute of Technology*
Mami Wentworth, *Wentworth Institute of Technology*

In Spring 2024, we launched a pilot coaching program to target at-risk students in Calculus I. We met with several small groups of students weekly throughout the term. We surveyed their study habits regularly and encouraged them by email each day of class. Our interactions allowed us to gain insight into students' thinking that would not have been possible in a normal classroom environment. At the same time, we found our assumptions about our students challenged; being able to state principles or use certain terms did not indicate their true understanding of those terms or the underlying concepts. Additionally, many of the study habit changes that we asked students to make were not adopted or were adopted half-heartedly. In this talk, we will discuss our piloted approach including our suggested study practices, and our efforts to understand the cause of our students' struggles and poor performance. We will also present our plans to modify and expand this program in the fall.

Losing the Model in the Calculations: Classifying Critical Points
11:30 am - 11:45 am
Jessie Oehrlein, *Fitchburg State University*

In a Multivariable Calculus course, I wrote an activity in which students would identify patterns in classifying critical points by finding critical points of given functions, calculating second partial derivatives, and graphing the functions. I imagined a class of students compiling a table of different functions and critical points as a collective model to explore and then using those explorations to find patterns for classification of critical points. Students building that kind of collective model is great!... when they reach it correctly, quickly, and without too much cognitive load. In this talk, I will explain the activity, what went wrong, and possible fixes moving forward.

Quantum Computation in the Undergraduate Curriculum
Thursday, August 8, 8:00 am - 10:35 am

Historically, the background required for learning the mathematics of quantum computation would place it near the end of the undergraduate curriculum, drawing on topics from linear algebra, abstract algebra, differential equations, topology, and more. Using projects, problems, demonstrations, and other curricular materials, aspects of quantum computing can be introduced effectively in these traditional courses, increasing the accessibility of this emerging field. This session will explore approaches to incorporating quantum computational ideas throughout the undergraduate mathematics curriculum. These contributions can range from a series of examples in a course to entire modules. Evidence- based assessment of the effectiveness of including quantum computation ideas and examples in a course towards helping students meet learning goals is encouraged but not required.

Organizers:
Shannon Talbott, *Moravian University*
Wade Bloomquist, *Morningside University*
Santosh Kandel, *California State University, Sacramento*
Cheyne Glass, *State University of New York at New Paltz*
David Freund, *Cornell University*
Jennifer Vasquez, *University of Scranton*

Sprinkling in Some Quantum
8:00 am - 8:15 am
Jennifer Vasquez, *University of Scranton*
Shannon Talbott, *Moravian University*

"Given the rapidly evolving field of quantum computing, it is important that students learn the mathematics behind it. Assuming no quantum background, this talk will aim to describe small and easy ways to incorporate quantum ideas into undergraduate classes such as discrete math, linear algebra, and probability without altering the curriculum. This approach can help generate excitement for and increase the accessibility of quantum computing."

Exploring the Entanglement Between Quantum Computation and Trigonometry
8:20 am - 8:35 am
Zijian Diao, *Ohio University*

"From a distance, teaching and learning the rudimentary subject of trigonometry seem light-years away from conducting cutting-edge research in quantum computation. However, many basic facts of trigonometry have found their way into the study of various research problems in quantum computation. Conversely, quantum computation can also offer novel approaches to generate non-trivial knowledge in trigonometry. In this talk, we will explore these intriguing interplays through a few examples, which can be easily incorporated into trigonometry, calculus, and number theory courses. In particular, we will resolve the exactness issue of Grover's quantum search algorithm, revealing that irrationality matters not only in the mathematical world but also in the quantum realm.

Prior knowledge of quantum computation is not needed."

A Case for Teaching Tensor Products Earlier
8:40 am - 8:55 am
Cheyne Glass, *State University of New York at New Paltz*

Despite often being left out of undergraduate syllabi, tensor products are a key mathematical formalism used in modern applications including quantum computing and language processing. This talk will review some motivating applications and make a case for prioritizing these structures throughout the curriculum. Some course modules and materials will be shared based on experiences in prioritizing tensor products across various mathematics courses at primarily undergraduate institutions.

Q&A Period
8:55 am - 9:10 am

A Theorem of Joseph-Alfred Serret and Its Relation to Perfect Quantum State Transfer
9:10 am - 9:25 am
Anastasiia Minenkova, *University of Hartford*
Maksym Derevyagin, *University of Connecticut*
Nathan Sun, *Harvard University*

In this talk we recast the Serret theorem about a characterization of palindromic continued fractions in the context of polynomial continued fractions. Then, using the relation between symmetric tridiagonal matrices and polynomial continued fractions we give a quick exposition of the mathematical aspect of the perfect quantum state transfer problem and its place in the undergraduate curriculum.

Quantum Connect 4 as an Introduction to Quantum Computing
9:30 am - 9:45 am
Shuler Hopkins, *Sewanee: The University of the South*

"Quantum games have often been used to help build intuition toward the highly unintuitive properties of quantum physics. For this reason, using quantum games as a starting point for undergraduate research in quantum computing is a natural choice. In this talk, we will discuss the results of an introductory summer research project which investigates such a game.

Our talk will include insights into the design and implementation of a mathematical model for a Quantum Connect 4 game, including results related to the existence of winning strategies under certain conditions. We will discuss the challenges encountered during the project and other problems that arose while we worked on this project."

Quantum Mastermind
9:50 am - 10:05 am
Joshua Qualls, *Morehead State University*

Games are often used in the classroom to teach mathematical and physical concepts. Yet the available activities used to introduce quantum mechanics can be overwhelming even to upper-level students. Further, the "games" in question range in focus and complexity making it nearly impossible for people interested in quantum computation to have a simple introduction to the topic. In this paper, we introduce a straightforward and newly developed "Quantum Mastermind" based on the original version of Mastermind. We replace the colored pegs with 6 possible qubits (x+, x-, y+, y-, z+, z-). The player makes up to 9 measurements with 1 final submission. We report on the mathematical analysis of three strategies

for play and conclude by previewing how a "quantum" player could potentially outperform even optimal "classical" players.

Q&A Period
10:05 am - 10:20 am

Incorporating Guest Speakers in a Quantum Computation Course
10:20 am - 10:35 am
Helen Wong, *Claremont McKenna College*

"I'll discuss how I incorporated guest speakers in my quantum computation course. The guest speakers were actively working on quantum computation. Students found the presentations highly enlightening, even if the talks mentioned ideas and vocabulary not covered in our course. I will also talk about ways that I incorporated the guest talks in homework sets and other aspects of the course."

Open-Source Products for the Advancement of Math Education Research and Practice

Friday, August 9, 2:00 pm - 5:15 pm

In this session we will highlight research enabled by, and pedagogical uses of, open-source products in mathematics education. Technology is an increasingly essential element of mathematics education research and practice. However, commercial and proprietary technologies raise a barrier to participation by students and researchers who cannot afford them. Likewise, freely-available services that are built upon closed-source software may still change their terms of service at any time, removing access to user-created content for those who cannot pay. This session will provide a platform for scholars who contribute to the development of open-source educational products, as well as the scholars who use these products for mathematics education research and/or practice. In particular, this session will center educational technologies and resources that ensure both the legal and practical right for scholars to innovate at no cost, sustained by the collaborations of open-source communities and ecosystems. Presentations will include original research enabled by such products, expository presentations on the use of such products in the classroom, and demonstrations showing how to use such products for the advancement of mathematics education research and practice.

Organizers:
Steven Clontz, *University of South Alabama*
Gavin LaRose, *University of Michigan*

Tailoring TBIL Resources Using GitHub
2:00 pm - 2:15 pm
Jordan Kostiuk, *Brown University*

Team Based Inquiry Learning (TBIL) is a style of learning in which class time is dedicated to students problem-solving in permanent teams, with the Instructor facilitating discussions about the problems to develop course content. To support the widespread adoption of TBIL, a resource library of Open

Education Resources is publicly available; users may use the most recent version of these materials or else customize them on Github. In this presentation, I will demonstrate how I use GitHub Codespaces to customize and publish a custom version of the Linear Algebra for TBIL Activity Book to further support the specific learning needs of my students in a way that is aligned with my instructional values. Specifically, I will showcase additional supports I have added in order to help my students develop a personal practice of mathematical writing and exploring.

Autograding graphical problems with DoenetML
2:20 pm - 2:35 pm
Duane Nykamp, *University of Minnesota*

"We illustrate how to use the DoenetML markup language to create problems where students create a graphical representation of their solution using an interactive web page. When students submit their responses, they receive immediate validation of the correctness of their solution as well as feedback on what they missed. We demonstrate example activities in Precalculus, Calculus, and Dynamical Systems. We discuss challenges and strategies for authoring these types of problems.

DoenetML is a semantic XML-based language created by Doenet (the Distributed Open Education Network). Doenet is part of a larger ecosystem of open source educational tools constituting the PROSE Consortium, which also includes PreTeXt, Runestone, and WeBWorK."

WeBWorK and Mastery Assessment in Calculus and Before
2:40 pm - 2:55 pm
P. Gavin LaRose, *University of Michigan*
Hanna Bennett, *University of Michigan*
Robert Cochrane, *University of Michigan*
Paul Kessenich, *University of Michigan*
Anthony King, *University of Michigan*

There is increasing evidence that reducing the weight of high-stakes exam assessment in math courses can have a positive impact on student achievement and persistence, especially for students in groups that have historically been marginalized in STEM fields. In this talk we describe the implementation of mastery assessment in Calculus and our course before that, including a discussion of how the assessment instruments were created, the material they assess, and implementation considerations. Assessments are implemented using the open-source platform WeBworK. We describe the impact of curricular changes that included adding these assessments, technical issues with implementation, practical implications of the adoption of this type of assessment, and some enhancements that were made possible by the open-source nature of the assessment platform.

Using Open-Source Tools to Develop a CRAFTY Compliant Business Calculus Online Text
3:00 pm - 3:15 pm
Mike May, *Saint Louis University*

This talk focuses on an example of using open-source tools to build an open source textbook. The initial project was to make a textbook for a one semester course in calculus for business students following the MAA recommendations for courses for partner disciplines. (CRAFTY CFP reports.) The first iteration was a collection of PDF files on a webpage. PreTeXt gave a true online format and allowed linking of auxiliary files. YouTube has allowed the attachment of screencasts. The exercises have been converted to WeBWorK, so an open-source homework option works. Using GitHub has allowed other schools to

create an independently controlled copy of the text. Future plans include setting up a version to work with Runestone for better course management and to convert the homework to MyOpenMath.

Realizing the Dream: My Adventure in Writing an Online, Open-Access, Interactive, Discovery-Based Geometrical Explorations Textbook
3:20 pm - 3:35 pm
Teresa Magnus, *Rivier University*

How can a first-time author convert a set of tactile classroom exploratory activities and notes into an online geometry textbook that others can use? How does one self-produce a professional-looking, freely available textbook? How can one use HTML capabilities to enhance the learning experience? Highlighting features of her textbook, the presenter will discuss the philosophical and technical challenges encountered in producing it. Philosophical challenges included adding clarity while maintaining the nature of active learning. PreTeXt enables free access, scaffolded yet flexible book structure, use of LaTeX, inclusion of images and other diagrams, embedding of dynamic interactives, simultaneous production of multiple formats and versions, and the ease of updating. Personal determination, online resources, and community support played an essential role in overcoming her limited experience with programming, open-source tools, and markup languages. A link to the textbook will be provided.

Ximera in the Classroom
3:40 pm - 3:55 pm
Bart Snapp, *The Ohio State University*
Jim Fowler, *The Ohio State University*

"Ximera, pronounced “chimera,” (Ximera: Interactive, Mathematics, Education, Resources, for All) is an open-source platform that leverages authors' prior knowledge of LaTeX to produce online interactive content. You can learn more about the project here: https://github.com/XimeraProject/

In this talk we will discuss how Ximera can be integrated into existing classrooms and learning management systems. Central to this discussion is our new online gradebook functionality, which records student performance not only for Ximera sites, but also across a variety of other websites.

Besides the technology, we will discuss the community-driven development model of Ximera which takes place through workshops and on GitHub. Whether you are a novice seeking to create your first interactive document or an expert aiming to extend the platform's capabilities, you are invited to participate."

Understanding Linear Algebra: Using ULA and Sage to Build Student Understanding
4:00 pm - 4:15 pm
Matt Boelkins, *Grand Valley State University*

David Austin's free, open text, Understanding Linear Algebra, is an exemplary book that engages student in active learning and encourages them to use Sage to advance their understanding. In this expository talk about using OER effectively, I'll share my experiences with ULA, examples of how my students interact with the text, and evidence that the text has promoted not only better understanding of core ideas, but also encouraged transformative changes in students' perspectives on the nature and power of mathematics.

Dynamic, Randomized Exercises Defined in PreTeXt Facilitate Server-free Interactive Exercises
4:20 pm - 4:35 pm
D. Brian Walton, *James Madison University*

PreTeXt is an open-source authoring system for texts that uses an XML markup schema to define the content and role of the textual elements and provides software that generates a variety of output modes from that source, including traditional static PDFs as well as rich and interactive web-based texts. Web-based homework systems such as WeBWorK or WebAssign rely on problems defined in a delivery-specific language syntax and then require the student connect to a server for evaluation of correctness. This talk will introduce an extension of PreTeXt to define dynamic, randomized math problems using a markup schema which can be translated into WeBWorK problem files or interactive javascript problems that run within the student's browser without requiring any additional external server communication using open source technology provided by the author's npm package btm-expressions and Runestone Academy's component framework.

CANCELLED ~~Reframing and Redesigning Calculus for Life Science~~
~~4:40 pm - 4:55 pm~~
Malachi Alexander, *University of California, Santa Cruz*
Sophie Aiken, *University of California, Santa Cruz*
Deewang Bhamidipati, *University of California, Santa Cruz*
Jennifer Guerrero, *University of California, Santa Cruz*
Nandini Bhattachayra, *University of California, Santa Cruz*
Pedro Morales, *University of California, Santa Cruz*
David Rubinstein, *University of California, Santa Cruz*
Ryan Pugh, *Foothill College*

A team of graduate students and mathematics instructors worked together to redesign the UCSC Calculus for Life Sciences series. We recognized the average math course serving non-math majors has contrived application questions designed to serve math skills exclusively. Our graduate student researchers interviewed faculty members in STEM departments to determine the math concepts the course needed. These cross-disciplinary conversations led to the development of an application-based course solving real-world scientific problems. We first created projects where students use math as it authentically arises when solving scientific problems. We also created homework assignments and built the course's supplemental instruction curriculum and facilitation guides. In this talk, we will discuss how the Open-Access Resources in this class support the various student populations at UC Santa Cruz.

Mathematical Puzzle Programs: Open Source Puzzle Hunts for High School Outreach
5:00 pm - 5:15 pm
Bryan Clair, *Saint Louis University*
Abby Noble, *Middle Georgia State University*

In a puzzle hunt, teams of players solve a series of themed pencil-and-paper puzzles while navigating between interesting locations in the world. Mathematical Puzzle Programs (MaPP) is now in its ninth year of creating puzzle hunts for mathematically inclined students. The annual MaPP Challenge is a half-day hunt designed for high school (or sometimes middle school) students to play on college campuses. It engages student teams in creative thinking, problem solving, and abstract reasoning, while enticing students to engage with deeper mathematical questions. Each MaPP Challenge is open-sourced with a Creative Commons license and made freely available. The program boasts a supportive community that

will help you organize and host the event on your campus. Running a puzzle hunt is a great way to reach students in your community, have them explore your campus, and get them excited about mathematical ways of thinking.

How My Philosophy of Mathematics Affects My Teaching

Part A: *Friday, August 9, 10:15 am - 12:15 pm*
Part B: *Saturday, August 10, 8:00 am - 10:00 am*

One's philosophy of mathematics can affect their approach to a particular subject matter, their attitude toward group work, and many other aspects of teaching. Some of these issues have been with us for generations. Others are relatively new, such as the recent discussions of the effects of generative artificial intelligence (AI) on student work. This session invites talks on any aspect of the interaction between issues in the philosophy of mathematics and the teaching of mathematics, including but not limited to emerging issues like the impact of AI on the teaching and learning of mathematics. Other topics in the philosophy of mathematics are welcome as time permits.

Organizers:
Bonnie Gold, *Monmouth University (Emerita)*
Jason Douma, *University of Sioux Falls*

Sponsor:
SIGMAA on the Philosophy of Mathematics (SIGMAA POM)

Part A: *Friday, August 9, 10:15 am - 12:15 pm*

Mathematical Platonism and the Five Components Model of Leadership
10:15 am - 10:30 am
Mark Miller, *Marietta College*

This paper focuses on the decade-long experience of the author as a mathematician teaching a specially created course at Texas Woman's University (TWU), the largest university in the US focused on women and is also classified as a Hispanic Serving Institution (HSI). The course is Women and Minorities in STEM. This course fulfills both the baccalaureate degree requirements for graduation (i) "women's studies (3 credit hours)" and (ii) "global perspectives (3 credit hours)" at TWU. The author will describe how her philosophy of mathematics and her Asian American background have shaped the evolution of how this course has been taught for the last few years.

Questions and Discussion
10:30 am - 10:40 am

The Trapezoid Debate as a Vehicle for Discussing Definitions in Mathematics
10:45 am - 11:00 am
John Chase, *Montgomery County Public Schools (MD)*

I have been a believer in articulating one's philosophy of one's academic discipline since my graduate studies in the history of technology and science. To this day, undergraduate history majors at University of Maryland Global Campus prepare their philosophies of history because I introduced the assignment into the curriculum in 2006. Although I do not currently hold a teaching position and I spend most of my time around mathematicians, I still find myself drawing upon my philosophy of history as a researcher and editor. Even more so, I utilize my philosophy of teaching as I polish my own writing and coach mathematicians in communicating their mathematical and pedagogical ideas. In this talk, I'll share some observations from my experiences with MAA Convergence, CSHPM's Bulletin, and CSHPM Notes, a regular column in Notes of the CMS. I hope to invite cross-disciplinary conversations about the intersections between our philosophies of mathematics, of education, and of history.

Questions and Discussion
11:00 am - 11:10 am

Teaching a Choose Your Own Adventure Gened Math Course
11:15 am - 11:30 am
Jessie Hamm, *Winthrop University*

Mathematical Induction is a powerful and invaluable tool. But students often struggle to master it because many templates and examples used to teach induction lead to several errors, notably the ``induction trap." One such error leads to a ``proof" of the Four Color Theorem. We will look at a different approach to teaching induction that avoids this error. The associated ``map" for the induction step provides a clearer, deeper understanding for how to apply induction beyond the familiar examples.

Questions and Discussion
11:30 am - 11:40 am

How My Philosophy of Teaching Affects My Communication of Mathematics
11:45 am - 12:00 pm
Amy Ackerberg-Hastings, *MAA Convergence*

I deeply believe that mathematics is the most universally agreed upon human creation. It is both our agency and our unanimity that give mathematics its power. As a consequence meaning is central to all that I do, and classes emphasise constructivism over rule adherence. Furthermore, I have a deep respect for the power and role of gestures and physical expression of mathematics, often as an inspiration toward verbal communication. I will explore several examples of the influence of human-centred mathematics across the undergraduate curriculum.

Questions and Discussion
12:00 pm - 12:10 pm

Part B: *Saturday, August 10, 8:00 am - 10:00 am*

The Trapezoid Debate as a Vehicle for Discussing Definitions in Mathematics
8:00 am - 8:15 am
Jeff Johannes, *SUNY Geneseo*

In 2018, John Chase and Will Rose staged a debate at the national NCTM conference that sparked a math war. The topic? The definition of trapezoids. Many mathematicians staunchly defend the more traditional "exclusive" definition – a quadrilateral with *exactly* one pair of parallel sides. But in recent decades,

there has been a groundswell of support for the “inclusive” definition – a quadrilateral with *at least* one pair of parallel sides. After exhaustively summarizing the debate, we will look at how this debate can open larger conversations about the nature of definition in mathematics and weigh the costs and benefits of the “openness” of definitions. By bringing students into this debate, they have a chance to see that mathematics is not finished but is a conversation that welcomes all to participate.

Questions and Discussion
8:15 am - 8:25 am

Mathematical Platonism and the Five Components Model of Leadership
8:30 am - 8:45 am
Jessie Hamm, *Winthrop University*

This talk examines the relationship between mathematics and leadership, from both epistemological and pedagogical perspectives, drawing from McManus & Perruci’s Five Components Model of Leadership. Specifically, the talk will explore the ways that mathematical philosophy and leadership theory can inform the way we engage our students with an eye toward ethics, belonging, and justice – particularly in the context of first year mathematics courses with diverse student populations.

Questions and Discussion
8:45 am - 8:55 am

Teaching a Choose Your Own Adventure Gened Math Course
9:00 am - 9:15 am
Jeff Johannes, *SUNY Geneseo*

Despite what most of my students say, I believe we're all "math people". I believe that math is an art and it can be appreciated by everyone if seen in the right light. Because of these views, I have started using a new approach to teaching my general education Joy of Mathematics course-a "Choose Your Own Adventure" approach. Students are allowed to choose the topics they want to learn from a variety of given options and the course operates in a flipped fashion. In this talk I will discuss my motivations for this approach, the logistics of how the course runs, and some preliminary results on the outcomes.

Questions and Discussion
9:15 am - 9:25 am

Watching our language: syntax, semantics, and pragmatics in teaching
9:30 am - 9:45 am

"A broad philosophy of mathematics entails many hard questions: Is mathematics constructed or discovered? Formal or experimental? Really “true” or only agreed-upon? Related, and perhaps easier, are “linguistic” questions: How are mathematical claims constructed syntactically? How effectively do syntactically correct claims actually convey meaning? What do human readers and hearers, especially students, make of mathematical claims, many of which are grammatically and logically complicated? How can we teachers help students develop ease, precision, and (eventually) deep understanding of mathematical claims? How can mathematical texts help students navigate these rough waters?

I will argue—with concrete examples—that mathematical syntax, semantics, and pragmatics are all difficult, but that concrete examples, chosen with due attention to language, have a special role in motivating and helping students engage the abstract ideas and theories of higher mathematics."

Questions and Discussion
9:45 am - 9:55 am

Building Community in Mathematics Departments
Part A: *Thursday, August 8, 8:00 am - 10:55 am*
Part B: *Saturday, August 10, 8:00 am - 10:35 am*

Current undergraduates have faced abrupt changes to normalcy through COVID-prompted online schooling, forced avoidance of social interaction, and lots of quality time with family. They also have to cope with social media stressors and cell phone dependency. On day one of the semester, professors often look out at their class and receive no eye contact – all eyes are glued to individual phones. One month into the class, students still don't know everyone's name in class. And who hangs out outside of class to work on homework together?

Does this sound like your students? Or do your students chatter before class forcing you to have to repeat yourself until you have their attention? Do your students gather in public spaces to work on homework and talk about math? Well, we hope it's the latter!! If so, we want to hear about your successes and ideas for building community among undergraduates within your mathematics department. Perhaps you have a weekly Departmental Tea, a thriving Math Club, or Poker Nights – let's share these ideas and help build community in all math departments. If available, include some evidence of success with building community by use of these ideas.

Organizers:
Maggie Rahmoeller, *Roanoke College*
Abby Bishop, *University of Cincinnati*
Alex Dempsey, *University of Cincinnati*
Molly Lynch, *Hollins University*
Mike Weselcouch, *Roanoke College*

Part A: *Thursday, August 8, 8:00 am - 10:55 am*

Activities That Build Community Among Mathematics Majors
8:20 am - 8:35 am
Katarzyna Kowal, *Ramapo College of New Jersey*

The author will present numerous successful activities for mathematics majors that she designed as an advisor of the local chapter of the Pi Mu Epsilon Mathematics Honor Society, as a member of the mathematics department, and as a former department chair. Many of the activities were the result of going from the Covid-affected semesters back to in-person semesters. Some examples include ways of introducing and connecting math majors with each other, valuable email announcements, managing

outreach to alumni, alumni guest speakers, award ceremonies, methods to increase the number of math majors. The author will also share her experiences of building mathematics community among the undergraduate students from her years of being a director of the New Jersey Undergraduate Mathematics Competition.

EmpowHER Hour at UC Santa Cruz
9:00 am - 9:15 am
Jennifer Guerrero, *University of California, Santa Cruz*
Sophie Aiken, *University of California, Santa Cruz*

Graduate Students at UC Santa Cruz wanted to build an intentional community of support in the Math Department. In response in the Spring of 2022, the AWM Student Chapter at UCSC began regularly hosting "EmpowHER Hour." EmpowHER Hour is a biweekly discussion group put on by the AWM Student Chapter at UCSC that encourages constructive conversations about gender equity and inclusion in our department and general academia. In this talk, we will discuss why we created EmpowHER Hour, and how EmpowHER Hour has positively impacted our community.

FEM in STEM: A Club to Connect Students and Faculty across STEM Fields
9:20 am - 9:35 am
Julie Barnes, *Western Carolina University*

Several years ago, some of our female math majors told me that they wanted to meet female students from other STEM fields, and that started the creation of our FEM in STEM club. The purpose of the club is to provide a supportive environment for women in science, technology, engineering, and mathematics. Anyone is welcome from a wide range of fields, including hard sciences, engineering, and computer science as well as health sciences, finance, and anyone who is simply interested in STEM fields. Sometimes men participate as well. It has also opened communication among faculty in STEM fields. It seems that the club gives faculty an excuse to do fun things together and get to know each other better because we are doing it for the students. In this talk we will address how we started the club, the kinds of activities we do, and how we have been able to fund events.

Research Training Seminar Series - Training Undergraduate Students for Math Research
9:40 am - 9:55 am
Christina Jamroz, *University of St. Francis*
Angela Antonou, *University of St. Francis*

This presentation will include an overview of the research training seminar series that has been offered at University of St. Francis. The goal of the series is to provide undergraduate students some of the skills needed to engage in mathematical research. Specifically, this presentation will discuss the logistics of running the series, suggestions/tips for those wanting to run a similar program at their own institutions, and student feedback on their perceptions of mathematical research after having attended some of the series events.

Mathematics Monday
10:00 am - 10:15 am
Afshin Ghoreishi, *Weber State University*

At the Weber State University Mathematics Department, we host a weekly event known as ‘Mathematics Monday.’ The purpose of these gatherings is to foster a vibrant mathematics community among our

students and faculty. Our events are open to all and encompass a diverse range of activities, including puzzle-solving sessions, undergraduate research talks, and presentations related to careers and graduate studies. Additionally, from the pool of interested students, we create teams to participate in local, regional, and international mathematics contests. For a more impactful educational experience, students also have the opportunity to enroll in a 1-credit hour course at either the lower division or upper division level, allowing them to develop into independent learners. During our discussions, we will delve into the various types of events we organize, reflect on our experiences before and after the COVID-19 pandemic, and discuss both the challenges we've faced and our achievements.

Building Community among Future STEM Educators at Aurora University
10:20 am - 10:35 am
Lindsey Hill, *Aurora University*
Chetna Patel, *Aurora University*
Alma Rodriguez Estrada, *Aurora University*
Aubrey Southall, *Aurora University*

Aurora University received an NSF Noyce Track 1 Scholarship grant in April 2023 to recruit and retain culturally diverse STEM educators. A fundamental goal of our grant is to cultivate a community among Noyce Scholars and local teachers which will provide continued support as the Noyce Scholars begin their teaching careers. Grant activities such as alumni and internship panels, networking events, and a Teaching Hackathon will be discussed. The activities of our mathematics department's lively Kappa Mu Epsilon chapter will also be presented.

Building Community Through a Mathematics Seminar Course
10:40 am - 10:55 am
Jacquelyn Rische, *Marymount University*

In this talk, I will discuss Marymount University's Mathematics Seminar, a one credit course taken by mathematics majors during the fall semesters of their Sophomore, Junior, and Senior years. Making Seminar a requirement for the mathematics major gets students into the class (mathematics minors are also welcome to enroll). All the mathematics faculty also attend the weekly meetings. Bringing everyone together helps to build community. Topics for seminar include: learning about mathematical topics outside the regular curriculum, fun mathematical activities, career preparation (student presentations on REUs or internships, mock interviews, resume and cover letter writing), and field trips.

Thriving Through Tumultuous Turnover
11:00 am - 11:15 am
Axel Brandt, *John Carroll University*
Jillian Stupiansky, *John Carroll University*

"In the past 3 years, 8 of 10 tenure lines in our department have turned over. This has shattered the sense of departmental community, particularly given its timing in the wake of the pandemic. As two tenure-track hires to ""replace"" 5 retirees, we have spent the past two years working to rebuild community. An added challenge has been balancing our limited bandwidth with the varied interests of students across our department's three majors: mathematics, computer science, and data science.

In this talk, we describe our student-driven approach to building community, challenges we have faced, and some lessons learned along the way."

Part B: *Saturday, August 10, 8:00 am - 10:35 am*

Designing a Seminar to Increase Departmental Engagement
8:00 am - 8:15 am
Scott Williams, *University of Central Oklahoma*

With few exceptions, a student in our department typically only sees/meets/speaks with the faculty who are teaching their current classes. In addition, those same students are usually only exposed to the mathematical content described therein. One method we found of increasing engagement among not only students and other faculty, but also among the faculty themselves was by implementing a (short, low-stakes, and fun!) departmental seminar. The incorporation of these seminars in our department has led to multiple students (graduate and undergraduate) presenting, faculty presenting, and maybe most importantly, thoughtful and intellectual conversation outside of the typical classroom setting between both of these groups. In this talk we will discuss how such a seminar has been implemented into our department, outlining its structure (topics/length/frequency/etc.) and discussing outcomes and observations after running it for several semesters.

Intentionally Weaving Community through the Major
8:20 am - 8:35 am
Brooke Buckley, *Northern Kentucky University*
Lisa Holden, *Northern Kentucky University*

The Department of Mathematics & Statistics has woven two experiences into the mathematics major to support the creation of a mathematical community. A revamped first-year experience launched in fall 2022. Course topics are carefully chosen to center on some application of mathematics and statistics accessible to an audience with a wide range of mathematical preparedness. In fall 2023, a career exploration course was launched for majors with junior standing. Both of these courses weave intentional touchpoints into the major to help foster a mathematical community. The first-year experience includes objectives of building community, supporting retention, and engaging students in mathematical thought. The career exploration course seeks to expose students to a variety of post-graduation outcomes and network with departmental alumni. This presentation will discuss the early offerings of these experiences and the self-reflections on the course outcomes.

Empowering Students to Build a Community
8:40 am - 8:55 am
Rachel Funk, *University of Nebraska-Lincoln*
Johan Benedict Cristobal, *University of Nebraska-Lincoln*

Drawing upon an ongoing study of perseverance in a STEM career within a National-Science-Foundation-funded S-STEM (Scholarships in Science, Technology, Engineering, and Mathematics) project focused on mathematics and computing, we reaffirm the importance of community for all undergraduates. Using a lens for social and cultural capital and examining interviews with underrepresented students, we report themes that allowed this S-STEM program to build a positively-impacting community for these undergraduates. A main theme is the importance of empowering students to direct what their community looks like. We see these themes as applicative within mathematics departments and we share our ideas of how to meaningfully involve students in building thriving communities.

Turning a Geometry Project into a Geometry Festival
9:00 am - 9:15 am
John Ross, *Southwestern University*

Many math courses have an end-of-semester project that can serve as a capstone experience for the class. However, when designed as a public-facing project, these can also offer an opportunity to bring the community together in a celebration of learning. This talk describes one such endeavor: an end-of-semester project in a differential geometry class that spawned a Geometry Showcase festival. We will discuss the practical strategies used to design the project, as well as lessons learned in hosting the event.

The Minton Invitational: Community Building and Ping Pong
9:20 am - 9:35 am
Michael Weselcouch, *Roanoke College*

This semester, I organized a semester long ping pong tournament at Roanoke College for the Math, Computer Science, and Physics students. The tournament brought students from different majors and class years together for competition and fun. Using real game data, we ranked the players using techniques discussed in our Linear Algebra class. In this talk, I'll explain the set up of the tournament, the various student projects that arose it, as well as feedback from students about what they liked about the tournament.

Math Club Involvement on a Primarily Commuter Campus
9:40 am - 9:55 am
Erin Williams, *University of Central Oklahoma*

The University of Central Oklahoma is Oklahoma's largest metropolitan university -- meaning many of our students are commuter and/or non-traditional. Trying to get an active and successful Math Club up and running has been a challenge for a few years; however, we have noticed that once more faculty members took interest and became involved the club has thrived. In this talk, we will discuss the past and current state of our Math Club, the difficulties being a metropolitan university brings, the changes that we have made to increase participation (from both students and faculty), and what the future holds for our club.

How to Help Commuting Students Associate!
10:00 am - 10:15 am
Melanie Pivarski, *Roosevelt University*
Steve Cohen, *Roosevelt University*

Roosevelt University is located in downtown Chicago, and most of our math majors are commuter students. Many also have jobs far from campus. In order to build a community, we've had the students meet each other where they are– in the classroom– with group projects and research. We've created additional opportunities outside of class for them share collaborations through reliable annual events: our Math x-Position, actuarial networking events, Pi(e) day, our campus' research week, and an annual field trip in our research class as well as our Illinois Section MAA meeting.

Story Circles: A Partnership with Student Affairs
10:20 am - 10:35 am
Mike O'Leary, *Towson University*
Sandy Spitzer, *Towson University*

Alexei Kolesnikov, *Towson University*
Nathan McNew, *Towson University*

"Towson University is engaged in a multi-year project to improve our mathematics major student community. One innovative dimension of this project is a new partnership with the Office of Civic Engagement and Social Responsibility within the Office of Student Affairs.

We collaborated with this office to jointly plan and implement two events for mathematics majors. We began Fall 2023 with a Story Circle, where students and faculty shared an experience that meaningfully impacted their academic career in story form. We finished Spring 2024 with a Celebration Circle, where students shared something academic/mathematical that they learned, and who (other than their instructor) helped them. These events built community by allowing students to hear, identify with, and empathize with other students' struggles and triumphs.

The talk will discuss strategies that we found useful to develop the partnership, how we developed and ran the circles, and our preliminary evaluation of their impact."

Life Together: A Holistic View of Mathematical Community
10:40 am - 10:55 am
Derek Thompson, *Taylor University*

Taylor University's math majors consistently rate the department highly on its sense of community and camaraderie among students and faculty. Similar ratings are given from students who take Foundational Core offerings through the Mathematics Department. This talk will identify key components of the success the department has had on this front.

Environmental Science for Mathematics Students
Friday, August 9, 4:30 pm - 6:05 pm

Sustainability of our world and resources is one of the largest issues facing humanity. Environmental Mathematics serves to help understand many of the systems and understand critical features needed to analyze intervention strategies. Many professionals have found new and innovative ways to bring this topic to their students and we want to hear about it.

This session welcomes talk proposals for natural resource modeling, sustainability, and climate science used in the classroom or for student research projects. We would particularly enjoy hearing how innovative research ideas translate into learning experiences for students.

Organizers:
Amanda Beecher, *Ramapo College of New Jersey*
Eric Marland, *Appalachian State University*
Russ deForest, *Penn State University*
Kevin Murphy, *Dominican University*
Kayla Blyman, *Saint Martin's University*

Sponsors:

Standards Presentations in Elementary Education Math Courses
4:30 pm - 4:45 pm
Sandra Zak, *Monmouth University*

How do we get pre-service elementary teachers to understand the K-6 New Jersey Student Learning Standards and their interconnectedness to the mathematics that exists all around us? More specifically, mathematics can be integrated into topics including climate change, sustainability and other social justice topics to illustrate interdisciplinary teaching.

Infusing Social Justice Contexts in STEM Environmental Science Lessons for Mathematics Teacher Education
4:50 pm - 5:05 pm
Mary Stapleton, *Towson University*
Diana Cheng, *Towson University*

Using social justice applications is encouraged as an aspect of culturally responsive mathematics teaching (Aguirre & Zavala, 2013). At Towson University, the MATH 325/525: Problem Solving for Middle School Teachers is a cross-listed mathematics content course which is required for undergraduate pre-service mathematics teachers and is an equity-focused core course for graduate in-service teachers. We provide examples of STEM lessons used during the course related to scientific and social impacts of warming oceans and environmental racism (discrimination in environmental policymaking, such as the selection of location for toxic and hazardous waste facilities in poor communities and communities of color), and describe how we added social justice themes to the lesson. We also discuss students' changes in their beliefs to teach for social justice.

Saving the World with Mathematical Modeling: An Introductory Course in Mathematics for Sustainability
5:10 pm - 5:25 pm
Jacob Duncan, *Winona State University*

Some of the biggest challenges facing humanity today stem from issues surrounding unsustainable environmental, social, and economic practices. The need to address the ramifications of these issues from a STEM perspective is greater than ever. This talk centers around a recently developed course and textbook called Mathematics for Sustainability which applies an array of mathematical concepts and tools to quantitatively explore real-world, topical problems pertaining to sustainability. Topics are motivated by exciting hands-on experiences, e.g., experiments, demonstrations, and outdoor data collection excursions. This introductory course is designed primarily for undecided and non-STEM majors with the intent of sparking interest in the usefulness of mathematical modeling in solving the world's pressing environmental, social, and economic problems.

Maximum Sustainable Harvests
5:30 pm - 5:45 pm
Eric Marland, *Appalachian State University*

"In the past, a frequent task in wildlife and fishery management has been to optimize sustainable harvesting. This involves looking at steady state values of harvests, along with regular data collection and sensitivity analyses make sure rare events do not drive populations dangerously low. Both the harvest and the maximization can take a number of different forms and the results differ.

In this talk, I will quickly go over those ideas and how they might fit into a modeling or calculus class. Then, I will explore an extension of the idea to forests and harvested wood products. Can these same ideas be applied to conservation efforts in maximizing storage of carbon from forestry? Does a ``no harvest"" policy actually store the most carbon? We will see."

Air Quality Dashboard for ReNewport
5:50 pm - 6:05 pm
Nelum S. S. M. Hapuhinna, *Northern Kentucky University*
Andrew Long, *Northern Kentucky University*

"Mathematicians and Statisticians at NKU were approached by a community group who needed help creating an air-quality dashboard to keep the local citizens apprised of any dangers. Two faculty members and two students undertook the challenge, and have been working to create (and will work through the summer to refine) an open-source dashboard featuring choropleth maps, time series plots, and data dumps that serve the community. The challenges include pulling from public-domain and private data sources; creating models to predict air quality readings off of the data locations; cross-validating models incorporating winds, etc.; developing warning systems; and determining how best to populate the dashboard itself. We will feature the ways that our students' educational objectives and opportunities have been enhanced by this experience."

Teaching and Learning of Calculus

Part A: *Thursday, August 8, 8:00 am - 9:55 am*
Part B: *Friday, August 9, 8:00 am - 10:35 am*
Part C: *Saturday, August 10, 8:00 am - 11:15 am*

Calculus plays an important role in the retention of students in the STEM fields, and many universities in the US are facing historical drops in enrollment and retention of undergraduate students. As a result, there are numerous efforts to enhance students' learning experience in calculus classes by providing them with equitable and innovative teaching practices. We are calling for research proposals in three main areas: culturally responsive pedagogies, curriculum design, and technology integration.

In the theme of culturally responsive pedagogies we expect proposals related to making courses relevant to STEM fields as well as incorporating students' experiences as assets for teaching and learning calculus. In the theme of curriculum design, we expect to have proposals related to requisite and corequisite policies, and calculus placement practices. Regarding technology, we are expecting proposals about the implementation of technologies in calculus instruction such as mathematics software and applications, online mathematics assessment, artificial intelligence, and augmented reality.

Organizers:
Kevin Palencia, *Northern Illinois University*
Ricela Feliciano-Semidei, *Northern Illinois University*
Alcibiades Bustillo-Zarate, *University of Puerto Rico at Mayagüez*

Part A: *Thursday, August 8, 8:00 am - 9:55 am*

Experiential Learning in Calculus with Technology: Coding and 3D Printing
8:00 am - 8:15 am
Rebin Muhammad, *Montgomery College*

Calculus often represents a significant hurdle in STEM education, prompting a reevaluation of teaching strategies to enhance engagement and comprehension. In this talk we showcase how experiential learning, powered by technology like coding and 3D printing, can help students have better experiences. By integrating these tools, we offer students a tangible connection to abstract concepts, fostering a deeper understanding and retention. Our approach not only makes calculus more accessible but also demonstrates its real-world applicability, thereby maintaining student interest and motivation in STEM fields. We'll share insights from our implementations and discuss the potential for broader application in calculus education.

GeoGebra Webpages Impact on Multivariable Calculus Learning
8:20 am - 8:35 am
Linda Burks, *Santa Clara University*
Mehdi Ahmadi, *Santa Clara University*

GeoGebra provides multiple representations of math concepts and allows students to visualize multivariable graphical representations. An open source dynamic system, GeoGebra is accessible to all students. At a mid-sized private university, approximately 100 students had the opportunity to work through one webpage a week during their fourth quarter calculus class. Use of the webpages was optional. Students who chose to work through the webpages could do so alone or during a one-hour group session facilitated by an undergraduate peer tutor in the mathematics learning center. Webpage topics included multiple integrals, line integrals, surface integrals, Green's Theorem and Divergence Theorem. Each webpage provided a brief summary of the topic followed by guided work through custom-made GeoGebra activities and conceptual questions. We will discuss the design of the webpages, student and tutor perceptions of the webpages, as well as the impact of using the webpages on student learning.

Applications of SageMath to Calculus
8:40 am - 8:55 am
Leon Kaganovskiy, *Touro University*

In this presentation, we would like to explore Computer Algebra calculations using Sage Math. It can significantly enhance students' Calculus learning by providing graphical and numerical illustrations. Among the topics considered are limits, derivative, tangent line visualizations, 3D surface visualizations, projectile motion, contour lines and gradient fields, heat-seeking particle paths, Lagrange multipliers, multidimensional integration, vector fields, etc.…

Visualization in MY Math Apps Calculus
9:00 am - 9:15 am
Philip Yasskin, *Texas A&M University*

Many students struggle with spatial reasoning. MY Math Apps Calculus is an online text for a 3 semester calculus course for STEM students. You can see a sample of about half the chapters at https://mymathapps.com/mymacalc-sample/. The emphasis is on visualization with 2D and 3D graphics which are static or animated, and simply visual or manipulatable with a mouse or sliders. Prime examples are arc length, surface area, volume, related rates and maxmin problems. Course surveys show the students actually read the book and find the interactivity engaging. Students also like having solutions to many exercises. Nearly all theorems have proofs which are either directly in the text or accessible for interested students by clicking a button. The order of material is slightly modified to enhance the learning process.

Animations in Multivariable Calculus
9:20 am - 9:35 am
Jeffrey Clark, *Elon University*

"One of the gifts of modern technology to the calculus sequence is visualization: no longer do we need to rely on hand-drawn surfaces or static images projected on a screen. In multivariable calculus we are able to present dynamic changes to curves of all kinds as well as moving tangent planes to surfaces and osculating planes for curves. This talk will demonstrate different categories of animation and their pedagogical uses with Mathematica."

Resolving the "Undermatching" Problem in a College Level Calculus Course
9:40 am - 9:55 am
Joseph Lindquist, *United States Military Academy*
Anthony Mastroberardino, *United States Military Academy*
Thomas Kendall, *United States Military Academy*
Ira Crofford, *United States Military Academy*
Mike Scioletti, *United States Military Academy*

For more than 10 years, math classrooms at West Point have observed increased variance in incoming student capability. A growing majority of students enter West Point with some level of calculus exposure in high school, but may have gaps that preclude them from validating coursework. In these cases, students are "undermatched" to a course that is mostly review. At the same time, these classes enroll students with little or no exposure to calculus. This combination has resulted in a classroom environment where students with vastly different capabilities are intermingled. Instructors lament that this creates a classroom where it is difficult to deliver instruction - either teaching too slow (for students who have calculus exposure) or too fast (for students who have not had calculus). This talk will share results from a pilot course that sought to challenge students at their capability level. Spoiler alert... the pilot course is on track to be a permanent offering starting in 2025.

Part B: *Friday, August 9, 8:00 am - 10:15 am*

Broadening Interest in Calculus with Data Science
8:00 am - 8:15 am
Adam Spiegler, *University of Colorado Denver*

The rapidly growing demand in data science presents an exciting opportunity for math and statistics departments to redesign courses to benefit both traditional math and statistics majors as well as new students from other disciplines. In this talk I will demo a set of newly created Python labs for a first semester calculus course that integrate data and coding as tools to welcome more diversity into our mathematics community and provide students a virtual lab setting to experiment with mathematical concepts. Each lab is an interactive Jupyter notebook that students interact with using Google Colaboratory (Colab) which is free, cloud-based platform where students experiment with Python code to help deepen their understanding of calculus. The materials are open source and freely available to share. The only technology requirement for instructors and students is a device with an internet connection and web browser.

Literacies for Life, Career, and Calculus
8:20 am - 8:35 am
Silas Johnson, *Washington University in St. Louis*

WashU's Literacies for Life and Career initiative aims to highlight and enhance cross-disciplinary competencies in courses throughout the College of Arts and Sciences and foster greater awareness of the objectives of a liberal-arts education. This project is currently in the pilot stage, and we implemented it in Calculus I and II in 2023-24 as part of the pilot. I will discuss the initiative and its goals as a whole, how we developed a literacies-based approach in calculus, and how it helped improve the design of certain aspects of the courses. I will also share preliminary results from the pilot year.

Calculus Co-requisite Model
8:40 am - 8:55 am
Kimberly Roth, *Juniata College*
John Bukowski, *Juniata College*
Kristin Camenga, *Juniata College*
Henry Escuadro, *Juniata College*

Student's skills in precalculus when they arrive in calculus have always been variable. Post pandemic there have been more missing topics. To help improve student success in calculus, Juniata has added a one hour a week co-requisite session with direct instruction in precalculus topics. It is required of students whose scores on the precalculus skills assessment are lower or whose grade in the class is below a 80%, but open to all students to attend. We will discuss the model we used and the results from the first two semesters of its implementation.

Mastery Grading in Calculus
9:00 am - 9:15 am
Megan Wendler, *Colorado Mesa University*

"Many students struggle to do well on in-class exams if they struggle with anxiety or completing problems quickly within a given time period. Therefore, these students may do poorly in classes where grades are focused heavily on exam scores. With mastery grading, there are a number of mathematical standards, or objectives, and students have many opportunities to demonstrate "mastery" of these standards. A student's final grade in the course is determined by how many standards they have mastered throughout the semester. This type of grading encourages a growth mindset and is meant to reduce stress. In this paper, we discuss how to implement a version of mastery grading in Calculus I and II courses, in combination with some other pedagogical approaches to teaching. We also look at some student

comments about this style of teaching, and we look at some data collected over the course of several semesters using mastery grading."

Enhancing Student Success in First-Year Differential Calculus: Introducing Test 0
9:20 am - 9:35 am
Kelli Karcher, *Virginia Tech*

This talk delves into an innovative approach to improve student outcomes in first-year differential calculus courses. Recognizing the historical challenges faced by students, particularly those from underserved backgrounds, we implemented a strategic intervention: Test 0. Introduced during week 2 of the course, Test 0 is a summative assessment covering material taught up to that point. Following the assessment, we engage students in targeted discussions on effective learning (and testing) strategies. These insights empower students as they prepare for the subsequent graded summative assessment, Test 1. Join us to explore the impact of Test 0 and its implications for enhancing student success in calculus education.

Making Connections with Calculus
9:40 am - 9:55 am
Paul Sisson, *Louisiana State University Shreveport*

Students in calculus classes arrive with a great diversity of backgrounds, experiences, and interests, and the challenge of helping them find meaningful connections with calculus has only grown over time. Fortunately, the collection of techniques that we can use to help them engage with the material has also grown. Such techniques include providing historical and human context in the development of calculus, exploiting the artistic elements of calculus, and judiciously employing technology in the learning of calculus. Dr. Sisson approaches the topic of calculus engagement with a background as a professor, university administrator, and textbook author, and shares lessons learned from each position.

Encouraging Attendance in Large Calculus Classes
10:00 am -10:15 am
Erica Whitaker, *University of Kentucky*

"We put effort into planning our calculus lessons, but it is hard to reach students who do not attend. Required attendance can be difficult for students with illness or complicated lives; and processing attendance records can be overwhelming in a large class. But if we don’t require it, students can feel as if it doesn’t matter to us if they show up. For large calculus classes, I have tried both real-time location-based assessment (using clickers) and participation assignments (short assignments completed during or shortly after class). Either can help encourage attendance in large lectures, without overly burdening either a challenged student or an overworked instructor. We’ll look at some tips I’ve learned in implementing these, and the pros and cons I’ve found with each method."

Part C: *Saturday, August 10, 8:00 am - 10:55 am*

Foundations of Calculus: Calculus Success with Focused Precalculus, Study Habits and Metacognition
8:00 am - 8:15 am
Mami Wentworth, *Wentworth Institute of Technology*

Mel Henriksen, *Wentworth Institute of Technology*
Mark Mixer, *Wentworth Institute of Technology*
Youssef Qranfal, *Wentworth Institute of Technology* Deirdre Donovan, *Wentworth Institute of Technology*

"Over the years, we have seen that many students' unsuccessful experiences in Calculus stem from a lack of preparation. We suspect their lack of prerequisite skills is due to poor study habits and a memorization mindset with little concern for conceptual understanding.

In this talk, we will present our approach for improving student success in the Calculus sequence through Foundations of Calculus, a new course to be taught starting in Fall 2024. All students who place below Calculus I in our placement test will take this course regardless of their Precalculus background. This course will differ from traditional Precalculus by introducing metacognitive strategies and encouraging good study practices while emphasizing fundamental algebra and precalculus skills. We will promote deeper learning by relating procedural skills to conceptual understanding. The course will have a common in-class curriculum, assessments, and homework to achieve a consistent student experience across all sections."

Supporting Calculus Students through a Collaborative Learning Program
8:20 am - 8:35 am
Jennifer McNeilly, *University of Illinois Urbana-Champaign*

The Mathematics Merit Program, originally based on Treisman's Emerging Scholars Program model, has been supporting a diverse population of students in the calculus sequence at the University of Illinois Urbana-Champaign for over 30 years. Through collaborative learning recitation sections, the Merit Program aims to foster a community, encourages students to persist through STEM majors, and provides additional professional development to graduate teaching assistants. This presentation will include a brief overview of the program and its history as well as a summary of both qualitative and quantitative studies of Merit student experiences and outcomes.

Using Writing To Learn Mathematics (WTLM) Activities To Unpack Students' Understanding
8:40 am - 8:55 am
Alexandra Cuadra, *Purdue University*

One of my goals is to give students a larger voice in their thinking and understanding and a larger ownership in the learning process by teaching mathematics literacy as part of the learning process. To empower students in mathematics learning, I integrate Writing to Learn Mathematics (WTLM) activities. These include "The Important Thing About..." prompt, inspired by Brown (1949), and "My Aspects of Mathematical Phenomena" (AMP) chart, building on Frayer et al. (1969) and Musingsofamathteacher (2011). Through these, students articulate their understanding of concepts like partial derivatives and address my research questions: (1) What are students' concept definitions and evoked concept images when learning about partial derivatives in calculus? (2) How are students' concept definitions, and concept images of partial derivatives affected by different representations and/or applications of partial derivatives provided in class?

Improving Student Engagement in Calculus Classes through Active Learning Strategies: Connecting Classroom to the Community
9:00 am - 9:15 am
Buna Sambandham, *Utah Tech University*

"This presentation will focus on strategies aimed at fostering active learning and problem-solving skills through hands-on activities and calculus fun projects within a Calculus course. The primary goal is to encourage student reflection by facilitating experiential learning opportunities. By selecting real-world problems from the local community, students will engage in solving these challenges using concepts learned in the classroom. Through this approach, we aim to bridge the gap between classroom learning and real-life applications, promoting a deeper understanding of calculus principles while making meaningful contributions to the community."

Comparing Active Learning Strategies: An Analysis of Discursive Routines
9:20 am - 9:35 am
Mark Watford, *Florida State University*

This presentation compares two active learning strategies implemented in a Calculus 1 course. One strategy required students to work in pairs to solve a textbook problem and explain the solution to their peers. The other strategy consisted of students working in small groups on GeoGebra to respond to tasks focusing on relationships between functions and their derivatives. The theory of commognition, which promotes that thinking is communicating, guided an analysis of discursive routines in both activities. Findings reveal that students engaged in performative routines in the first strategy and explorative routines in the small group work. While the latter may have looked “messy” in the moment, it allowed students to draw on domains of their own mathematical knowledge in ways not realized through the former. Implications include being attentive to the balance between structured and exploratory activities, recognizing that both contribute to different aspects of mathematical engagement.

Racialized and Gendered Experiences in Pre-Calculus & Calculus: A Literature Review
9:40 am - 9:55 am
Laurie Cavey, *Boise State University* Megan Barco, *Boise State University*

The last decade has seen an emphasis on documenting the racialized and gendered biases experienced by some students to better understand how students’ experiences are related to particular instructional practices. We will provide an overview of this research as it relates to students’ experiences with receiving messages of not belonging in the context of precalculus and calculus classrooms. Further, these types of negative experiences for students can occur regardless of an instructor’s best intentions. In addition to highlighting examples from the literature, we will share snapshots from data recently collected by the authors (two females, one math faculty member who is White, and one undergraduate computer science major who is White/Latina) to illustrate how interactions within academic contexts can be experienced as racialized and gendered. Implications for instructors and suggestions about how to mitigate the effects of gendered and racial biases will also be shared.

Proof that Calculus is Everywhere
10:00 am - 10:15 am
Douglas Meade, *University of South Carolina*

"A common statement made by many calculus instructors is that calculus is useful in many real-world settings. Many of these same instructors then struggle to come up with examples other than area, volume, surface area, projectile motion, exponential growth, and logistic growth.

Twenty-six (26) new applications of calculus are included in “Calculus and Analytic Reasoning”, a new calculus book by Sherman K. Stein and the presenter. Most Calculus is Everywhere (CIE) sections are no more than three pages. Sixteen (16) of the book’s 18 chapters have one or two CIEs. The majority of this

presentation will focus on three CIEs, from each semester of the traditional three-semester calculus sequence:

• How Banks Multiply Money (Chapter 1: Precalculus Review)

• The Mercator Map (Chapter 9: Polar Coordinates and Plane Curves)

• Space Flight: The Gravitational Slingshot (Chapter 14: Vectors)

The full list of CIEs will be presented but more CIEs will be discussed in this talk only as time permits."

Elements of Calculus
10:20 am - 10:35 am
Aloysius Kasturiarachi, *Kent State University*

In Chemistry, an element is described as a substance that cannot be separated into simpler substances by chemical means. In Biology, cells, amino acids, DNA, and RNA form the basis of the structures of all living organisms. In Number Theory, prime numbers play the role of elements, namely via the prime factorization theorem. In languages, phonology, semantics, syntax, and pragmatics are considered the key components. Is this fundamental notion present in Calculus? If so, what are the basic concepts upon which the key ideas of Calculus are developed? In this presentation we provide an argument to answer this question in the affirmative. Ten concepts that will be classified as elements of Calculus will be introduced. Understanding the importance of these elements will also help students to generalize ideas as they move to more difficult levels of mathematics. We will present a description of each element and provide a rationale for the choices we made.

Inverse Problems as Assessment in Foundational Undergraduate Courses
10:40 am - 10:55 am
Kseniya Fuhrman, *Milwaukee School of Engineering*

Inverse problems are prevalent in advanced mathematics and applied courses like Mathematical Modeling. However, the potential for introducing 'mini' inverse problems extends beyond specialized courses, reaching into foundational subjects such as Calculus, Differential Equations, and Linear Algebra. In this presentation, I will showcase a collection of curated problem sets that I've designed and incorporated into assessments. The integration of such problems emphasizes conceptual understanding and proves advantageous in evaluating student learning.

Mathematical Experiences and Projects in Business, Industry, and Government (BIG)
Thursday, August 8, 3:00 pm - 5:55 pm

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 Kumar Chellamuthu, *Utah Tech University*
Namyong Lee, *Minnesota State University, Mankato*
Mihhail Berezovski, *Embry-Riddle Aeronautical University*

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

Synergizing Academia and Industry: Developing Sustainable Water Solutions in Southern Utah
3:00 pm - 3:15 pm
Vinodh Kumar Chellamuthu, *Utah Tech University*

This presentation will detail a collaborative effort between Utah Tech University and Southern Utah's industry partners to address local water consumption challenges. Through a case study approach, we reveal how interdisciplinary student teams use advanced modeling and data analysis to create effective water conservation strategies, essential for the area's growing population and tourism. The project showcases the tangible outcomes of academic-industry partnerships, including the development of practical environmental solutions and the promotion of student engagement through mentorship and applied learning. Attendees will learn about the real-world impact of these collaborative endeavors on community resource management and planning.

Mathematical Modeling Using Regression Methods
3:20 pm - 3:35 pm
Mei Chen, *The Citadel*

Regression methods are often used to best fit a curve with a given set of data points collected from the curve, especially, when the data points are massive. For this talk, we will discuss several regression-based models through student projects. One model is a dynamic periodic regression model. This model detects the change of the model through data and revises the model accordingly to best fit the data for a period and overall. The model is applied to assess the effectiveness of lockdown policies for five states in the southeastern region during the first year of the COVID-19 pandemic. We will discuss the results. The other one is a regression model for the 2-D and 3-D parametric curves. The model is applied to approximate 2-D and 3-D soccer curves to estimate the possible impact force of moving soccer on a soccer player's head.

Partnering Math Students with Nonprofits
3:40 pm - 3:55 pm
Lauren Keough, *Grand Valley State University*

Grand Valley State University (GVSU) has had a PIC math course for several years, but I first ran the course in spring semester 2024. There were 18 students and 3 partners - the Kent District Library, the Johnson Center for Philanthropy, and the GVSU Tutoring Center. I'll talk about the partners, their posed

questions, the math that went into them, the final results, and what's left us still puzzled. I'll mention the skills math faculty have, and the things I learned, in an attempt to convince you that you, too, could run a PIC math course.

Investigating Spatial Disorientation Related Aviation Mishaps Utilizing Machine Learning Keyword Extraction Models
4:00 pm - 4:15 pm
Katherine Hoffsetz, *Embry-Riddle Aeronautical University*

Spatial disorientation (SD) is a critical factor contributing to accidents in general aviation (GA), posing significant challenges to flight safety. This study conducts a comprehensive data analysis of general aviation crash reports to investigate the patterns and underlying factors associated with spatial disorientation. The dataset, derived from official reports from the National Transportation and Safety Board, has about 700 SD cases to study. Utilizing advanced statistical methods and machine learning algorithms, the textual data is analyzed to extract and categorize instances of spatial disorientation. The methodology involves natural language processing (NLP) techniques to systematically review and classify the narratives within the reports, focusing on keywords and phrases indicative of SD. This study contributes to the ongoing efforts to enhance general aviation flight safety by providing a data-driven understanding of spatial disorientation accidents.

Empowering Student Research: Insights from Real-World Projects in Urban Development and Voter Rights
4:20 pm - 4:35 pm
Bree Ettinger, *Emory University*

In this presentation, I'll discuss a spring semester research course from MAA's PIC Math Program. Students worked on real-world projects from Atlanta Beltline Inc. and Fair Fight Action. They used spatial data for Beltline Inc. to map safe routes to Washington High School, and analyzed Georgia's voter rolls and absentee ballots for Fair Fight Action. I'll detail project outcomes, methodologies, and the challenges and benefits of teaching this open-ended course.

Case Study on Medical Image Analysis with Plain Radiography
4:40 pm - 4:55 pm
Namyong Lee, *Minnesota State University, Mankato*

In medical science, plain radiography is a popular way to assess the situation by obtaining a picture of internal structures by passing X-rays. In this case study, we illustrate various attempts to measure or diagnose medical images that were provided by a local medical community.

Intercollegiate PIC Math Experience – Successes, Challenges, and Lessons Learned
5:00 pm - 5:15 pm
Angela Antonou, *University of St. Francis*
Aaron Zerhusen, *Dominican University*

Preparation for Industrial Careers (PIC) Math is a program offered jointly through the Mathematical Association of America and the Society for Industrial and Applied Mathematics. This year, faculty from Dominican University and University of St. Francis collaborated to offer a cross-institutional PIC Math experience for their students. As smaller institutions, working together allowed us to widen the pool of potential students for the course, which also meant a greater variety of academic backgrounds and

technical skills. In this presentation, we discuss some of the logistics of running an intercollegiate PIC Math course as well as the successes, challenges, and lessons learned. We will also share some considerations for future implementation that we believe may further increase the likelihood of successful completion of the project and may also improve the experience for the students.

Identifying Post-Pandemic Customer Segmentations in the Grocery Retail Industry
5:20 pm - 5:35 pm
Lisa Holden, *Northern Kentucky University*
Dhanuja Kasturiratna, *Northern Kentucky University*

"Following disruptions to long-standing business models and significant changes in customer behavior caused by the COVID-19 pandemic, many companies are actively re-examining their customer base. Grocery retailers are particularly well-positioned to do so as they typically collect vast amounts of information on a daily basis.

In this project, we worked with early career undergraduates, a data analytics firm, and a large and representative subset of a grocery retailer's data to perform a segmentation analysis. We were able to identify groups with respect to buying patterns and price sensitivity based on customer demographics and transaction details that can potentially be used to help this grocery retailer better target the preferences of shoppers."

Integrating Generative AI into Applied Data Science Undergraduates Research with Business, Industry and Government: Enhancing Learning, Collaboration, and Ethical Awareness
5:40 pm – 5:55 pm
Mihhail Berezovski, *Embry-Riddle Aeronautical University*

"This presentation explores the transformative impact of integrating Generative Artificial Intelligence (AI) into educational and research settings at the Embry-Riddle Aeronautical University (ERAU) Research Experiences for Undergraduates (REU) site: Research Projects in Data-Enabled Industrial Mathematics, over the past three years. It also covers our experience in project-based classes with industry, business, and government.

Highlighting practical examples, the talk showcases the benefits of employing Generative AI as an innovative resource to enhance educational outcomes, foster collaborative learning environments, help with coding tasks, assist in report writing, and aid in structuring research publications.

Furthermore, it addresses the ethical considerations of incorporating AI into mathematics education, offering insights into how educators and institutions can navigate these challenges to ensure an equitable and inclusive learning experience."

Mathematics and the Life Sciences: Initiatives, Programs, Curricula, and Activities

Friday, August 9, 3:00 pm - 4:15 pm

In the 2015 CUPM Curriculum Guide to Majors in the Mathematical Sciences, the life sciences were clearly identified as a key path through the mathematics major to graduate programs and the workforce. This account echoed many prior high-profile reports (e.g., Bio 2010 (2003), A New Biology for the 21st Century (2009), Vision and Change (2011), The Mathematical

Sciences in 2025 (2013), and the SIAM white paper Mathematics: An Enabling Technology for the New Biology (2009)) that had previously discussed the changing landscape at the interface of mathematics and biology and had issued urgent calls for broadening students' exposure to mathematical methods for the life sciences. It appears that a wider array of curricular ideas, programs, and materials that can be scaled, modified, and assessed in a wide range of different institutions is still needed.

Topics include scholarly contributions addressing initiatives, programs, curricula, and course materials, and outcomes of undergraduate research activities at the interface of mathematics and the life sciences that have been implemented and tested successfully at institutions of higher education.

Organizers:
Timothy Comar, *Self-Employed*
Raina Robeva, *Randolph-Macon College*

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

The Advantages of Introducing Biomath Modeling Through Discrete-Time Models
3:00 pm - 3:15 pm
Erin Bodine, *Rhodes College*

For many students, the beauty of mathematics lies in its applicability to the real world. Mathematical modeling provides a framework to use mathematical expressions or algorithms to reproduce and deepen our understanding of observed patterns, and to make educated, quantifiable predictions for hypothetical scenarios. There are many biological systems whose dynamics can be modeled using discrete difference equations (DDEs). With just some knowledge of basic algebra students can understand model construction and some fundamental forms of model analysis. Thus, DDEs provide an excellent early introduction to modeling. For the past decade, I have been introducing undergraduates to mathematical modeling through DDE models applied to biological systems. Here, I will share some example models along with lessons learned through the development and continued refinement of an intro-level modeling course that appeals to students in a variety of majors and with a variety of mathematical backgrounds.

Student Research Projects In Mathematical Biology: Models Involving Nonuniform Environments
3:20 pm - 3:35 pm
Timothy Comar, *Self-Employed*

This presentation will discuss some ongoing student research projects in mathematical biology initially designed for students with only introductory experience in mathematics and no prior experience in mathematical biology. The projects are based on the development and analysis simple ecological models or vaccination models. These models consider environments that are not uniform. Examples include pest management models in which the pest may exhibit different behaviors in different areas or vaccination models in which the vaccination and disease dynamics vary by region. The modeling frameworks included agent-based models and impulsive differential equations. We will discuss how the students begin to explore problems and then progressively learn to ask and investigate further questions.

An Open Access Compartmental Modeling Text
3:40 pm - 3:55 pm
Meredith Greer, *Bates College*

This presentation previews a text for a semester-long undergraduate course in compartmental modeling. This text is Open Access, available for free online. Topics relate primarily to mathematical epidemiology using differential equations. The course assumes just one semester of calculus as a prerequisite, and optionally linear algebra. Students taking the course work in groups, communicate verbally and in writing, perform data analysis, apply mathematics meaningfully to real-world issues, contemplate career options, and analyze differential equations. Course goals track closely with the MAA's curriculum guide for undergraduate mathematics majors. The text includes uses of compartmental models that extend far beyond epidemics, so that students see a wide range of uses for this style of modeling.

Optimizing Treatment in Clear Cell Renal Cell Carcinoma Microenvironment: A Data-Driven Mathematical Model
4:00 pm - 4:15 pm
Dilruba Sofia, *University of Massachusetts Amherst*

Clear cell renal cell carcinoma (ccRCC) is the most common variant of renal cell carcinoma. Unfortunately, between 31% and 50% of ccRCC patients do not survive beyond five years after diagnosis. Additionally, when ccRCC metastasizes, the mortality rate increases to approximately 90%. In this study, we utilize a phase II trial dataset by Karam et al. (2023) that investigates neoadjuvant combination therapy of Sitravatinib and Nivolumab in ccRCC patients. The patients in the study underwent surgery after this therapy. Building upon our previously designed ccRCC microenvironment model, we incorporate treatment data and analyze the dataset to optimize combination therapy strategies for individual patients based on their tumor microenvironment characteristics. Our findings highlight the importance of combination therapy and individualized treatment strategies in advancing the survival rate for ccRCC.

New Twists on Your Favorite Math Circle Activity
Part A: *Thursday, August 8, 8:00 am - 10:55 am*
Part B: *Saturday, August 10, 8:00 am - 9:15 am*

Many of us revisit and reinvent our favorite math circle activities. During this session, presenters from diverse backgrounds and institutions will share new insights on their favorite math circle activities, whether it be an extension that explores the subject more deeply, a creative use of manipulatives to make the activity more accessible, or even a brand-new activity recently created for a math circle. By sharing these ideas with the larger community, we can inspire math educators to create new and exciting ways for people to explore mathematics.

We encourage presenters, whenever possible, to share their new twists via hands-on activities, with interactive sessions, and as if the audience were attending a math circle themselves.

Organizers:
Jeffrey Musyt, *Slippery Rock University*
A. Gwinn Royal, *Ivy Tech Community College*

Lauren Rose, *Bard College*
Gabriella Pinter, *University of Wisconsin - Milwaukee*
Tom Stojsavljevic, *Beloit College*

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

Part A: *Thursday, August 8, 8:00 am - 10:55 am*

Math History Spillover
8:00 am – 8:15 am
Sungju Moon, *Nevada State University*

The spillover began in a math history class, whose activities often extended beyond the classroom to our math & data sci club. Activity 1: reading reflections. While this may not sound very engaging, the twist was that the reading materials were "declared" rather than "assigned". I would synthesize the notes and produce a beautifully co-written chapter, leading to greater engagement and self-directed explorations of topics that were new to them. Activity 2: class wiki-project, with a twist in the assignment of roles. Each student became the "editor" of a wiki focusing on the theme of their choice. The editor's job was to solicit contributions and reviewers among their classmates. Activity 3: reacting-to-the past game. Here, the twist was not only having them play the game but also participate in designing certain aspects of the game. Even students who were not enrolled ended up participating in all three of the activities, creating a shared sense of learning and community.

The Game of Cycles: A Friendly Introduction to Mathematical Games
8:20 am - 8:35 am
Benjamin Gaines, *Iona University*

In the Play chapter of Mathematics for Human Flourishing by Francis Su, he introduces the Game of Cycles, a combinatorial game played on a graph consisting of vertices, non-overlapping edges connecting those vertices, and the two-dimensional cells enclosed by those edges. Players take turns marking arrows on edges, with the goal being to surround a cell with arrows all oriented the same direction. The only catch- players are not allowed to create any sinks or sources with their move. In this talk, we will describe how this game was used as the centerpiece for a new Math Circles-esque activity on mathematical games given to a number of High School teachers and students in the last year. We will talk about how the session was organized, what went well, what we're planning to revise, and where to take it from here. The materials used for the sessions will be made available to any interested participants.

Shut the Box With an Expert Player
8:40 am - 8:55 am
Edward Keppelmann, *University of Nevada Reno*

Shut the box is a classic board game in which players take turns rolling a pair of die and marking off numbers from 1 to 12 which add to the rolled total. In the classic game players compete to mark of the most (in total) of their numbers before they get a dice roll that they cannot accommodate. In a more competitive version of the game players can opt to mark off their opponents numbers instead of their own in order to keep playing. The trick here though is to realize that when you mark off your opponents

numbers, your opponent gets those points and not you! The game is enjoyable and intriguing for any math circle - our twist is to use the software package magma to code an expert player to throw into the mix when this competitive version is played with two or sometimes more than two players. The logic of the software exposes children and teachers to coding as well as giving a different kind of insight into the game.

The Never-Ending War
8:00 am - 8:15 am
John Weeks, *Texas A&M University*
Philip Yasskin, *Texas A&M University*
Sinjini Sengupta, *Texas A&M University*
Marshall King, *Texas A&M University*

Our Math Circle has been exploring non-terminating two-player games, which are games that enter a cyclical pattern. The games of War, Beggar-My-Neighbor, and Sticks offer examples of games that students can modify to be never-ending. We begin with examples of War and Beggar-My-Neighbor: if we allow a limited deck, can we choose how cards are positioned in the deck so that the game never terminates? In the game of Sticks, we ask the players to find a way to play so that the game enters a cyclical pattern where the game never ends. This makes the game a cooperative game rather than a competitive one. We share some of our discoveries with the students from our Circle in this talk.

A King's Carpet: Reimagining a Classic Area Puzzle
9:20 am - 9:35 am
Jeffrey Musyt, *Slippery Rock University*

Shikaku puzzles are a type of logic puzzle that involve fitting different sized rectangles into a numbered grid. In this talk, we'll explore ways to adjust the difficulty of these puzzles in multiple ways to make them suitable for a variety of students. We'll also discuss ways to incorporate these and similar area themed games/puzzles into elementary classrooms, math outreach events, and math circle sessions.

Culturally Responsive Pedagogical Practices with Adapted an Activity Inspired by Hey Google, Who's a Mathematician?
9:40 am - 9:55 am
Cynthia Sanchez Tapia, *California State University Dominguez Hills*
Eryn Maher, *Georgia Souther University*
Ha Nguyen, *California State University Dominguez Hills*
Alessandra Pantano, *University of California Irvine*

"With the aim of implementing culturally responsive pedagogical practices that supports using mathematics to learn more about participants' own communities and potential systemic injustices impacting their communities, we adapted Conway et al. 's (2022) module "Hey Google, Who's a Mathematician?"

The activity was adapted to use data and situations specific to middle school students' communities participating in the after-school program that is localized in the Los Angeles community area but it can easily be adapted to any other community. In this activity we seek to fit the technology available, the format of the after-school program sessions, and the students' communities. The lesson focuses on ratios and basic statistics as the mathematical goal. The social justice goal focuses on challenging perceptions of

who can be mathematicians. In this activity students will draw, practice statistics and write a letter to share their thoughts and wishes related to the activity."

Big Math
10:00 am - 10:15 am
Dave Auckly, *Kansas State University*
Dani Alvarez-Gavela, *Brandeis University*
Bruce Bayly, *University of Arizona* Henry
Fowler, *Navajo Technical University*
Kaybah Hoycott, *Navajo Math Circles*
Damien Hunter-Ben, *Dził Ditł'ooí School of Empowerment Action & Perseverance*
Dawnlei Hunter-Ben, *Dził Ditł'ooí School of Empowerment Action & Perseverance*
Matthias Kawski, *Arizona State University*
Kim Klinger-Logan, *Kansas State University*
Shay Logan, *Kansas State University*

"Making large mathematical models can provide new insights and inspire people of all ages. The authors have used these models in many places including the Navajo Nation and Ghana. In this session, we will describe (and maybe demonstrate) large (6-foot or more) models of polyhedral compounds, a ermutohedron, a multiplication table, and puzzles. Using these we will showcase some of the questions from graph theory and group theory, algebraic topology and differential geometry that may be explored with these models. [Additional presenters include Damien Hunter-Ben*, Dawnlei Hunter-Ben*, Henry Fowler*, Kaybah Hoycott*, Matthias Kawski*"

Lines of Sight: Activities Related to Visual Perspective
10:20 am - 10:35 am
Anna Davis, *Ohio Dominican University*

We will explore several interconnected activities related to anamorphic art, photography, and the geometry behind accurate perspective drawing. Our activities are based on techniques and concepts developed by artists and mathematicians such as Leonardo da Vinci and Desargues. These activities have been tested with teachers, middle school, and high school student math circle participants. We will share a repository of open-source supporting materials and demonstrate the use of manipulatives.

Scaffolded Explorations with a Modified Rubik's Cube
10:40 am - 10:55 am
A. Gwinn Royal, *Ivy Tech Community College* Lauren Rose, *Bard College*

Many people find the prospect of solving a Rubik's cube daunting. We will demonstrate the advantages of simplifying the cube by eliminating extraneous information. For example, in solving the first layer, the placement of colors on the second and third layers is mostly irrelevant. By removing this distraction, participants can more easily focus on the remaining colors, look for patterns, explore ideas, and try to develop their own solving strategies. This new twist can promote equity and better illuminate the underlying mathematical concepts.

Part B: *Saturday, August 10, 8:00 am - 9:15 am*

Collaborative Team Play
8:00 am - 8:15 am
Scott Berger, *Clear Lake High School*

"In this presentation, I'll share entertaining and inclusive team contests. Math Circles are an amazing blend of math enthusiasts from isolated communities: public, private, and home-schooled students from elementary through graduate school, professors, teachers, industry workers, and hobbyists.

My most enjoyable sessions have been collaborative problem-solving: members discuss, brainstorm, reason, persuade, and prove mathematical ideas in groups. For example, a Mandelbrot Team Play contest guided teams through conjecturing and writing up proofs of relationships among Fibonacci numbers. Purple Comet is a free online competition for six-person teams that has mixed-school and all-ages categories so that everyone can participate. In the Rocket City Interschool Contest, students from the same high school or two-year college collaborate as one team to solve problems as quickly as possible. Team events are a wonderful way for a Math Circle to unite mathematicians of all ages and backgrounds."

Notable Numbers, Noteworthy Lessons
8:20 am - 8:35am
Angie Hodge-Zickerman, *Northern Arizona University*
Cindy York, *Northern Illinois University*

In this session, we will give a sampling of a modified version of the "Notable Numbers" activity from the Math = Love Blog. Participants will actively engage in a portion of this Math Teachers' Circle. Often, the best lessons come from trial and error—realizing after the fact how things could have been done better or differently. We will share the adjustments we made after running this session at a summer camp for teachers. We will also discuss how this Math Teachers' Circle session can be customized for both in-person and remote settings.

What Do Those Graphs Look Like?
8:40 am - 8:55 am
Kun Wang, *Texas A&M University*
Steven Ning, *Friendswood High School*

"This activity is designed to introduce middle school and high school students to graph theory concepts. Students are divided into groups and tasked with identifying graphs that meet specific criteria: (1) They must contain no triangles; (2) If two vertices are not adjacent, exactly two other vertices connect them.

Through experimentation, students discover that all graphs meeting these conditions are regular graphs. However, for certain numbers of vertices, such graphs do not exist.

Specifically, if an n-vertices graph is k-regular, then n and k must satisfy some certain conditions. These results are proved by myself and Steven Ning. Steven is a high school student in the Houston area who joined our PReMa program, a research program for high school students funded by my colleagues and myself, in 2023 and 2024."

The Arithmetic of Lady Bugs
9:00 am - 9:15 am
David Crombecque, *American Institute of Mathematics*
Nathan Hall, *University of Southern California*

In this session, we will describe a math circle activity based on the Lady Bugs game from the Julia Robinson Math Festival (also known as the Magic Cauldrons game). We will look at the Mathematics underlying the game and how to use it to modify and twist the game in many ways. We will also see how to implement the game for different audiences, from elementary school students to high school math teachers.

Community-Focused Experiences in the Statistics or Data Science Classroom

Friday, August 9, 4:00 pm - 5:55 pm

Engaging with the community, whether directly through collaborative projects with community partners or indirectly through the use of community data in classroom activities, allows students to see the impact of their work in the "real world" and connect with the material on a deeper level. This session invites presentations that share insights, experiences, and lessons/activities about engaging with the broadly-defined "community" in the Statistics or Data Science classroom.

Organizers:
Melissa Innerst, *Dickinson College*
Helen Burn, *Highline College*

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

Using The Shippensburg Corn Festival In The Introductory Statistics Classroom

4:00 pm - 4:15 pm
Grant Innerst, *Shippensburg University*

The town of Shippensburg Pennsylvania has a street fair every year at the end of August called the Corn Festival. The fair attracts thousands of people from around the area! The time and scale of the fair offers students in statistics courses a unique opportunity to connect with their community and experience data collection early in the course. In this talk, I will describe activities I've used with my introductory statistics courses that utilize student-collected data to answer questions that are valuable to festival organizers and the community at large.

Community Engagement for Data Literacy with Non-STEM Students

4:20 pm - 4:35 pm
Michelle Friend, *University of Nebraska at Omaha*
Becky Brusky, *University of Nebraska at Omaha*
Kalyan Ghimire, *University of Nebraska at Omaha*
Betty Love, *University of Nebraska at Omaha*
Andrew Swift, *University of Nebraska at Omaha*
Mahbubul Majumder, *University of Nebraska at Omaha*

A promising practice for improving student outcomes in general education mathematics is integrating community engagement and data science. STAT 1100: Data Literacy and Visualization satisfies

university quantitative literacy requirements by introducing students to data science. Students learn basic statistics, data organization and manipulation, visualization techniques and industry-standard software. This is a service learning course: students work with a community partner, using data to answer questions such as program effectiveness and community impact. This novel course has the highest passing rate of any general education math course at our university and improves student attitudes about mathematics, along with ensuring students master critical 21st-century workforce skills.

Let's Talk About Data
4:40 pm - 4:55 pm
Shonda Kuiper, *Grinnell College*

DataSpace is freely available online curricula designed to help introductory students become more quantitatively skilled communicators. We use data journalism pieces, interdisciplinary stories, games, and interactive apps that allow students to explore, simulate, and modify data from a wide variety of datasets. The interdisciplinary nature of this site is designed to provide spaces for students to interact with their peers. Guided questions help students reflect on each researcher's viewpoint as well as explore other perspectives not directly examined in the story. This allows small groups or classes the opportunity to debate the importance of data-based decisions that are currently influencing our society.

A Capstone Course in Statistics using Local Data
5:00 pm - 5:15 pm
Heather Cook, *University of Southern Indiana*

Graduating majors in Statistics complete a capstone course during their last semester where they create a research question, collect data, explore the data, complete analyses, write an article, and present their work in an open colloquium. In spring 2021, students collected housing data from the city where the university is located and another city a student was moving to. Their goal was to predict housing prices based on descriptions and other factors using various regression methods. Being graduating seniors, they were about to enter the workforce and move to different locations while deciding if they wanted to buy a home in the near future. Personally knowing individuals who work with the fire department, students explored data from the local fire departments trying to predict emergency calls and type of calls using regression and classification methods in spring 2024. In both cases, students used community data that allowed them to explore questions they had about their lives.

Community-Based Research in a Regression Analysis Course
5:20 pm - 5:35 pm
Debra Hydorn, *University of Mary Washington*

To provide students with undergraduate research opportunities while connecting their learning with community-based issues, I organized my upper-level regression analysis course to focus on a student-designed project. I based the reorganization of my course on the structure described in "Developing Course-Based Undergraduate Research Experiences" by Jacqueline McLaughlin." Throughout the development of this course, I participated in the Mentoring the Integration of Research into the Classroom (MIRIC) program through the Council on Undergraduate Research. A data science colleague had introduced me to the University of Virginia's Biocomplexity Institute and the data repositories they have made available through their Social Data Commons site. A review of two of their repositories provided ample opportunities for students to explore a community-based issue of interest to them. Project topics included food insecurity, incarceration rates, and mental issues.

https://urfm.psu.edu/mentors/developing-course-based-undergraduate-research-experiences

https://uva-bi-sdad.github.io/sdc.intro/data.html

Enhancing Statistical and Data Science Education through AI-Powered Apps
5:40 pm - 5:55 pm
Immanuel Williams, *California Polytechnic State University, San Luis Obispo and GATO365 Learning Center*
Mia Hodges, *California Polytechnic State University, San Luis Obispo and GATO365 Learning Center*

This talk explores AI-powered apps enhancing statistical and data science learning. Recognizing the gap in customized teaching materials, we propose an AI app for statistics and data science education. The app provides dynamic, adaptable content, enabling personalized learning experiences. Catering to students' varying approaches - proactive learning, clearing misconceptions, or connecting topics not discussed in class. The app distinguishes between statistical and data science learning, providing tailored resources for each. It promotes interdisciplinary discussions, fostering a sense of community. By offering personalized content, it improves understanding, encourages exploration, and helps students connect different subjects. While AI apps like ChatGPT speed up learning, they don't replace the process of ideation.

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

Part A: *Thursday, August 8, 3:00 pm - 5:55 pm*
Part B: *Friday, August 9, 3:30 pm - 5:05 pm*

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. Submissions by undergraduates or examples of the use of the solutions of these problems in the undergraduate classroom are encouraged.

Organizers:

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

Sponsor:

SIGMAA on Recreational Mathematics (SIGMAA REC)

Part A: *Thursday, August 8, 3:00 pm - 5:35 pm*

Equilibria for the Penney Ante Game with a Biased Coin for Both Sequential and Simultaneous Moves
3:00 pm - 3:15 pm
Michael Jones, *Mathematical Reviews | AMS*
Stanley Huddy, *Fairleigh Dickinson University*

William Penney introduced the Penney ante game in the problem section of the Journal of Recreational Mathematics. In this game, two players sequentially select a string of three Heads or Tails. The player whose string appears first when a coin is tossed repeatedly wins the game. Martin Gardner featured this game in his Scientific American column because of the intransitivity of the strings (viewed as strategies). For a biased coin that returns Heads with probability p, we determine the probabilities of winning/losing for each pair of strategies and examine the transitive/intransitive structure of the strategies. Then, we determine the Nash equilibria for both sequential and simultaneous play for every value of p.

Playing Catch Up on The Chase and Bertrand's Ballot Problem
3:20 pm - 3:35 pm
Matthew Haines, *Augsburg University*
Michael A. Jones, *Mathematical Reviews | AMS*

The Chase is a television game show (2009-present in UK; from 2013-2015; 2021-present in US) that consists of three rounds and three contestants. This presentation explores the probability of a contestant "being caught" by the chaser in the second round of the game. A solution will first come through the use of Markov chains. This result will be improved upon by a method that reveals a connection to a generalized version of Bertrand's Ballot Problem.

Basic Strategy for Simplified Blackjack Variants
3:40 pm - 3:55 pm
Daniel Martin, *University of Hartford*
Basmalah Asad, *University of Hartford*

"In this talk, we discuss an optimal strategy for several variations of a simplified version of Blackjack. In short, for these variants the player has only the two options of hit or stand, and they may only make one decision. Other minor variations including rule modifications, changes in number of decks, and different given information about dealer's hand are considered. These variations provide a lower entry point into studying the game of Blackjack from a mathematical perspective while maintaining the same spirit of the game. They also serve as interesting and fruitful applications for instructors teaching basic discrete probability theory."

Using Board Games for Research in Mathematical Redistricting
4:00 pm - 4:15 pm
Ventsi Gotov, *University of Rhode Island*
Ed Lamagna, *University of Rhode Island*

"Gerrymandering is the manipulation of electoral district borders in a way that gives one party or group an unfair advantage over another in elections. In recent years, the problem has received renewed attention from mathematicians and computer scientists seeking to offer methods for fair redistricting of electoral maps.

In this work we demonstrate how board games can be used as a tool for conducting research on mathematical redistricting. The board game can be considered a small, lab version of the real world problem where we can carry out experiments and test hypotheses. Specifically, we provide a measurement called "packability", which quantifies the susceptibility of a party's vote to the gerrymandering practice of "packing". We also test a hypothesis in order to investigate the effect of low "packability" scores on election outcomes, and present our results."

How Many Mutually Non-attacking, Non-knight Pieces Can We Place on an *M*-by-*N* Chessboard?
4:20 pm - 4:35 pm
Doug Chatham, *Morehead State University*

How many black and white chess pieces -- excluding knights -- can we place on the squares of an m-by-n chess board so that none of those pieces attack or guard any other piece? We answer this question for all rectangular boards. If n>1, the answer is 2m/3, rounded up to the next integer, times n, plus either 0, 1, or 2.

From Pseudo-Hamiltonian Cycles to Jekyll and Hyde Chess Tours
4:40 pm - 4:55 pm
Karl Schaffer, *De Anza College*

What might movement games, partner folk dances, billiard ball paths in polygons, and lace shirtwaist buttons have in common? They all sometimes exhibit patterns known as pseudo- or (a,b)-step-Hamiltonian cycles. These are cyclic sequences of the vertices of a graph in which each vertex appears once and such that the graphical distance between successive vertices alternates between a and b. We briefly note the ubiquitous appearance of such cycles and see how they lead to a chess piece that must alternately move like a knight and bishop, which we call a Jekyll and Hyde piece. Chess pieces like this have a long history in the world of chess variants and we will note some connections between chessboard tours of these pieces and planar tilings.

Impartial Two-Player Pebbling Games
5:00 pm - 5:15 pm
Wing Hong Tony Wong, *Kutztown University of Pennsylvania*
Kayla Barker, *Stockton University*
Mia DeStefano, *Vassar College*
Eugene Fiorini, *Center for Discrete Mathematics and Theoretical Computer Science (DIMACS)*
Michael Gohn, *DeSales University*
Max Lind, *Princeton University*
Joe Miller, *Iowa State University*
Jacob Roeder, *Trine University*
Andrew Woldar, *Villanova University*

On a simple graph, a number of pebbles is assigned to each vertex. A pebbling move consists of removing two pebbles from one vertex and adding one extra pebble to one of the neighboring vertices. In this talk, we analyze a two-player version of this game, where players take turns to make a pebbling move, and the first player without a legal pebbling move loses. We also further consider a few generalizations of this game.

Variations On The Home Prime Conjecture
5:20 pm - 5:35 pm
Jay Schiffman, *Rowan University (Retired)*

The traditional Home Prime Conjecture asserts that if one takes any positive composite integer, resolves it into its prime factorization, concatenates the factors and repeats the process, eventually a prime ensued known as the Home Prime of the original composite integer. It is well known that the Home Prime of 49 is currently stalled after more than one hundred iterations. This paper considers the conjecture as well as variations when all factors are only raised to the first power, when the order of the factors is reversed and

then concatenated as well as when the order of the factors are reversed raised to the first power alone and then concatenated. A neat open sourced calculator attributed to Dario Alpern aids in my research as we consider all composite integers up to one hundred in each variation. Note only odd composite integers are needed to be investigated in the cases where the concatenation of the factors is in descending order.

Part B: *Friday, August 9, 3:30 pm - 5:05 pm*

Celebrating the role of Positional Notation Systems in Mathematical Magic
3:30 pm - 3:45 pm
Jon Stadler, *Capital University*

Positional notation systems play a significant role in several mathematical magic tricks. We begin by performing and describing two well-known illusions. Our discussion includes a reflection on how number systems work and we use a common mathematical induction proof to introduce a mixed radix numeration system. We conclude by presenting Eigen's Value, a trick described by Martin Gardner and later by Colm Mulcahy. An updated method for performing it that utilizes this mixed radix system will conclude the presentation.

Counting Celtic Knots
3:50 pm - 4:05 pm
Dana Rowland, *Merrimack College*

An alternating lattice on an $n \times n$ grid generates a link with n components. A single-component knot can be obtained by selecting a subset of the crossings and smoothing the link in a neighborhood of each selected crossing. Visually, this corresponds to inserting horizontal or vertical breaks in the lattice. How many different ways can breaks be inserted in an n by n square grid to combine components so that the result is a single entangled strand? We explore combinatorial, geometrical, and topological approaches to this puzzle.

New Venn Diagram Puzzles
4:10 pm - 4:25 pm
Rodney Lynch, *Indiana University Columbus*

Venn diagram problems in which the information is presented in a visual format will be presented. Puzzles will be created by considering projections of a Venn diagram onto various subdiagrams. If there is time I will show puzzles that involve symmetric difference of sets. Also, I will discuss how to improve on the Venn diagram puzzles that we assign students.

An Analysis of a Bounded Resource Search Puzzle
4:30 pm - 4:45 pm
Gopal Anantharaman, *HP, Inc.*

Consider the commonly known puzzle, given k glass balls, find an optimal algorithm to determine the lowest floor of a building of n floors from which a thrown glass ball will break. This puzzle was originally posed in its original form in $\cite{focs1980}$ and was later cited in the book $\cite{algthc}$. There are several internet sites that presents this puzzle and its solution to the special case of k=2 balls. This is the first such analysis of the puzzle in its general form. Several variations of this puzzle have been studied with applications in Network Loading $\cite{cgstctl}$ which analyzes a scenario where an adversary is changing the lowest floor with time. Although the algorithm specified in $\cite{algthc}$ solves the problem, it is not an efficient algorithm. In this paper, another algorithm is analyzed. It is

shown that if m is the minimum number of attempts required then for $k≥m$ we have $m=log(n+1)$ and for $k<m$ we have an interesting combinatorial sum.

Addressing the Classic Josephus Problem via the Fixed-point Recurrence Formula of its Associated Function
4:50 pm - 5:05 pm
Roy Quintero-Contreras, *Northern Illinois University*
Yunier Bello-Cruz, *Northern Illinois University*

In this brief presentation, we address the Josephus problem, when the reduction constant is three, through the fixed-point recurrence formula of its associated discrete function. By incorporating this formula into a recursive algorithm, we have found a significant improvement in computing the output of the Josephus function for any large input.

Innovative and Effective Pedagogical and Technological Practices to Teach College Algebra and Pre-calculus

Part A: *Friday, August 9, 8:00 am - 10:55 am*
Part B: *Saturday, August 10, 1:00 pm - 5:15 pm*

This session features talks that describe innovative teaching practices or examples of integrating technology in college algebra, pre-calculus, or other developmental math courses. Presentations will generally include some discussion of the success of presented methods or projects, such as in what ways the activity, course design, or method under discussion has improved student learning, retention, or interest in the course. We look forward to having speakers who are remarkably diverse in terms of academic rank and type of institution of higher education.

Organizers:
Tosh Shahrtash, *Pennsylvania College of Technology*
Evonne Haines, *Pennsylvania College of Technology*
Kimberly Yoder, *Pennsylvania College of Technology*
LeAnn Henry, *Pennsylvania College of Technology*

Part A: *Friday, August 9, 8:00 am - 10:55 am*

Teaching Strategies for Point-to-Point Math Classes
8:00 am - 8:15 am
Grant Kopitzke, *University of Wisconsin - Stevens Point*

In Point-to-point (P2P) classes, instructors are tethered to a specific physical classroom location while synchronously delivering content to multiple remote classrooms. This format often results in a sense of detachment and diminished student engagement. This talk will explore proven strategies employed in P2P math classes to enhance student engagement, promote collaborative problem-solving and elevate the overall learning experience. We will provide actionable takeaways for educators seeking to foster a more connected educational experience and improve the success and overall quality of pre-calculus instruction in a distributed learning environment.

Strategies in Implementing Technology and Active Learning in College Algebra and Pre-Calculus
8:20 am - 8:35 am
Dushanthi Herath, *Maryville University of St. Louis*
Sharmila Sivalingam, *Maryville University of St. Louis*

Studies show that integrating technology as a tool in teaching and learning motivates students and changes their attitudes about learning mathematics. (Higgins, Huscroft-D'Angelo, and Crawford). In this session, presenters will discuss the technologies that were helpful in learning developmental mathematics courses, particularly college algebra and pre-calculus. Some of the examples include integrating courseware with a learning management system (LMS), use of various educational apps and an introduction to mathematical writing when solving problems. Presenters will discuss how these activities motivated students and how they embedded these activities in their course design. Students' feedback collected after the activities will be shared during the presentation. References: Higgins, K., Huscroft-D'Angelo, J., & Crawford, L. (2019). Effects of Technology in Mathematics on Achievement, Motivation, and Attitude: A Meta-Analysis. Journal of Educational Computing Research, 57(2), 283-319.

Active and Adaptive Corequisite College Algebra
8:40 am - 8:55 am
Christy Sue Langley, *University of Louisiana Lafayette*
James Kimball, *University of Louisiana Lafayette*

The University of Louisiana Lafayette has been redesigning the corequisite college algebra course to address students entering with varying background knowledge and learning gaps in a manner that provides a more equitable education. Louisiana discontinued remedial mathematics courses in the fall of 2023 and moved to a corequisite model for all students entering public colleges and universities. The effort has had varying degrees of success and failure, with inconsistent instructional and methodological changes between higher-education institutions within the state. We will describe how our course has transformed from a traditional lecture-based course to one that implements active learning methods and adaptive learning software. These changes encourage a learner-centered educational environment that promotes student agency and a growth mindset. We will share the student-related data, our successes, and the challenges associated with the course redesign.

Reflections and More in a Precalculus Course Using Standards-Based Grading
9:00 am - 9:15 am
Rachel Epstein, *Georgia College*

During the height of the pandemic, I implemented standards-based grading in my Precalculus course in order to provide flexibility and help ease anxiety in a difficult time. However, student opinions of the grading system were mixed and many students had difficulty understanding the grading system and knowing how to study in a standards-based graded course. To respond to these challenges, I developed resources to help the students both to understand their grade and to learn from their feedback and plan out their studying. These included reflection assignments, a Standards Checklist, and a Grade Possibility Table. In this presentation, I will discuss these resources and the impacts they have had on the Precalculus students.

Team-Based Inquiry Learning in College Algebra and Precalculus
9:20 am - 9:35 am
Abby Noble, *Middle Georgia State University*

Tonya DeGeorge, *Georgia Gwinnett College*
Kathy Pinzon, *Georgia Gwinnett College*
Wendy Sheppard, *College of Charleston*

Team-Based Inquiry Learning (TBIL) combines the highly structured approach to small group instruction of Team-Based Learning (TBL) with the discovery model of Inquiry Based Learning (IBL). TBL uses active collaboration between teams of students working on the material. IBL guides students to discover concepts through carefully curated problems. This combination encourages students to think more deeply about the content and use their critical thinking skills to solve complex problems. Given the success of implementing these types of materials in Calculus and Linear Algebra, TBIL fellows have created open source instructional materials for College Algebra and Precalculus. In this talk, we will explain the tenets of TBIL, as well as present highlights from the newly written activity book, which are designed to promote a deeper understanding of the content, which in turn prepares students for postrequisite courses. We will also share our problem sets that align with the activity book.

Empowering Students to Succeed in Precalculus
9:40 am - 9:55 am
Latrice Bowman, *University of Alaska Fairbanks*

Using mastery-based learning and grading, corequisite instruction and collaborative activities here are ways to help students take control of their learning process. These approaches help students improve their study skills, reinforce prerequisite knowledge, help them learn to communicate mathematics effectively and master the content needed to do well in future STEM courses.

Rethinking Pre-Calculus: Integrating Trigonometry for Better Preparation in Calculus
10:00 am - 10:15 am
Monica Hennessy, *University of Cincinnati, Blue Ash College*
Rachel Frankel, *University of Cincinnati, Blue Ash College*

Explore a novel approach to pre-calculus, proposing a shift in traditional sequencing to prioritize trigonometry upfront and integrating trigonometric functions throughout the course. This presentation unveils a semester-long course outline, showcasing the rationale behind each week's content placement. Drawing from a year of implementation and student feedback, we demonstrate the efficacy of this restructuring in enhancing student learning and readiness for calculus.

A Precalculus Instructor's Use of an Applet as a Didactic Object: A Mechanism for Conveying Coherent Meanings to Students
10:20 am - 10:35 am
Abby Rocha, *Central College*

Digital technologies like graphing software and applets are commonly integrated into math curricula to support student learning and performance. While researchers suggest that instructors' use of applets and animations as didactic objects (Thompson, 2002) can help students develop coherent mathematical understandings, examples of such usage are scarce in math education literature. In this presentation, I share an example of a precalculus instructor's design and use of an applet as a didactic object for supporting students' construction of the output of the sine function as a quantitative operation. This example highlights the benefits of using applets as didactic objects in teaching and how instructors' conceptualizations of mathematical ideas influence their teaching goals, explanations, and ultimately the meanings that students have the opportunity to construct.

The Impact of Integration of AI in Mathematics Discussions
10:40 am - 10:55 am
Eunmi Joung, *Utah Valley University*
YoungRae Kim, *Texas A&M University-San Antonio*

"AI supports procedural knowledge with step-by-step algebra problems, enhancing skill development. It also boosts conceptual understanding through multimedia and conversations, improving math grasp (Jančařík et al., 2022). Despite AI's benefits, concerns about accuracy remain. Wardat et al. (2023) investigated perceptions of ChatGPT in teaching math, finding it beneficial for providing instant feedback to students but raising concerns about accuracy.

This presentation explores how AI-generated text assists students with mathematical discussions. In particular, we explored how students' discussion scores predict their final exam scores and their experiences using ChatGPT. The study highlights the potential benefits of AI integration in developmental mathematics in enhancing students' problem-solving and analytical skills. In doing so, the study offers educators and policymakers valuable insights into the effectiveness of AI integration."

Part B: *Saturday, August 10, 1:00 pm - 5:15 pm*

Using WeBWorK with GeoGebra Applets for Applications in Business Mathematics
1:00 pm - 1:15 pm
Timothy Flowers, *Indiana University of Pennsylvania*
Alfred Dahma, *Indiana University of Pennsylvania*
Valerie Long, *Indiana University of Pennsylvania*

In 2019, we introduced a 1-hour per week computer lab course to pair with our Business Mathematics course. The goal was for students to reinforce, practice, visualize, and apply the techniques from the lecture course using case-study style exercises. Originally, we had students learn to use GeoGebra for graphical visualizations. However, the technology started to become a barrier for the students and dealing with the notation distracted them from what we wanted them to learn. So, we redesigned this course entirely using WeBWorK, with GeoGebra applets in each problem. This has allowed students to use interactive graphs and applets as they work on their exercises and applications without needing to learn any syntax. Instructors do not need to spend class time troubleshooting graphics and can instead focus on helping students understand how to apply mathematics (e.g., interpreting slope of a profit function). We will share examples from across our business math curriculum.

Diverse and Inclusive Pedagogical Practices in College Algebra Classes
1:20 pm - 1:35 pm
Violeta Vasilevska, *Utah Valley University*

In this presentation, we describe a hybrid (flipped classroom) design of the College Algebra class used by the presenter. Students are required to learn the material and work on the online HW before class. In class, the 30-minute Q&A session allows for active participation through discussions. The 20-minute in-class problem-solving activity provides opportunity for teamwork and collaboration. This flipped classroom design provides diverse assignments (accommodates various learning preferences), allows flexibility in adapting it to different teaching modalities, and is inclusive (uses OER textbook and affordable software). Additionally, this design offers multiple ways students learn/review/practice new material and concepts (at least five times by the time they are tested on the Chapter Exam). At the end of

the presentation, students' feedback on the impact of the class structure will be shared as well how this feedback has been incorporated in shaping the design currently used.

Integrating Flipped Learning to Support Students' Success in College Algebra with Developmental Mathematics
1:40 pm - 1:55 pm
Michael Okone, *Texas A&M University - Corpus Christi*
Celil Ekici, *Texas A&M University - Corpus Christi*

Flipped learning with online videos has a great potential for incoming freshmen needing help in college math. Participants for this study attend to a college algebra course supported by a co-requisite course on brief developmental math. Support for student success and engagement include flipped learning and peer tutoring. Instructional videos are integrated into the course materials to be completed prior to class sessions. During class time, students engage in problem-solving activities. Paired T-test, Wilcoxon two-sample and Kruskal-Wallis test reveal superior academic performance among college algebra students in the flipped developmental math sessions compared to non-flipped counterparts. The strengths and weaknesses of the experimented flipped learning approach are discussed in the context of research on flipped learning practices. The students' expectations from flipped learning are compared to instructors' informing how to improve the instruction for effective flipped learning.

Institutional Cooperation and Cooperation in The Classroom: Active Learning and Embedded Tutor in Pre-calculus Courses
2:00 pm - 2:15 pm
José María Menéndez, *Pima Community College*

Causing change at an institution, particularly a change in culture, takes leadership and buying in (top-down approach); sometimes it takes the form of grassroots movement (bottom-up approach) and rarely a move in the two directions just "happens." I this session we will share our experience revamping the pedagogical approach at our college, in particular the redesign of Pre-calculus and Trigonometry courses. We will start by describing the institutional and cross-institutional initiatives, including activities led by faculty members, a research project and workshops in coordination with the local State University, an embedded tutor program sponsored by the deanship of Readiness and Student Success (previously Developmental Education), and a "Culture of Care" approach promoted by the Chancellor and Dean of Mathematics. This will be followed by identifying the elements of the new classroom dynamics. We will finish out presentation with preliminary results of the revamping efforts.

Navigating Trigonometry: A Student-Friendly Pre-Calculus Approach
2:20 pm - 2:35 pm
Sandra Fital-Akelbek, *Weber State University*
Sabina Akelbek, *Purdue University*

Trigonometry often poses a challenge for students, particularly those pursuing STEM fields. Traditional methods often rely heavily on memorization, such as the daunting task of learning the unit circle. In this presentation, we will show a different approach that is more accessible to students, where we focus on properties of trigonometric functions. Through concrete examples and student work, we demonstrate the efficacy of our method in college-level courses.

Thinking Classrooms in the Developmental and First-Year College Mathematics Classroom
2:40 pm - 2:55 pm
Scott Zinzer, *College of DuPage*

Liljedahl's Thinking Classrooms is a teaching methodology based on 14 key teaching practices aimed at boosting student engagement and autonomy while developing effective mathematical habits in students' approach to learning and doing mathematics. Thinking Classrooms has grown in popularity and use in K-12 mathematics in recent years and features a strong community of teachers using these strategies in the classroom. In this talk, I will share my experience in applying practices from Building Thinking Classrooms in a developmental algebra sequence of courses in a two-year college setting. Although we discuss successes in recent implementation, much of this talk will focus on failures in implementation, lessons learned, and iterative refinements to improve overall course design. The talk will conclude with impacts on students and suggestions for anyone who wants to incorporate features of Thinking Classrooms into their course design.

A Journey in Mastery-Based Grading in Precalculus
3:00 pm - 3:15 pm
Sarah Seger, *Concordia College*

Using mastery-based grading for precalculus over the last five semesters I have found that students are motivated to learn the material, students come to office hours for help in far greater numbers than my other classes, and setting higher expectations only motivates students to achieve them. Underprepared students benefit from this method because mastery-based grading enables these students to learn at their own pace, to an extent, and they aren't penalized for not understanding a concept right away. I have used both mastery based testing and specifications grading and I have made an effort to make my LMS not only work more effectively with my grading system, but also further incentivize students to keep engaging with the material and provide additional resources and support when needed.

Using Desmos to Visualize the Unit Circle and Transformations Of Functions in Pre-calculus
3:20 pm - 3:35 pm
Kevin LoPresto, *Francis Marion University*

"In this presentation I will describe two concepts I introduced in which I have used technology, specifically Desmos in my Pre-calculus course. One topic is the unit circle at the beginning trigonometry. The interactive graphing calculator allows students to see how a point traveling around the unit circle generates the sine, cosine and tangent graphs. We start with intervals of $\pi/2$ when discussing quadrant angles, then decrease the interval size to $\pi/12$ when the discussion turns to special angles.

The second topic is that of function transformations where the students are guided through the four basic transformations of functions using sliders and clickers to see what is happening to a function. They are then asked to generalize their findings. Both activities utilize the dynamic nature of Desmos in allowing the students to see what is happening to the graphs as they are created. The activities will be shared as well as responses from the students."

So...What Exactly IS a Solution?
3:40 pm - 3:55 pm
Anurag Katyal, *Palm Beach State College*

Students often learn algorithms for solving various equations and inequalities in Algebra courses leading up to the Calculus sequence without necessarily understanding what they are finding or what it means for some mathematical object to be a solution. In this talk, we will discuss the 'What is a Solution?' activity developed in Doenet, an open-source interactive platform facilitated by a Team-Based Inquiry Learning framework in Active Learning Studios, where students collaboratively work in groups to build a more nuanced understanding of solutions in a mathematical context without first needing to know how to solve the equations or inequalities themselves. We will also discuss the benefits of such an alternative sequence of content presentation to the long-term persistence of the notion of a solution in student assessments.

UDL and the use of Digital and Physical Manipulatives in Constructing Mathematical Knowledge in College Mathematics
4:00 pm - 4:15 pm
Clark Wells, *Grand Valley State University*
Paul Yu, *Grand Valley State University* Joy Oslund, *Grand Valley State University*

This research is part of a larger study on the use of technology and physical representational tools in the teaching of college mathematics.

In Winter 2023, a STEM major with a low-incidence disability (legal blindness) enrolled in one of the presenters' section of pre-calculus, a prerequisite for Calculus, required in their major.

The student had limited vision in one eye, but the degree of disability necessitated rethinking instructional strategies to make the material accessible.

Using ideas from Universal Design for Learning (UDL), the authors integrated novel use of technology and manipulatives to improve the learning experience for all students.

In this talk, we discuss how UDL informed technology, materials, and pedagogy.

We reflect on the impact on the blind student, on other students, and on our approach to teaching.

We will discuss digital whiteboards, manipulatives (such as wikki stix), and authoring software that allows for the creation of accessible materials.

CANCELLED ~~**Small Steps and Big Steps for Continual Improvement in College Algebra**~~
~~*4:20 pm - 4:35 pm*~~
~~Chloe Wawrzyniak, *University of Kentucky*~~

In the last few years, enrollment in our College Algebra has nearly doubled to over 2000 students in the fall semester, but continual improvement efforts during that time have resulted in enormous gains in student success. Despite the increased needs of our students due to the pandemic, the percentage of students earning A's has nearly doubled, and grades in follow-on courses have increased accordingly. These gains are seen across our regular, corequisite, and dual-credit sections, as well as across demographic identifiers such as gender, race, and first-generation status. In this talk, I will discuss the various steps taken in the last four years to improve the course, including both small, iterated changes such as streamlining content, use of active learning, and flexible homework policies, as well as the major course overhaul of switching from common-hour exams to growth-based grading. Finally, I will discuss what is not yet working and our plans in the coming years to address it.

A Note on Notation: Activities to Help Precalculus Students Tackle Strange New, Notation
4:20 pm - 4:35 pm
Kelly Buch, *Austin Peay State University*

Precalculus introduces students to new mathematical operations beyond the basic few they've studied most of their lives (+,-, x, /, ^ and √). With those new ideas come notations, the likes of which they've never seen before. Now, functions and operations are represented with words, not just symbols! (Think log, cos, arcsin, and more!) This notational shift can cause confusion and misconceptions of their own, intensifying the common misconceptions from the new functions themselves. In this talk, I'll share some bite-size, ready-to-go activities and approaches to use in your classroom to familiarize students with this form of mathematical notation before introducing concepts with this notation.

Recent Changes in Precalculus to Improve Outcomes for Students
4:40 pm - 4:55 pm
Steven Derochers, *University of South Carolina*

STEM students entering college underprepared for calculus tend to struggle with the required mathematics for their degree. This talk will focus on the recent changes implemented in precalculus at the University of South Carolina to increase these students' successful outcomes in calculus. Some of the changes include the introduction of application labs highlighting precalculus material appearing in other STEM areas (Newton's Law of Cooling, pH scale, velocity and acceleration, etc), a streamlining of course material, and an overhaul of course coordination. Active course coordination is key with the high frequency of turnover necessary for graduate instructors. We will present some early feedback, and we would welcome conversations with others who have had or are having similar experiences.

Using Generative AI in the College Mathematics Classroom

Friday, August 9, 8:00 am - 10:55 am

The increasing importance and availability of AI require faculty to carefully assess its role in the mathematics classroom. While the use of AI seems inevitable, there are many issues—pedagogical, curricular, and ethical—that must be addressed. This is new territory, and community dialogue is essential for effective use of AI.

Presentations can describe how the presenters have introduced AI into the mathematics classroom: what has been done, what has succeeded, how students have responded, and what improvements will be made. Presentations that contribute actionable insight or ideas are encouraged.

Presenters can also raise issues that they are grappling with as they seek to use AI: What aspects of AI should we teach? How do we help students avoid misusing AI? What are the ethical issues surrounding AI? How does the use of AI affect the choice of other topics in a course?

Organizers:
Riaz Ahmed, *Maharishi International University*
Cathy Gorini, *Maharishi International University*
Kira Hamman, *Penn State Mont Alto*

Britney Hopkins, *University of Central Oklahoma*
Leslie Jones, *University of Tampa*
Gizem Karaali, *Pomona College*
Lew Ludwig, *Denison University*
Siamak Tavakoli, *Maharishi International University*
Kathryn Appenzeller Knowles, *The University of Texas at Austin*
Rachael Lund, *Michigan State University*
Luke Tunstall, *Trinity University*
Catherine Crockett, *Point Loma Nazarene University*

Sponsor: SIGMAA on Quantitative Literacy (SIGMAA QL)

Generative AI: A Hero or a Villain in the Classroom?
8:00 am - 8:15 am
Feryal Alayont, *Grand Valley State University*

The moment I realized that ChatGPT could solve some of my take-home exam calculus problems, I panicked. How was I going to ask students to think carefully about what their calculations, which they could do in a computer algebra system, meant? Or to explain their own ways of determining when to use which method of solving a problem? When they turned in an answer, could I be sure that it was their own writing? Would I have to give up take-home exams? Or would I have to find brand new problems that generative AI couldn't solve, at least for now? It turned out that some problems were indeed not generative AI-proof. But generative AI also offered many other ways to help students learn. In this talk, I will describe my transition from panicking and wishing that ChatGPT didn't exist to someone who is now actively trying to use generative AI more often in assignments and classroom activities.

Incorporating ChatGPT in College Mathematics Teaching
8:20 am - 8:35 am
R. Cavender Campbell, *Texas A&M University - Commerce*
Tingxiu Wang, *Texas A&M University – Commerce*

Mathematics teaching changes with the introduction of new technologies. Graphing calculators and Computer Algebra Systems (CAS) provided new ways to teach math content (Wang, 1994) and changed mathematics instruction, particularly Calculus teaching and assessment. Now, Large Language Models (LLM), such as ChatGPT, will further change the dynamics of the mathematics classroom. These models provide an additional tool for teachers to engage students in critical thinking and problem solving. Examining the best methods for using these tools in the classroom is just beginning to be studied. We will explore strategies for using ChatGPT in the classroom. Specific examples of lecture demonstrations, exploration activities, and supplemental assessment questions will be shown. Also, early results from a survey of student opinions about the use of ChatGPT demonstrations and assessments in Differential Equations and Pre-Calculus classes will be shown.

Using ChatGPT in First Year Math Classes
8:40 am - 8:55 am
Grace Cook, *Bloomfield College of Montclair State University*

In the past year, I have used ChatGPT in my first-year math courses for two main purposes: creating assessments and offering extra tutoring outside regular class hours. Coordinating multiple class sections necessitates generating various assessment versions and review materials. I will explain how I leverage ChatGPT to craft diverse assessments of differing difficulty levels along with corresponding review resources. Additionally, I will detail my methods for teaching students to utilize ChatGPT effectively for tutoring and exam prep beyond class hours. Throughout my usage over the past year, I've encountered ethical dilemmas that I will address. The free version, ChatGPT 3.5, does have accuracy limitations, as evidenced by a lively (and sometimes humorous) conversation I had with it regarding factoring quadratics. ChatGPT 4 notably improves mathematical accuracy; yet, its monthly cost may deter many students. I will also share student feedback regarding the tutoring functionalities.

Word Problems in an AI Age
9:00 am - 9:15 am
Andrew Miller, *Belmont University*

Quantitative literacy includes the abilities understand a problem or scenario, extract any relevant data from its description, select an appropriate formula or computational tool, and accurately calculate the numerical values needed to resolve the scenario. In other words, quantitative literacy includes the ability to successfully solve "word problem." Until recent years, calculational tools were not able to solve such problems directly. I will demonstrate, using some quiz problems from my QL class, that generative AI is now quite good at these problems. This poses some challenges to identifying what skills we need to teach quantitatively literate citizens in an AI age. I will argue that we may need to pay less attention to the ability to solve single word problems and more attention to reflecting on the consequences and broader meanings of such calculations and to the ability to build computational models (e.g., spreadsheets) instead of performing single calculations.

Using an LLM to Code Online Assessment Questions
9:20 am - 9:35 am
Corrin Clarkson, *Indiana University*
Shuchi Grover, *Looking Glass Ventures*

Randomized, machine-graded, online, assessment questions with fully explained solutions are a powerful and efficient tool to support student learning. Unfortunately, the coding skills required to create these types of assessment questions can make question authoring challenging and even inaccessible.

The online homework system Edfinity (which uses the WeBWork problem format) is developing ALICE an LLM to help make the authoring of new assessment questions easier. ALICE generates the PEARL code for both questions and their solutions from natural language prompts.

In an NSF funded partnership between Edfinity and Indiana University, we trained teachers of dual credit courses in Indiana high schools to use ALICE and collected data on their experience. In this talk, I will discuss, both the capabilities ALICE and the teacher's responses to using it.

Using Generative AI to Design Educational Content from Recorded Videos
9:40 am - 9:55 am
Bevin Maultsby, *NC State University*

Are you wondering what to do with all those videos you recorded during the pandemic? In this presentation, we will explore several ways that generative AI, specifically ChatGPT, can transform

recorded transcripts into a variety of reusable educational materials. I will present two specific examples with step-by-step instructions: creating lecture summaries and designing review questions. The output is educational material that retains the speaker's original tone and perspective. Calculus students have responded positively to these additions, finding that the new materials accommodate different learning needs and styles.

Incorporating Generative AI into a Proof-based Course
10:00 am - 10:15 am
Paul Tokorcheck, *University of Southern California*
Felicia Tabing, *University of Southern California*

In upper-division proof-based courses, we try to clarify the limits of generative AI's contribution to proof writing and highlight the role of human actors. Large language models like ChatGPT are, by programming, purely probabilistic and do not have the ability to discern the truth or falsity of a statement. We want students to use AI to generate ideas and create drafts or outlines of proofs and we shift emphasis to editing, checking proofs for validity, and humanistic aspects like style and presentation.

We discuss a set of demonstrable learning objectives applicable to a variety of proof-based courses, and for each learning objective we offer supporting activities and assessments that involve generative AI.

ChatGPT as an Instructional Tool for Proof Validation
10:20 am - 10:35 am
Chloe Lewis, *University of Wisconsin-Eau Claire*

Although proof validation is a critical skill for undergraduate students seeking careers in professional mathematics or mathematics teaching, explicit instruction in this skill is not common in undergraduate mathematics classes, where tasks are often centered around the construction of proofs (Selden and Selden, 2003). In this talk, we describe the use of large language model generative AI, including ChatGPT, as a tool to incorporate validation tasks into introductory proof courses at the undergraduate level. We discuss the development of in-class group activities, project-based activities, and a collaborative research project with undergraduates utilizing ChatGPT as a vehicle for understanding student validation of proofs.

Confidence in AI in the Pursuit of Mathematical Knowledge
10:40 am - 10:55 am
Leslie Jones, *University of Tampa*

I will present a review of literature on the ability of current generative AI models to successfully answer mathematics questions posed in typical undergraduate mathematics classes. I will share the results of a questionnaire and project from a business calculus class on student confidence in ChatGPT to answer questions on topics they have studied throughout the course of the semester, and how the actual ChatGPT answers compared to their confidence. I will also discuss the role of prompting and user knowledge in interacting with generative AI models.

Engaging All Students in Meaningful Mathematics and Accessibility by Design
Saturday, August 10, 8:00 am - 10:15 am

Mathematics faculty have long recognized the need to engage students using a variety of approaches. Fostering student engagement is a prevalent theme addressed in the MAA

Instructional Guide, which advances nine engagement approaches such as responding to student contributions in the classroom. In recent years, new ways to engage students in learning have been explored such as writing-to-learn activities, digital educational resources, technology for accessibility, and culturally responsive pedagogies. Furthermore, effective inclusive practices that engage students with and without disabilities are needed to retain students and bring needed diversity to collegiate mathematics.

We invite presentation proposals of scholarly work on engaging students in learning mathematics by making mathematics accessible and meaningful to them. Proposals may focus on curricular materials, single class descriptions, whole course designs, or other ideas. Proposals will be selected that demonstrate innovation, documented evidence of effectiveness, and potential for transferability. We especially invite proposals that focus on introductory courses where student impressions about college mathematics are formed; best practices for ensuring students with disabilities have access to the mathematical content; and/or proposals that could offer specific assistance to faculty interested in fostering student access and engagement.

Organizers:
Aaron Trocki, *Elon University*
Brittany Riggs, *Elon University*
Emily Elrod, *Elon University*
Laura Watkins, *MAA Subcommittee on Curriculum Renewal Across the First Two Years (CRAFTY), Committee on Professional Development, American Mathematical Association of Two-Year Colleges (AMATYC)*
Kathryn Kozak, *MAA Subcommittee on Curriculum Renewal Across the First Two Years (CRAFTY), American Mathematical Association of Two-Year Colleges (AMATYC)*

Sponsors:
MAA Subcommittee on Curriculum Renewal Across the First Two Years (CRAFTY)
MAA Committee on Professional Development
American Mathematical Association of Two-Year Colleges (AMATYC)

Making Early College-Level Mathematics Relevant to Students' Interests
8:00 am - 8:15 am
Aaron Trocki, *Elon University*
Brittany Riggs, *Elon University*
Emily Elrod, *Elon University*

In this session, we share research on the effectiveness of revisions to an early college-level math course, Applied Calculus, also called Business Calculus. Our team of instructors revised problem sets to include modeling problems, which we based on data sets relevant to students' reported interests. Students from eight course sections responded to surveys to provide their perceptions of the revised curriculum. Examples of revised math problems and survey findings will be shared. Session participants will gain strategies to make their mathematics curriculum more relevant to the lives and interests of their students.

Project-Based Learning to Enhance Student Critical Thinking
8:20 am – 8:35 am
Hwayeon Ryu, *Elon University*

To meet the growing need of in-depth quantitative skills for STEM students while promoting engaged learning, I conduct a SoTL project on assessing the effectiveness of Project-Based Learning to enhance student critical thinking skills in 4000-level Numerical Analysis by implementing several projects with real-world problems and corresponding writing assignments. The proposed project is designed to improve student's ability to expand their knowledge across disciplines and beyond the classroom while fostering students' critical thinking skills, which all support to deepen students' engagement in the arts and sciences with challenges facing our world.

Voice Recognition and Mathematics. Reclaiming a Lost Technology.
8:40 am - 8:55 am
Jodin Morey, *University of Minnesota*

"Students with disabilities, who need voice recognition as an accommodation to do mathematics, are largely out of luck at the moment. I was fortunate that this technology's zenith occurred during the years I was pursuing my degrees in mathematics. The system I use requires three pieces of software: Dragon Dictate, Scientific Notebook, and MathTalk. Dragon recognizes the user's words, MathTalk interprets those words as math symbols, and then enters those symbols into Scientific Notebook (think Microsoft Word, but for math).

Unfortunately, the companies which make Scientific Notebook and MathTalk recently went out of business. No alternatives currently exist. However, I have been developing Dragon Dictate scripts for use in an application called Lyx. Lyx is a free, open source, WYSIWYG, math typesetting program. I'm hoping Lyx will replace Scientific Notebook. During this talk, I will demonstrate both the previous technology, and an early version of the eventual replacement."

Engaging Non-STEM Students through Quantitative Justice
9:00 am - 9:15 am
Mark Branson, *Stevenson University*
Sean Leavy, *Stevenson University*

First-year non-STEM majors courses are frequently a challenging environment when it comes to fostering student engagement. Math For the People is a freely available online textbook (https://web.stevenson.edu/mbranson/m4tp/) which provides ingress to mathematical topics through social justice issues that students already care about, like environmental racism, predatory lending, and racially-biased policing. We will present the results of a semester long pilot of this course, highlighting feedback from students on their experiences & engagement, and discuss strategies for including this material in your classroom.

A General Framework for Incorporating Ethical Reasoning into Mathematical Modeling
9:20 am – 9:35 am
Erin Griesenauer, *Eckerd College*
Feryal Alayont, *Grand Valley State University*
Korana Burke, *University of California Davis*
Jeremy Shaw, *Oregon State University-Cascades*
Rohit Thomas, *University of California Davis*

Ethical reasoning is an essential component of applying mathematical modeling in solving real-life problems, both in research and business settings. Our mathematical models exist in the context of a larger system and have implications on the lives of others, the planet, and future generations. However, instruction often treats mathematical work as if it exists in a vacuum devoid of context and omits careful consideration of affected parties, validity of data, assumptions, and limitations of the analysis. In this talk, we present a general framework that can be used to modify any mathematical modeling problem in a way that helps students to fill in the missing ethical reasoning components in the problem/project. Incorporating ethical reasoning into modeling gives students a fuller picture of how mathematics relates to the real world and their lives, giving students a more authentic view of how mathematical models are used and making math more accessible to a wider variety of students.

Unveiling Student Potential: Harnessing Classroom Knowledge through student-led Project-Based Learning
9:40 am - 9:55 am
Md Sazib Hasan, *Utah Tech University*

The aim of this presentation is to underscore the importance of student-led projects stemming from their exposure to class material. These projects serve as markers of their creativity, originality, and the depth of their cognitive engagement. Implemented across various courses, this pedagogical strategy nurtures students' innate creativity over the semester. The discussion will delve into the advantages, obstacles, and underlying rationale of this approach, illuminating its impact on students' authentic learning experiences. Furthermore, the presentation will spotlight select student projects, highlighting the value of fostering collaborative dynamics within the classroom.

The Forgotten Mathematician
10:00 am - 10:15 am
Alexander McCurdy, *Eastern Washington University*

How many discoveries by mathematicians of color throughout history have been credited to white, European mathematicians? How big is the problem? In this talk, we will discuss the role of mathematicians of color in the development of mathematics. We will explore the contributions of four major countries: China, Arabia, India, and Japan. Our goal for this talk and future book is to show students of color that people like them can do mathematics and that they too have heroes to look up to in the math community.

Equity Minded Practices in Placement and Entry-level Courses
Thursday, August 8, 8:00 am - 10:15 am

Placement and entry-level courses are the first touchpoints a mathematics department has with its incoming students. To set up students for success, careful and innovative design is needed, including not only attention to mathematical content but also to equity, so all students are included and have the resources they need for success. This session focuses on initiatives, projects, and activities by the instructors, departments, and institutions which address either placement and advising for incoming students, including transfer students, or student success in entry-level courses.

We are particularly interested in innovative placement processes and programs that support the transition of developmental mathematics students to college-credit bearing courses. We also invite researchers who have contributed to improving the forward and upward movement of so-called "underprepared" students via equity-minded strategies at the classroom-, department-, college- and institutional-level. For placement, possible topics include integrating equity and accessibility in placement, assessing placement effectiveness, placing & supporting non-traditional students, and allowing students to improve their placement. Original research, expositions, innovative ideas, and projects are welcome.

Organizers:
Allan Donsig, *University of Nebraska-Lincoln*
Luke Tunstall, *Trinity University*
Junalyn Navarra-Madsen, *Texas Woman's University*

Our Students Are Changing: Are We?
8:00 am - 8:15 am
Samuel Tunstall, *Trinity University*

Over the last five years, I have organized math placement support programs for incoming students at my institution. Each year, I have fine-tuned the programming to try to increase student access to the support and improve students' transition from the programming to their first math course. While the programming is effective for many participants, not all eligible students participate, and as a result, not all students are able to start out in a three credit-hour math course. A next step is to either create a new course (below our current lowest course offering), or to provide just-in-time support for these students within our current offerings. In my view, both of these options are not long-term solutions if we want our curriculum to live up to the ideals of equity and inclusion. In this presentation, I share how our placement support has evolved in the last five years, provide data on its efficacy, and discuss concerns about equity and inclusion as we consider next steps.

Using Equitable Grading to Enhance Learning and Student Retention
8:20 am - 8:35 am
Benedict Nmah, *Morehouse College*

Whether screening applications for employment, assessing the skills and knowledge of academic scholarship applicants, or assessing the knowledge and skills of students in the classroom, grading continues to play a pivotal role. When it comes to the classroom, the goal of the concept of equitable grading is to give students, especially struggling students, the hope, and a fighting chance to learn and succeed in the classroom. In this talk we will share our preliminary data on the impact of equitable grading on the percentage of passing grades and the overall student retention.

Creating and Evaluating a Directed-Self Placement Instrument
8:40 am - 8:55 am
Emily Gismervig, *University of Washington Bothell*
Rejoice Akapme, *University of Washington Bothell*
Nicole Hoover, *University of Washington Bothell*

Jennifer McLoud-Mann, *University of Washington Bothell*
Alexandria Musselman, *University of Washington Bothell*

"In 2020, UW Bothell designed and implemented a directed self-placement (DSP) process to address data demonstrating that our placement test was inequitable and ineffective. Our DSP instrument empowers and supports students to choose a course that best fits their mathematical background and academic goals by guiding them through reflection. Students examine how their current content knowledge aligns with the content covered and the prerequisite knowledge and skills needed for each introductory mathematics course at UWB.

In this talk, we will discuss the evolution of our DSP instrument and summarize a report on the efficacy of our current DSP process. In particular, we will describe how course enrollment has shifted to higher-level courses with the implementation of DSP, summarize student survey results on the efficacy of DSP, and share DFW rates in Calculus I both before and with the implementation of DSP."

Corequisite Support in Quantitative Reasoning and College Algebra
9:00 am - 9:15 am
Wesley Hough, *University of Wisconsin - Whitewater*
Rachel Chaphalkar, *University of Wisconsin – Whitewater*

Co-requisite math courses have increased in prevalence in recent years to reduce remedial coursework and to help students succeed in early mathematics courses. At the University of Wisconsin – Whitewater, we have been implementing co-requisite courses for almost 10 years, starting small with a single section of a single course. Since Fall 2021, we have been offering co-requisite courses for nearly 40% of incoming students, paired with our Quantitative Reasoning and College Algebra courses, which serve 1500 and 300 students per year, respectively. In this talk, we'll share details about our co-requisite courses and implementation structure, as well as what we have learned from instructors, students, and assessment. We will also share modifications we have made and the impact on the equity gap.

Implementing Alternative Grading Practices: A Department Case Study
9:20 am - 9:35 am
Lynda Wynn, *California State University, Stanislaus*
Jessica De Silva, *California State University, Stanislaus*

"Our NSF IUSE-HSI grant theme of "Small changes. Big rewards.", gave us the opportunity to explore the alternative grading practices in use in the department of mathematics, identifying commonalities and differences, and comparing historical records to current records to document the effectiveness of this movement from traditional to alternative grading practices. Additionally, we explored the modifications faculty have made over the course of implementation to help develop guidance for those who wish to implement alternative grading methods.

In this case study, we answer the following research questions: (1) What impact, if any, has the implementation of alternative grading practices had on DFW rates, persistence, achievement gaps, and equity gaps?, (2) What commonalities and differences exist amongst the alternative grading methods implemented in our mathematics department?, and (3) What best practices for implementing alternative grading methods can be learned from our faculty?"

Addressing Equity and Identity in a General Education Mathematics Course
9:40 am - 9:55 am

Michelle Homp, *University of Nebraska - Lincoln*
Theresa Jorgensen, *University of Texas at Arlington*

Recent curricular changes focused on decreasing equity gaps and STEM identity have been implemented into UNL's general mathematics course (Contemporary Mathematics). These include integrating the work of mathematicians from underrepresented minorities throughout the course in natural and meaningful ways. Data collection regarding course components is ongoing. Several strategies will be discussed along with feedback from students. The impact on achievement and mathematical identity will be shared based on findings from the data.

Deepening Corequisites Across Texas Project: Working Across the State for Continuous Improvement
10:00 am - 10:15 am
Tammi Perez-Rice, *Charles A. Dana Center- University of Texas-Austin*

Corequisite models in education aim to accelerate student success by allowing students to enroll in credit-bearing courses while simultaneously receiving additional academic support. This talk introduces the Dana Center's "Deepening Corequisites Across Texas Project". The Center recently received a grant to build capacity among at least thirteen postsecondary institutions with the purpose of aligning corequisite course implementation with evidence-based best practices. The Center will support the institutions in evaluating and modifying their corequisite models, analyzing placement trends, and fostering improved outcomes in entry-level mathematics courses for a more diverse student population.

Posters

MAA Contributed Poster Sessions
Part I: *Thursday, August 8, 2:00 pm - 3:15 pm*
Part II: *Friday, August 9, 1:00 pm - 2:15 pm*

Given previous years' success with the MAA Contributed Poster Session (CPS), the MAA is pleased to continue with this session at MathFest 2024 in Indianapolis. The MAA will provide corkboards for the posters – you just need to bring your poster.

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

Organizers:
Kimberly Roth, *Juniata College*
Steve Butler, *Iowa State University*
Eric Ruggieri, *College of the Holy Cross*

Part I: *Thursday, August 8, 2:00 pm - 3:15 pm*

Some Results on $\tau(_n)$ -graphs
Reyes M Ortiz-Albino, *University of Puerto Rico-Mayaguez*
The notion of a τ-factorization or τ-products in the general theory of (nonatomic) factorization was defined by Anderson and Frazier, in 2006. We are interested when τ is the equivalence relation modulo n over the integers, usually denoted by $\tau_{(n)}$. This type of factorizations were further studied by Hamon(2007), Ortiz (2008), Florescu(2011), and several Ortiz's students(2010-present). We study whether the least copatmmon $\tau_{(n)}$-product of two nonzero nonunit exist.
In 2007, Coykendall, based on the idea of a zero-divisor graph, he defined the notion of a irreducible divisor graph of a nonzero nonunit element. We modify such definition a little bit to apply such graph to the notion of τ-factorization, show examples and some results.

Extended Springer Fibers Big Picture
Amber Russell, *Butler University*
William Graham, *University of Georgia*
Martha Precup, *Washington University in St. Louis*
The Springer correspondence is an important topic within the field of representation theory that has inspired a wealth of research with connections in a wide variety of fields over the past 60 years. The result itself lies at the intersection of Lie theory, group representation theory, algebraic geometry, and combinatorics. In the past decade, I and my collaborators William Graham and Martha Precup have worked to better understand how a related variety defined by Graham fits into the picture of the Springer correspondence and its generalized version. In already-published work, we have shown that study of this variety gives us a new perspective on the generalized Springer correspondence in the Type A Lie algebra setting. In this poster, I will summarize these results, and also present our newest findings where we consider connections in Lie algebras beyond Type A.

Introducing Symmetric Special Linear Group
Marcus Shell, *Jacksonville State University*
Jaedeok Kim, *Jacksonville State University*
A new group is formed on the set $SSL_2(\mathbb{Z})=\{UU^T\,|\, U \in SL_2(\mathbb{Z})\}$, where $SL_2(\mathbb{Z})=\left\{ \begin{bmatrix}
a & b \\
c & d
\end{bmatrix} \, \Big| \, a,b,c,d \in \mathbb{Z} \text{ and } ad-bc=1 \right\}$. We use the binary operation $\ast$ on $SSL_2(\mathbb{Z})$ defined as follows: For $A=UU^T$ and $B=VV^T$, $$A \ast B = UVV^TU^T.$$
Many interesting number theoretic properties of integers of the form m^2+n^2, where $\gcd(m,n)=1$, can be determined by expressing these symmetric matrices in terms of two generating matrices RL and LR where $R=\begin{bmatrix}
1 & 1 \\
0 & 1
\end{bmatrix}$ and $L=\begin{bmatrix}
1 & 0 \\
1 & 1
\end{bmatrix}$.
In this project, we study the relationship between the special linear group $SL_2(\mathbb{Z})$ and the symmetric special linear group $SSL_2(\mathbb{Z})$ by constructing homomorphism between the two groups.

Preliminary Results on the Asymptotic Expansion of all Derivatives of a Solution of the Strongly Damped Wave Equation
Joe Barrera, *Converse University*
The Fourier transform turns the Cauchy problem for a strongly damped wave equation into an ordinary differential equation in time. We let u(t,x) be the solution given by the Fourier transform. With suitable initial data u(0,x) and u_t(0,x) it was shown by Barrera–Volkmer (2019, 2021) that it is possible to obtain the asymptotic expansion of the L^2-norm of u(t,x) as t→∞. We now treat the general case of finding the expansion of the L^2-norm of any time- or space-derivative of the solution: $\partial^n\partial^\beta u(t,x)$, where ∂^n and ∂^β are the time- and β space-derivatives, respectively. To obtain preliminary results we make the simplifying assumption that the initial condition u(0,x)≡0. If both n and β are of order zero, then we arrive at the previously studied u(t,x). We thus further assume that not both n and β are of order zero. It can then be shown that in all space dimensions $\partial^n\partial^\beta u(t,x)$ exhibits polynomial-order decay, unlike the N=1 and N=2 cases of the bare solution u(t,x).

On the Distribution of Roots of a Transcendental Equation in the Complex Plane
Israel Ncube, *Alabama A & M University*
We consider a certain class of transcendental equations characterised by kernels of unbounded time delays. Our approach seeks to exploit inherent statistical properties of the delay kernels to establish some fairly sharp criteria for the location of roots, which may be complex, in an appropriate parameter plane.

An Analysis of COVID-19 Social Vulnerability and Racial Disparity in the Mid-South Using Model Prediction and Machine Learning
Harrison Shao, Mississippi School for Mathematics and Science
Increasing research shows that COVID-19 has disproportionately impacted racial minorities and people with low socioeconomic status (SES). By using statistical methods and machine learning data analysis, my study predicted how the interactions between community-level social vulnerability and individual-level factors affected COVID-19 infection, hospitalization, and mortality in the Mid-South. Risk-adjusted

multivariate logistic regression models were used to assess the associations between risk factors and COVID-19 outcomes. Bootstrapping machine learning methods were used to improve model predictions. My findings showed that people living in communities with vulnerable household composition and a high percentage of minority residents were more likely to get infected. Overall, my findings showed the racial disparity and community-level social determinants and the interactive relationships between community-level social vulnerability and race affecting COVID-19 infection.

Reducing Gibbs Phenomenon with a Modified Fourier Series
Catherine Crawford, *Elmhurst University*
Jon Johnson, *Elmhurst University*
We modify the classical Fourier series by introducing a weight function in the inner product used to define orthogonality. Using the Gram-Schmidt method, we obtain a new orthogonal basis, which is then used to find a modified Fourier series representation of a function. For a function with a finite jump discontinuity, we show that the choice of the weight function can greatly reduce the size of the observed Gibbs phenomenon.

Modeling the Devastation of Hemlock Trees in the Great Smoky Mountains
Jillian Stupiansky, *John Carroll University*
Jessica Stovall, *University of North Alabama*
Recently there has been a great decline in the health and number of Eastern hemlock trees found in the Great Smoky Mountains National Park. This is due to the presence of the Hemlock Woolly Adelgid, an insect which prevents the spread of nutrients through a tree by feeding on the tree's sap. In conjunction with a GSM park biologist, we have created a model that represents the spread of the devastation, and analyzed it both theoretically and with simulations. The ultimate goal is for the analysis of this model to be used to help find a solution that will revive the hemlock population.

Functionless Analysis to Estimate Reliability from Accelerated Life-Test Data
Genghmun Eng, Retired Scientist
High-Temperature Life Tests (HTLT) measure $\mathscr{R}$(T/test\) device failure rates at T/test\[°K] to set $\mathscr{R}$(T/use\) at lower T/use\[°K]. Let E/m\(T;t) be data vs time (t) and temperature (T) for m={1,N}. Often E/m\(T;t) starts off gradually then drops off, as a device failure. Arrhenius plots using 3 T/test\:

$$\mathscr{R}(T/use\) \approx \mathscr{R}(T/test\)\ \exp\{-Uo[1/(kT/use\)-1/(kT/test\)]\}\ ,$$

can determine the Activation Energy Uo. At 200°C=473.15°K, a [1/$\mathscr{R}$(T/test\)]=1hr failure time with Uo=1eV gives [1/$\mathscr{R}$(T/use\)]≈100years at T/use\=30°C=86°F. Cooling devices to T/use\ for measurement gives E/m\(T/test\; t/n\) data only at pre-selected times $\{t_1,t_2,..t_5,...\}$. Large device-to-device variability Ψ/m\(T) requires large HTLT with large m={1,N}. How do you analyze this data if the average device ⟨E/m\(T;t)⟩ performance is unknown? What if Ψ/m\(T) variability is also unknown? Our new Functionless Analysis shows how to find Uo here, while providing ⟨E/m\(T;t)⟩ and Ψ/m\(T) estimates.

Cellular Automata based Graph Partitioning Algorithm for Districting Problems
Vamanie Perumal, *Indian Institute of Technology Madras*
Districting problems involve merging smaller sub-regions of a specific geographic region to create larger, non-overlapping partitions. Examples include partitioning for healthcare systems, delivery solutions, urban planning, marketing experiments, and political campaigns. These are typically modelled using multi-objective optimization and graph partitioning. The set of all likely partitions for a big graph is astronomical, making it crucial to assess them effectively. This work proposes a Cellular Automata (CA)-based partitioning algorithm for large scale districting problems. The dimension of CA grid is set by the number of partitions and geographic regions. Potential partitioning configurations are created during CA's evolution. The objective functions are evaluated for each of the configurations until optimal results are

found. CA approach is beneficial due to its fast running time and parallelization capabilities, while also facilitating progressive and streaming partitioning.

A Novel Entropy Based Heuristic Algorithm For Solving The Maximum Matching Problem In K-partite Hypergraphs
Arjun Agarwal, *Jesuit High School*
This research proposes a fast, efficient, and innovative algorithm to solve the maximum matching problem in k-partite hypergraphs using entropy-based heuristics. Matching in k-partite hypergraphs is a class of NP-complete partitioning problems in graph theory. Worst case performance of a factor of k from optimum is an existing gap of traditional heuristic algorithms, as they do not use any information about the state of the graph. The two entropy-based algorithms developed iteratively build the solution by optimizing the state of the graph at each step. The hypergraphs were transformed into a regular graph and an optimum solution was generated by iteratively moving to a least constrained state based on vertex degrees. These algorithms performed 30% better than traditional heuristics with a time complexity that is polynomial in the number of edges of the hypergraph. A novel connection density metric was developed to characterize properties of graphs and predict expected performance.

Irreducible $L(2,1)$-Labelings for the Torus Graphs $C_5 \Box C_n$
Karrolyne Fogel, *California Lutheran University*
John Villalpando, *California Lutheran University*
An $L(2,1)$-labeling of a graph is a labeling of the vertices using non-negative integers such that distance two vertices differ in label and adjacent vertices differ in label by at least two. An $L(2,1)$-labeling of a graph is irreducible if reducing the label on any vertex violates an $L(2,1)$-labeling condition. The invariant icaps is the minimum number of distinct labels required to create an irreducible $L(2, 1)$-labeling on a given graph. For the family of torus graphs $C_5\Box C_n$, we determine icaps for each value of n except 13.

CANCELLED ~~A Formula for the Transient of a Family of Boolean Monomial Dynamical Systems~~
~~Arnaldo Vera, *University of Puerto Rico at Mayagüez*~~
~~Omar Colón, *University of Puerto Rico at Mayagüez*~~
An open problem in the theory of discrete dynamical systems is linking the structure of a system with its dynamics. For fixed point systems we are interested to know how long it takes the systems to stabilize. This work contains an answer for a certain family of systems who dependency graph is the wedge of cycles of prime length. Specifically, we stablish the transient of a monomial dynamical system over $\mathbb{Z}_2$ whose dependency graph is the wedge of a 2-cycle, p-cycle and q-cycle where p and q are co-prime.

Hyperfunctions: The Role of Generalized Function Theory in Math and Physics
Connor McCranie, *University of Colorado at Boulder*
When looking for solutions to equations, it can turn out (somewhat annoyingly) that the object which satisfies the given equation doesn't belong to the space in which you are working. For example, a differential equation may admit "weak solutions" which fail to be differentiable, e.g. a step function. The theory of hyperfunctions provides a framework to represent these solutions in a larger space, where one can rigorously define what it means to take the derivative of a step function. Hyperfunctions are constructed via Cauchy's Integral Formula from complex analysis, and they are particularly good at solving PDE's, even when singularities are present. For this reason, hyperfunctions are useful in applications to quantum physics.

Topology and Art
Catherine Gorini, *Maharishi International University*

It is well known that artists use mathematics in their work, especially symmetry and perspective. But what about topology? Besides the famous melting clocks, Salvador Dalí creates elephants with elongated legs and other topological contortions. M.C. Escher depicts Möbius bands and topological metamorphoses. This poster will show innovative ways that artists including Dalí, Escher, Picasso, El Greco, Modigliani, and Botero use topological transformations for various effects.

Compact Bicomplex Linear Transformations
William Johnston, *Butler University*
Rebecca Wahl, *Butler University*
This poster shows how the linear algebra theory for bicomplex linear transformations on finite dimensional bicomplex vector spaces extends to compact bicomplex linear transformations on infinite dimensional bicomplex Hilbert and Banach vector spaces. The generalization mimics that for compact complex linear transformations.

Outer Product Decompositions, Generalized Identities, and Generalized Inverses
Rodney Lynch, *Indiana University Columbus*
A product of a column matrix and a row matrix is an example of an outer product. Starting with a 3 x 3 matrix A with distinct eigenvalues that has determinant 0, I will show how to obtain a multiplicative identity that has determinant 0 and a multiplicative inverse that has determinant 0. The matrix A can be written as a sum of outer products where the coefficients are eigenvalues, but A is not assumed to be symmetric (so this is not a spectral decompositon). Progress on non-diagonalizable matrices A will be presented.

Modeling the Transport of Notch Signals along Cytonemes during the Development of Bristle Cell Patterns in Fruit Flies
Emmanuel Asante-Asamani, *Clarkson University*
Wilson Komla, *Clarkson University*
Ginger Hunter, *Clarkson University*
Self-organized patterns are important for epithelia that sense the environment. Such patterns form as a result of coordinated signaling between distant and neighboring cells within a developing tissue. One such signaling mechanism is Notch-Delta signaling, which regulates the organization of bristle cells on the thorax of fruit flies. Over long distances, signaling filopodia (cytonemes) are known to regulate Notch signaling, yet little is understood about how Notch is activated and transported along cytonemes. In this work, we present a system of partial differential equations for investigating the significance of two primary mechanism: active transport and diffusion, in distributing activated Notch signals along cytonemes. When compared with experimental data, our model permits an analysis of the relative contribution of these transport mechanisms during bristle patterning.

Interaction of Solitary Waves in Nonlinear Optical Systems Using a Fourth Order Generalized Lugiato-Lefever Equation
Sabrina Hetzel, *Southern Methodist University*
Solitons are self-reinforcing localized wave packets that have remarkable stability features that arise from the balanced competition of nonlinear and dispersive effects in the medium. Traditionally, the dominant order of dispersion has been the lowest (second), however in recent years, experimental and theoretical research has shown that high, even order dispersion may lead to novel applications. My research focuses on investigating the interplay of dominant quartic (fourth-order) dispersion and the self-phase modulation due to the nonlinear Kerr effect in laser systems. Using numerical simulations, I investigate the interaction of solitary waves under dominant quartic dispersion and how the dynamics can differ from the conventional case of dominant quadratic dispersion.

Continued Fractions and Patterns in World Calendars
Frederic Latour, *Central Connecticut State University*
Throughout history, humankind has developed a large number of different calendars, most of which fall in one of three categories: solar, lunisolar, and lunar. Despite the cultural differences, solar and lunisolar calendars throughout the world often involve the number 19 somewhere in their calculations. For example, the number appears in the calculation of which years are leap years in the Hebrew calendar, in the calculation of the date of the Western and Eastern dates of Easter, and can be found in the cycle of dates of the Chinese New Year. The purpose of this poster is to give a mathematical explanation for the appearance of that number, using continued fractions.

Generalized Fibonacci Sequences via Dirichlet Convolution of Arithmetic Functions
Emil Daniel Schwab, *The University of Texas at El Paso*
Gabriela Schwab, *El Paso Community College*
The goal of the talk is to point out a different and an effective strategy of approaching Fibonacci numbers using the Dirichlet convolution of multiplicative arithmetic functions. Completely and specially multiplicative functions, are used to highlight the benefit offered by the theory of multiplicative arithmetic functions and play an essential role in the development of basic properties of sequences defined by a linear two-term recurrence relation. Specially multiplicative prime-independent arithmetic functions and the generalized Fibonacci sequences are two equivalent mathematical objects in the sense that each can be reconstructed from the other. Concepts as Dirichlet convolution, Busche-Ramanujan identities, Fibonacci-Möbius function are used to investigate generalized Fibonacci numbers. For example, many identities with Fibonacci Numbers are obtained as immediate consequences of Busch-Ramanujan's identity.

The Milk and Monge Shuffles and Three Self-working Card Tricks
Stanley Huddy, *Fairleigh Dickinson University*
Well-known shuffles, such as the riffle shuffle and the standard overhand shuffle, are meant to randomize the order of the cards, making it difficult to predict the appearance of specific cards in games like poker or blackjack. However, shuffles have a different purpose in self-working card tricks: they reorder the cards so that the position of the target card (the card revealed at the end of the trick) is known to the magician, but not to the observer. In this work, we generalize three self-working card tricks that are based on the milk and Monge shuffles and have appeared on social media. Stop by our poster to learn some card tricks!

Spreading the Word about Teaching with Primary Historical Sources: The TRIUMPHS Society and its \textit{Annals}
Michael Saclolo, *St. Edward's University*
TRIUMPHS stands for TRansforming Instruction: Understanding Mathematics via Primary Historical Sources. The TRIUMPHS Society was formed in 2022 by individuals united in their collective vast experience in the use of primary historical sources in teaching mathematics and their credence in its effectiveness. Building on the legacy of three NSF grants, which supported the development and classroom testing of Primary Source Projects (PSPs), the Society seeks to bring together present and future practitioners of the use of primary historical sources in teaching mathematics, advance the development and use of classroom resources based on such sources, and publicize related scholarship. The \textit{Annals of the TRIUMPHS Society}, launching in the fall of 2024, shall be the flagship open-access and peer-reviewed publication of the Society. The \textit{Annals} will publish new PSPs and scholarly articles related to the use of primary historical sources in teaching and learning mathematics.

Estimating Multiple Missing Observations in Factorial Experiments
Mohammad Shaha (Shaha) Patwary, *Butler University*

Aaron C Marshall, *Virginia Tech*
Kumer P Das, *University of Louisiana at Lafayette*
This study introduces a new methodology for estimating multiple missing observations in scenarios where data is missing at random, comparing it with existing methods such as Mice, Amelia, MissForest, and Hmisc. Through simulation studies across three scenarios, the new method consistently outperforms the others by yielding smaller L2-norms, demonstrating its effectiveness and accuracy in estimating missing data. This research provides a significant contribution by offering a superior alternative for handling missing observations.

Understanding Why Mathematics Teachers Leave Teaching: A Qualitative Multi-case Study
Brocha Siff, *Towson University*
Liyan Song, *Towson University*
Vacancies among teachers in secondary mathematics are pervasive. There is a need to better understand why mathematics teachers leave teaching before they are eligible for retirement. This multi-case study delved into ten mathematics teachers' experiences that resulted in their decision to leave teaching. Issues with school-based support, pressures from testing, changes in curricula, and misaligned values emerged as influencing factors for the participants' decision to leave the teaching profession. Participants shared issues connected to Maslach's burnout symptoms such as emotional exhaustion, depersonalization, and diminished feeling of personal accomplishment. Additionally, Maslach and Leiter's (1997) burnout causes including workload, lack of control, imbalanced reward, community issues, and misaligned values were reported during the interviews with the participants. Suggestions are made to help retain mathematics teachers in the classroom.

Undergraduate Student Views of the Nature of Mathematics
Christopher Bonnesen, *Middle Tennessee State University*
Jeremy Strayer, *Middle Tennessee State University*
This poster presents results of a study investigating students' views of the nature of mathematics (NOM) using a survey developed and implemented by the authors. Participants included over 60 undergraduate students enrolled in various mathematics courses (Calculus I, Calculus III, Mathematics for elementary education, and Abstract Algebra) at a public 4-year university in the Southeastern United States. Participants completed a survey comprised of five demographic items and twelve NOM items intending to measure distinct dimensions of one's philosophy of mathematics—whether: (1) mathematics exists independently of humans, (2) nonphysical abstract mathematical objects exist, and (3) mathematics is more conceptual or procedural in nature. Cognitive interviews revealed promise for survey validity of dimensions (1) and (3) and difficulty validating dimension (2). Latent profile analysis techniques revealed three subgroups of participants: Conceptual Platonists, Centrists, and Humanists.

Part II: *Friday, August 9, 1:00 pm - 2:15 pm*

Subscore-Based Assessments in Calculus to Improve Understanding and Reduce Anxiety
Bevin Maultsby, *North Carolina State University*
This poster will present an innovative assessment strategy that focuses on demonstrated mastery through topic-specific subscores rather than overall test scores. This method involves standard mid-semester exams and a final, each comprising questions from designated topics such as Applications of Integration, Techniques of Integration, Sequences and Series, and Power Series. Students have multiple attempts to improve their subscores in these topics across the assessments, with only the highest scores retained. This approach not only reduces test anxiety by allowing multiple opportunities for improvement but also promotes a deeper understanding of material by encouraging students to focus remediation efforts on

weaker areas. This poster will discuss the pedagogical philosophy behind this grading method, its implementation, and the observed benefits on student outcomes and engagement.

Collaborative Grading in an Introduction to Proofs Course
Megan Patnott, *Regis University*
I've used a mix of standards-based and specifications grading in most of my classes for a few years. In my introduction to proofs course in Spring 2024, I removed the specifications for final letter grades from my syllabus. Instead, my students and I collaboratively determined their grades through self-assessment reflections and grading conferences. I'll describe how the course was structured and how collaborative grading went.

Portfolios for Program Assessment
Debbie Narang, *University of Alaska Anchorage*
Mark Fitch, *University of Alaska Anchorage*
By creating and updating a mathematics program ePortfolio consisting of example work and reflections on what they have learned, math majors increase their awareness of what they have learned and document their mastery of program learning objectives. We will describe how the portfolios are used for program assessment and lessons learned over ten years of experience with student portfolios.

Secondary Mathematics Teacher Candidates' Perceptions of a Statistics TACTivity Designed to Support Equitable Teaching Practices
Liza Bondurant, *Mississippi State University*
Cindy York, *Northern Illinois University*
Angie Hodge-Zickerman, *Northern Arizona University*
Eric Stade, *University of Colorado Boulder*
We present a statistics TACTivity involving creating a two-way table that models data on the number of people who are and are not infected with COVID-19 and the number of people who tested positive and negative. Secondary mathematics teacher candidates utilized relative frequencies to determine the true positive, true negative, false positive, and false negative rates. We use the Equity-centered Transformative Technology (EqT-tech) Lesson Analysis Tool to share how the TACTivity can support equitable teaching practices. Finally, we share secondary mathematics teacher candidates' perceptions of the TACTivity.

Lesson Planning in Secondary Rural Schools: Challenges and Opportunities
Andrea Carranza, *Northern Illinois University*
Landrut Vargas , *University of Atlántico*
Ricela Feliciano, *Northern Illinois University*
Kevin Palencia , *Northern Illinois University*
Recent research has expanded on culturally responsive teaching practices in mathematics education. However, the implementation of these practices in rural communities, particularly at the middle and high school levels, remains understudied. This study examines the integration of mathematics standards and students' lived experiences in lesson plans developed by nine teachers following professional development activities. Our findings indicate a tendency towards the use of similar standards, with a focus on lower-level standards rather than those aligned with the teachers' course level. Additionally, we observed a prevalence of mathematical problems related to food preparation or sales when attempting to connect mathematics to students' real-life experiences. The implications of this study highlight the need for targeted professional development initiatives focusing on the development of tools to support teachers in understanding diverse student contexts for effective lesson planning.

Supporting English Language Learners' Experiences in Middle and Secondary Mathematics Classrooms

Yardley Dominguez Lopez, *Towson University*
Ericka Castillo, *Towson University*
There are over 4 million English Language Learners (ELLs) enrolled in grades k-12 nationally and this number has been increasing recently. This poster presents research-informed strategies to assist ELLs in learning mathematics content and discusses how our own university has provided programmatic support to encourage pre-service teachers to earn certification in English as a second language on their teaching licenses. Additionally, we provide personal experiences undergoing this training and sharing it with our classmates in the Towson UTeach mathematics and science preparation program.

Insights from a Math Anxiety Interventions Workshop
Jeremy Edison, *Mount Mary University*
This poster will include some reflections and data regarding a workshop on Math Anxiety Interventions and Reframing Mathematical Mindsets that I have co-facilitated with Dr. Laurel End at Mount Mary University. The workshop is open to faculty from all disciplines and academic staff and focuses on how best to support students who experience math anxiety across campus. This poster will include information on the workshop, including some background material on math anxiety, as well as some conclusions and reflections on the effectiveness of the workshop.

Empowering Young Minds: Forsyth County's Blueprint for Mathematics Enrichment in Grades K-8
Brian Lack, *Forsyth County Schools, GA*
Join me as I unveil Forsyth County's innovative program for mathematics enrichment across grades K-8. Discover how our district implements a comprehensive approach, integrating math enrichment curriculum from Art of Problem Solving and Beast Academy, engaging family math nights using puzzles and activities from Julia Robinson Math Festivals, and fostering participation in prestigious math competitions like AMC 8/10, MATHCOUNTS, MOEMS, Math Kangaroo, MathLeague.org, and more. Learn how this systematic and coherent strategy equips students with essential mathematical skills and fosters a love for learning from an early age.

TACTivities Explored: Understanding Instructor and Student Perspectives in Mathematics Education
Cindy York, *Northern Illinois University*
Angie Hodge-Zickerman, *Northern Arizona University*
Eric Stade, *University of Colorado Boulder*
Liza Bondurant, *Mississippi State University*
TACTivities are learning activities that involve the manipulation of concrete or virtual objects. TACTivities are designed to promote collaboration and engagement. Common features include self-checking and very few (if any) directions. With permission, we adapted the Learning Object Evaluation Scale for Students and for Teachers along with the Classroom Engagement Inventory (CEI) survey to assess university instructors' and students' perceptions of TACTivities in terms of ease of use, engagement, and collaborative problem-solving during mathematics learning. Participating instructors (n=9) engaged pre-Calculus student participants (n=151) with two different TACTivities. Preliminary results suggest that students and instructors both found TACTivities useful for engagement and learning mathematics. We will discuss the implications for practice and future research.

The Influence of High School Math Teachers on Students' STEM Major Choices
Jinhua Zhao, *Texas A&M University*
The demand of additional STEM workers in the U.S. encourages colleges to enroll more STEM undergraduate disciplines yearly. However, there are gaps between high school STEM education and college major choices. This research applies ecological system theory (EST), uses data from the

Education Longitudinal Study (ELS:2002), and runs a logistics regression model to answer whether and how math teachers' perceptions and behaviors are associated with high school students' choices of STEM majors. The preliminary findings suggested a significant positive correlation between teachers' gender congruence with students and students' choice of STEM majors. Additionally, a more positive classroom climate as perceived by math teachers is related to a higher likelihood of high students to choose STEM majors in colleges. However, there is no significant relationship between the interaction of math teachers and parents, and students' choices.

Mentoring across the MAA's National Research Experiences for Undergraduates Program (NREUP)

Gulden Karakok, *University of Northern Colorado*
Sam Waters, *University of Northern Colorado*

The MAA's NREUP has been supporting undergraduate students and faculty in mathematical sciences to collaborate on summer research projects since its inception in 2003. The NREUP goals are to increase undergraduate completion rates and students' interest in obtaining advanced degrees and careers in mathematical sciences. Since 2003, the NREUP has supported about 100 faculty and 768 students, with approximately 50% of students self-reporting as Black/African American and about 35% as Latinx or Hispanic. In our external evaluation, students consistently reported gains in research experience and the value of formal and informal mentorships they received. They also reported gains in knowledge about career opportunities and graduate school programs, as well as gains within affective and emotional domains. We will share results focusing on different program structures, research activities, and mentorship approaches that could be beneficial for those planning to host a summer research program.

Kent State University's Mathematics Excellence for Girls in STEM

Aloysius Kasturiarachi, *Kent State University*
Dinah Qutob, *Kent State University*

The Kent State University's Mathematics Excellence for Girls in STEM program is a collaboration between Kent State University and high schools from a tri-county area in Ohio, designed to provide a year-long series of enrichment experiences for female high school students pursuing degrees in Mathematics and STEM. The main portion of the program is a week-long summer academy on applications of mathematics with a focus on enrichment activities in Mathematics, Biology, and Data Science. Following the summer workshop, in the fall semester, the participants will have the opportunity to virtually connect with peer girls in a high school in Brisbane, Australia, as they continue to develop their love for mathematics. In the spring semester, the cohort will network one-on-one with local women professionals in STEM. The students who complete the program and matriculate to Kent State University, will be awarded a Choose Ohio First (COF) scholarship in Mathematics or a qualified STEM field.

Mathematical Optimization in Culinary Practices: Reducing Food Waste and Costs through Surface Integration, Euclidian Geometry, Fluid Dynamics, and Dilution Calculus

BangTam Ngo, *LexObserver*

This outreach explores the application of math techniques to culinary practices. We employ surface integration to precisely measure the weight of ingredients, with the formula:
\text{Surface Integral} = \int \int_{S} f(x,y) \, dS
where f(x,y) represents the volume density of the ingredient. Fluid Dynamics is used to model cooking times through differential equations, using ingredient thickness and oven temperature:
\frac{dT}{dt} = k(T_{\text{oven}} - T_{\text{ingredient}})
We apply principles of Euclidean geometry to create appealing food presentations. Furthermore, dilution calculus is employed to analyze diffusion, represented by Fick's second law of diffusion:
\frac{\partial C}{\partial t} = D \nabla^2 C

where C is the concentration of flavor compounds. With this, we can grasp how acids, salts, and fats interact, contributing to the overall flavor profile. We present strategies that culinary enthusiasts can adopt to enhance sustainability in food prep and presentation.

Learning to Learn Mathematics
Kathleen Guy, *Florida International University*
Learning mathematics in higher education is so much more than learning content. It requires students to have metacognition skills, growth mindset, time management, emotion control, and more. It is common for students to struggle with the rigors of higher education both academically and psychologically. In this poster session I will discuss how I created a special workshop which is being facilitated as an educational intervention that helps students learn to learn mathematics by focusing on nonacademic skills and mathematics strategy skills specific to learning Business Calculus. I will showcase how the workshop is being facilitated and present examples of different activities. Furthermore, I will discuss the preliminary data analysis of the ongoing research study which is measuring its effectiveness and usefulness (from the student perspective) as an educational intervention.

A Regional University's Work to Increase Success in Calculus 1
Britney Hopkins, *University of Central Oklahoma*
Over the last decade, the Department of Mathematics and Statistics at the University of Central Oklahoma has instituted several initiatives aimed at increasing student success in Calculus 1. This poster will examine each of those initiatives with an emphasis on successes, set backs, and failures. We will detail where we currently are in the process as well as what plans we have moving forward.

Narrowing Achievement Gaps & Increasing Student Motivation
Jordan Kostiuk, *Brown Unversity*
Dana Hayward, *Brown University*
Sehee Oh, *Brown Unversity*
Nina Py Brozovich, *Brown Unversity*
Carmen Yu, *Brown University*
In order to address inequities in student outcomes and persistence in Math and STEM programs more broadly at our institution, we redesigned our introductory Linear Algebra course to incorporate two evidence-based practices: Team Based Inquiry Learning and Mastery Based Grading. In order to assess the impacts of these interventions, we collaborated with our institution's Center for Teaching Learning to collect and analyze student outcome data. This analysis includes student grade and student record data, as well as measurements of student internal motivation obtained by using a survey derived from self-determination theory. Our findings indicate that achievement gaps for underrepresented students narrowed and that all student groups experienced an increase in internal motivation. These motivational impacts were strongest for historically underrepresented students, women, and students with low confidence in their ability to succeed in the course.

Flipped Classroom and Guided Inquiry Strategies in Remote Teaching
Chris Oehrlein, *Oklahoma City Community College*
Student engagement and development of affective and process skills in both synchronous and asynchronous online math courses is a concern of professors, administrators, and accreditation agencies. Course flipping and process oriented guided inquiry learning are proven methods for addressing the need to develop students beyond just knowledge of the course content in traditional and hybrid classroom courses. Why not use them in the remote environment? One professor has been flipping and using guided inquiry in both synchronous and asynchronous online courses. He will report on missteps, the evolution of his process, and perceptions (his own, his students', his colleagues', and his administrators').

Teaching BIG Problems
Michelle Jeitler, *Marietta College*
The Preparation for Industry Careers in Mathematics (PIC Math) Program allows mathematics faculty to learn how to develop an applied mathematics course to show students the power of mathematics in solving business, industry, and government problems. Through this experience, relationships are formed with local organizations who are looking to solve a problem. The students are tasked with owning this problem and finding a solution using mathematics and quantitative thinking. Over the spring semester a group of five students from Marietta College participated in this course. They worked with, Community Food Initiatives, a local non-profit organization, to build a better bidding strategy at the local produce auction. This presentation will take you through the many challenges faced by students and the instructor. Support is provided by the National Science Foundation (NSF grant DMS-1722275).

Equal Play, Equal Pay! Engaging Students in Actuarial Justice
Kristin Kuter, *Saint Mary's College*
Laura Elder
A mathematical exploration of the gender pay gap in a Financial Math course. Following an introduction to calculations and explanations of the gender pay gap globally, students calculate total wages lost through the pay gap over the course of their working lives. They are then asked to develop and reflect upon individual and collective bargaining tactics. To engage students in gender pay equity more broadly, we feel that inequities are particularly visible within sports entertainment. The US Women's National Team and US Soccer Federation's long-term fight over "equal pay" is a dramatic case study in the ongoing fight for pay equity. We examine their class-action law suit as a case study in how culture and calculation come together to enable gendered wage discrimination. Our approach is a template to help encourage students to think critically about the intersection of accounting and accountability and as a means for building financial literacy and social justice across the curriculum.

Learning Expected Value through Board Games
Joshua Ruark, *Indiana Academy for Science, Mathematics, and Humanities*
Calculating Expected Value is a powerful tool in playing games where random chance with dice rolls is a mechanic of the game. Such a game is Settlers of Catan. Players generate resources based on the position of pieces in accordance with potential outcomes of dice rolls. Calculating the Expected Value of having your piece at a certain location dictates the desirability of occupying that space. The greater the Expected Value, the greater likelihood of generating resources, and the better chance of winning the game.
This poster describes a classroom activity where students simulate playing the games Settlers of Catan. Given a theorectical piece of the gameboard, student select locations for their pieces, then take a fixed number of ""turns"" recording how many resources were genrated by each player. Students then compare this to the expected number of resources earned over the ""turns"" simulated and analyze why there were any discrepancies, if any.

Quiver Representations: Explorations with Undergraduates
Dan Wackwitz, *University of Wisconsin – Platteville*
Quivers (or directed graphs), 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.

Spherical Geometry for Mathematics Majors
Marshall Whittlesey, *California State University San Marcos*
This presentation will illustrate some of the topics and features in an undergraduate course in spherical geometry designed for mathematics majors. We will illustrate some of the classical formulas relating the sides and angles of spherical triangles. Most of these are analogous to those in plane geometry - but others are not. Then we will illustrate how these formulas can be used to do important classical calculations in astronomy, featuring determination of the time of sunrise and sunset, and the time of the beginning and ending of twilight. Connected to this are the Gauss two-altitude and three-altitude problems, which concern determining the latitude and longitude position of an observer given the altitudes of known stars. These problems are featured in the presenter's book "Spherical Geometry and its Applications." The author feels that spherical geometry is, for some students, worth studying before learning hyperbolic geometry because its applications are so important.

Like Sunlight to a Plant - Utilizing DEIA in Mathematics to Help Students Grow and Flourish in Academia
Haseeb Kazi, *Trine University*
Areeba Kazi, *Trine University*
Do you love to give back to academia? How about giving something unique–a gift of accessibility, wrapped in affordability, and packed in accountability? Let's talk about making directed moves, going the extra mile, and empowering the ones who will shape our future - the students! Are all of them alike? No! Are all of them equally gifted? No! Are all of them equally privileged? No! However, are all of them equally important? Yes! We must learn how to appreciate, adopt, and incorporate diversity, equity, inclusion, and accessibility in going the extra mile for students and education as a whole…let's learn how to do it the right way, and let's talk about how to walk through an enriching present transitioning into a brighter future through the implementation of DEIA in academia!

Entrepreneurial Mindset in Teaching Mathematics
Wojciech Kossek, *University of Denver*
There is a growing movement in education, so far primarily in engineering education, which aims to promote Entrepreneurially Minded Learning (EML) environment in the classroom. In this talk, ideas of the Entrepreneurial Mindset will be presented. We will look at specific examples of mathematical concepts and ideas where this approach can be successfully applied.
The ideas of EML are promoted by the Kern Family Foundation, whose mission is to "empower the rising generation of Americans to build flourishing lives anchored in strong character, inspired by quality education, driven by an entrepreneurial mindset, and guided by the desire to create value for others.
Educators who wish to implement the ideas of EML in their classroom and curriculum development, can access a large collection of well-prepared material, at no cost. Some of this material applies directly to teaching mathematics and its applications.

Academic Performance and Class Meeting Frequency
Daniel Kern, *Florida Gulf Coast University*
Institutions of higher education have sometimes switched (or considered switching) between a combination of twice a week and thrice a week classes for undergraduates, and predominantly twice weekly classes with a few once a week classes. For faculty the latter can result in a better schedule for research, meetings, and service. Additionally, some students may prefer fewer travel days and greater flexibility for work schedules. A primary concern is that fewer class meetings could affect student performance negatively. This work examines mathematics classes at a medium-large state university to see if there are differences in course grades and passing rates between biweekly and triweekly sections of lower division courses.

Poster Session for Projects Supported by the NSF Division of Undergraduate Education
Thursday, August 8, 9:00 am - 10:30 am

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.

Organizers:
Jana Talley, *Jackson State University*
Erin Moss, *Millersville University*

Sponsors:
MAA Math Values
NSF DUE Point Blog

Enhancing First Calculus Course Success: Evaluating the Revised Calculus Concept Inventory with Modern Test Theory
Jaehoon Lee, *Texas Tech University*
Woonyoung Song, *Texas Tech University*
Minju Yi, *Texas Tech University*
Brock Williams, *Texas Tech University*
The Revised Calculus Concept Inventory (RCCI) project, funded by NSF (IUSE 1916751), is at the forefront of developing a rigorously validated concept inventory tailored for introductory calculus courses. Building on previous research and concept inventory efforts, the RCCI is meticulously crafted to meet contemporary educational needs while solidly validating its psychometric properties. A pivotal aspect of our endeavor is the RCCI's potential to foster the successful completion of introductory calculus for a broad spectrum of students, aligning with the broader impact goals of the project. In Years 4 and 5, our team has delved into an array of modern test theory analyses—confirmatory factor analysis, measurement equivalence, item response theory, and analysis of differential item functioning—to refine and validate the instrument's psychometric reliability and applicability. Our presentation will share our pivotal findings, inviting engagement from the academic community.

Undergraduate Service-Learning Experiences with Data: Mathematics in the Community
Michelle Friend, *University of Nebraska at Omaha*
Becky Brusky, *University of Nebraska at Omaha*
Betty Love, *University of Nebraska at Omaha*
Andrew Swift, *University of Nebraska at Omaha*
Mahbubul Majumder, *University of Nebraska at Omaha*
STAT 1100: Data Literacy and Visualization is designed to satisfy the University of Nebraska at Omaha general education quantitative literacy requirement. Students learn basic statistics, data organization and manipulation, appropriate visualization techniques, and industry-standard software. It is a service learning

course: students demonstrate mastery of data analysis and communication skills by working with a non-profit community partner, using data to answer questions such as program effectiveness and community impact. This novel course has the highest passing rate of any general education math course at our university and improves student attitudes about mathematics, along with ensuring students master critical 21st-century workforce skills.

Lift-off or let-down? Launching college teaching through early-career professional development
Sandra Laursen, *University Colorado Boulder*
Timothy J. Weston, University Colorado Boulder
Tim Archie, *University Colorado Boulder*
Sarah B. Wise, *University Colorado Boulder*
Nancy Emerson Kress, *University Colorado Boulder*
Teaching-focused professional development (TPD) is often targeted to early-career faculty, with the intent to support instructors who earned a STEM Ph.D. but had little opportunity to develop as teachers. New instructors' work efficiency and career satisfaction, and their effectiveness with students, may benefit if they learn early to apply research-based methods in their teaching. However, little research evidence backs this early-launch argument, or whether initial changes to teaching beliefs and practices persist. We will share selected findings from Project Launchpad, a study of early-career TPD in mathematics, that highlight differences in the career activities, career settings, and current teaching of program alumni in comparison with non-participants. Overall, the results suggest that early-career TPD can have lasting impacts on participants' careers and on their teaching practices, whether through direct teaching or through socialization into a teaching-engaged cohort.

Integrating Differential Equations in Undergraduate Teaching: Applications in Mechanics of Materials and Circuit Analysis
Priyankarage Pradeep Ranaweera, *Siena Heights University*
The integration of differential equations is vital in undergraduate mathematics, offering insight into diverse scientific phenomena. This abstract focuses on integrating them into teaching, particularly in Mechanics of Materials and Circuit Analysis. Differential equations are crucial in analyzing structures under pure bending in Mechanics of Materials, aiding in understanding stress, strain, and deformation distributions. In Circuit Analysis, they are essential for understanding electrical systems' dynamics, enabling effective design and optimization. The presentation explores instructional methods emphasizing practical applications and hands-on exercises, equipping students with problem-solving skills for real-world challenges in both fields.

Making STEM Matter: Transforming Learning through Teacher Leadership, Justice-Centered Pedagogy & Makerspace Technology
Mary Stapleton, *Towson University*
Diana Cheng, *Towson University*
This Robert Noyce Teacher Scholarship Program Track 3 project develops highly effective STEM teacher leaders to create sustainable improvements in secondary STEM education. We will address how we leveraged a 2019-2021 Noyce capacity building grant into a successful Track 3 proposal. We will also describe the Making STEM Matter professional learning community that brings together 15 Master Teacher Fellows (MTFs) in a large urban school district in Maryland. We will detail our plan to support MTFs' becoming teacher leaders and transforming their instruction by integrating equity- and justice-centered STEM pedagogies and leveraging makerspaces to introduce new opportunities for STEM learning. Our poster will include reflections from an MTF on how the professional learning community in the first semester of the Making STEM matter project addressed themes of Leadership, Social Justice/Equity and the use of Maker Spaces in STEM education.

Building and Sustaining a Change Community
Bob Sachs, *George Mason University*
Joanna Jauchen, *George Mason University*
Catherine Sausville, *George Mason University*
Karen Crossin, *George Mason University*
Timothee Bryan, *George Mason University*
Gabriela Bulancea, *George Mason University*
Ahsan Chowdhury, *George Mason University*
Samuel Fairchild, *George Mason University*
At George Mason, we have been working in a multigenerational (faculty, GTAs, UG LAs) and multidepartmental fashion, with a focus on the precalculus to calculus 2 sequence. We hope to chat with others about ways we have leveraged local and national resources and the departmental and university culture amidst unanticipated challenges.

Preparing to Teach Mathematics with Technology: Curricula for Secondary Math Teacher Preparation Programs
Purity Muthitu, *North Carolina State University*
Rachel Abel, *North Carolina State University*
Adrian Kuhlman, *North Carolina State University*
Hollylynne Lee, *North Carolina State University*
Since 2005, the Preparing to Teach Mathematics with Technology (PTMT) project has been funded by the National Science Foundation to develop research-based materials for mathematics teacher education focused on using technology tools for teaching major topics in middle and secondary mathematics in Algebra, Statistics, and Geometry. The materials include video cases of students and teachers interacting with technology tools such as Desmos, dynamic geometry tools, and CODAP. The materials are available for free and have been used to prepare over 8,000 teachers to use technology in their mathematics classrooms. The poster will highlight two of the newest sets of materials that focus on statistics investigations with CODAP and examining students' practices with exploring algebra and functions with Desmos and GeoGebra.

OPEN Math: Online Professional Enhancement and Capacity Building for Instructional Practices in Undergraduate Mathematics
Doug Ensley, *Mathematical Association of America*
Stan Yoshinobu, *University of Toronto*
Sandra Laursen, *University of Colorado - Boulder*
This collaborative project (DUE-2111260 & 2111273) serves the national interest by implementing, assessing, and understanding effective practices in delivering online, teaching-focused professional development to instructors of undergraduate mathematical sciences. Traditional face-to-face models limit impact by tacitly restricting participation, largely because those models require travel or other support that is neither universally available nor sustainable in the long term. To this end, MAA and CU-Boulder are implementing and studying 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. (IUSE)

Taking CalcPlot3D to the Next Dimension: Creating 3D Printed Learning Materials for Multivariable Calculus
Shelby Stanhope, *U.S. Air Force Academy*
Paul Seebuger, *Monroe Community College*
Deb Moore-Russo, *University of Oklahoma*

When students enter multivariable calculus, a unique transition occurs. Up to this point, students have spent their mathematical careers becoming experts in the two-dimensional xy-plane. Adding another dimension allows us to explore this 3D world we live in, but the transition to three-dimensional mathematical thinking does not come easily to many students. To better support students' spatial understanding of concepts in the course, we should incorporate computer visualization and tactile manipulatives. The free web applet CalcPlot3D can be used to provide insightful computer visualizations and to generate STL files for 3D printing. The program requires no coding syntax and is extremely accessible for students and instructors. Through this grant project, we have developed a series of classroom activities for multivariable calculus using 3D printed surfaces and have enhanced the 3D printing capabilities of the program. NSF-IUSE-2121152, 2121133, and 2120660

Enhancing Data Science and Statistics Teacher Education-Transforming and Building Community
Adrian Kuhlman, *North Carolina State University*
Rachel Abel, *North Carolina State University*
Rick Hudson, *University of Southern Indiana*
Hollylynne Lee , *North Carolina State University*
With growing efforts to include more data science and statistics (DS&S) in K-12, there is a need to transform undergraduate teacher education programs so future teachers are prepared to effectively teach DS&S. ESTEEM has three major goals: Investigate the current systems in undergraduate teacher preparation for teaching DS&S and use findings to drive improvement efforts; Build and sustain a networked improvement community; Reach a diverse teacher education audience through developing, curating and disseminating high-quality DS&S teacher education curriculum materials. The poster will highlight findings from our research about preparation to teach DS&S in teacher education programs and early career mathematics teachers; progress made in updating curricular materials and emphasizing equity and new features in CODAP; and the partnerships we have built in our networked improvement community to build momentum for meeting our transformative goals.

Cross-Disciplinary Collaboration to Build a Strong STEM Learning Community
Susan Pustejovsky, *Alverno College*
Our NSF supported S-STEM grant project, New Futures in Science and Mathematics, award #742597, is the centerpiece to Alverno College's Division of Natural Sciences, Mathematics, and Technology efforts to build a strong learning community among our students and faculty in the sciences and mathematics. Cross-disciplinary collaborations among faculty and project leaders created activities and structures to support women in science and mathematics majors. Some examples: enhanced faculty mentoring and early advising, pre-semester kick-off events including faculty advising and fun, professional organization memberships for students, leadership opportunities in peer mentoring, in-class peer tutoring, summer research projects for both beginning and more advanced students, and travel and presentation at professional conferences. This poster will describe various successful grant activities and summarize results in terms of student retention, graduation, and post-graduation employment.

Undergraduate Teaching in Mathematics with Open Software and Textbooks (UTMOST)
Vilma Mesa, *University of Michigan*
Rob Beezer, *University of Michigan*
We present a summary of the major findings from this project and the work that we have been advancing regarding identifying students' use of mathematical ideas when answering open ended questions embedded in the textbooks. We present the work that we plan to pursue based on these results.

Shifting Mathematics Instruction at the College Level
Priya Prasad, *University of Texas at San Antonio*
Jessica Gehrtz, *University of Texas at San Antonio*

Despite copious evidence of the effectiveness of inquiry-oriented and student-centered instructional practices, many college instructors do not implement these instructional strategies. We report on a three-year project aimed at shifting instruction in College Algebra at one institution. This project established a professional learning community (PLC) of instructors around an incremental instructional improvement framework to guarantee instructor buy-in and increase the practicality of the development materials for use in the classroom. Preliminary results indicate that structural factors such as course coordination, dedicated PLC time, a lesson-study-like framework for improving course curricula and materials, and video clubs contributed to changes in both instructors' thinking and practice of inquiry-oriented teaching.

QuantNet Ohio: Developing a Statewide Network to Support Effective Teaching of Quantitative Reasoning

Gregory Foley, *Ohio University*

With National Science Foundation support, from 2022 through 2026, a team of researchers and practitioners is forming a statewide professional development network to support instructors who teach a freshman-level course in Quantitative Reasoning at public college and universities in Ohio. This poster will address the premises, plans, progress, and prospects of this project while answering several questions: What does high-quality teaching of Quantitative Reasoning entail? Who teaches Quantitative Reasoning at colleges and universities across Ohio? What type of professional development is needed to support this QR teaching workforce? What are the implications of this project for higher education across the United States? How can this network be adapted to and implement in other states? This NSF IUSE: EHR exploratory Engaged Student Learning project has award number 2216197.

Reinventing Null Spaces in Inquiry-Oriented Linear Algebra: Students' Mathematical Activity in Relation to Social Positioning

Mark Watford, *Florida State University*
Christine Andrews-Larson, *Florida State University*
Matthew Mauntel, *University of New Hampshire*
David Plaxco, *Clayton State University*
Minah Kim, *Florida State University*
Jessica L. Smith, *Vanderbilt University*

The NSF Collaborative Research Project "Extending Inquiry-Oriented Linear Algebra" has developed a set of four new instructional units, including instructional support materials, for inquiry-oriented linear algebra. In this poster, we feature research related to the development of the unit focused on subspaces, particularly related to the topics of null spaces and column spaces. In particular, we draw on data from a paired teaching experiment to detail the nature of students' mathematical activity in the context of a guided reinvention of null spaces. More specifically, we detail one student's developed (what we refer to as) loop-based reasoning within the task setting, another student's efforts to draw on mathematical constructs external to the task setting (including graph theory), and the ways students' social positioning shaped students' opportunities to engage in particular forms of mathematical activity.

PVAMU SUMS Scholars: Evolution of the Self-Efficacy and Anxiety of the Project's Mathematics Cohorts

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

The Prairie View A&M University Scholars in Undergraduate Math and Sciences (SUMS) project is funded by the NSF S-STEM program. This is a multidisciplinary effort, with Biology, Chemistry, Physics, and Mathematics working together to provide a program for high-achieving students who

demonstrate financial need and plan to enter the workforce or pursue a post-undergraduate degree or licensure in the aforementioned fields. Housed at an HBCU, this project provides a multiyear learning and mentoring experience preparing students for undergraduate research, internship opportunities, and overall preparation for life after undergraduate studies.
This session will explore the results of a survey, evaluating mathematics self-efficacy and mathematical anxiety, as administered in two sessions (Summer 2023 and Spring 2024). Of particular interest will be the changes measured from the scholars compared year-to-year as well as student recommendations regarding their Calculus I course.

Center for Undergraduate Research in Mathematics
Kathryn Kozak, *Coconino Community College*
Nancy Neudauer, *Pacific University*
Alicia Prieto, *Youngstown State University*
The Center for Undergraduate Research in Mathematics (CURM) is an NSF-funded program that provides funding and training for academic-year undergraduate research groups in mathematics. CURM has supported more than 300 faculty and 1000 students across the US for more than 15 years. CURM research groups are collaborations between faculty and students at two institutions, one that is a Bachelor's-granting institution, and one that is a 2-year or community college.
The basic components of CURM are:
Training professors as mentors for undergraduate students doing research;
Advising professors on how to maintain undergraduate research groups at their institutions;
Fostering connections to the broader mathematical community through cross-institution partnerships, regional networks, and community engagement requirements;
Preparing undergraduate students to succeed in their future studies and careers in the mathematical sciences;
Revitalizing faculty research programs.

PosterFest 2024: Scholarship by Early Career Mathematicians

Friday, August 9, 3:00 pm - 4:30 pm

This poster session and networking event allows early career mathematicians to present and discuss their scholarly activities with senior mathematicians in an informal atmosphere. Nontenured faculty and graduate students are especially encouraged to apply. Examples of scholarly activities suitable for this poster session include expository work, preliminary reports, scholarship of teaching and learning, and research reports. (Undergraduate submissions will not be accepted.)

Organizers:

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

Sponsor:

MAA Committee on Early Career Mathematicians

Resolving the Module of Derivations on an $n \times (n+1)$ Determinantal Ring
Henry Potts-Rubin, *Syracuse University*

We use the construction of the bar resolution via differential graded structures to obtain the minimal free resolution of $\text{Der}_{R \mid k}$, where R is a determinantal ring defined by the maximal minors of an $n \times (n+1)$ generic matrix and k is its residue field. Along the way, we compute an explicit action of the Hilbert-Burch differential graded algebra on a differential graded module resolving the cokernel of the Jacobian matrix whose kernel is $\text{Der}_{R \mid k}$. As a consequence to the minimality of the resulting bar resolution, we get a minimal generating set for $\text{Der}_{R \mid k}$ as an R-module, which, while already known, has not been obtained via our methods.

Some properties of parameter estimation in LINEX Regression Model

J.M. Thilini Jayasinghe, *University of Dayton*
Leif Ellingson, *Texas Tech University*

In the regression model, the LINEX loss function can be used to reduce overestimation or underestimation instead of using the squared error loss function. The LINEX loss function is widely used in the Bayesian approaches for reducing underestimation or overestimation. However, it is not commonly used in frequentist approaches. A frequentist approach using the LINEX loss function in Regression analysis to reduce the underestimation is presented in this study. Parameter estimation of the LINEX regression model is done numerically since there is no closed-form solution. We present the bias of coefficient estimates and distribution of parameter estimates in the LINEX regression model under the frequentist approach using simulated data with a specific error distribution. Further, the importance of choosing the scale parameter for the LINEX loss function is presented in different aspects.

Standards-Based Grading in a Calculus 1 Class: Investigating Student Progress throughout the Semester

Melissa Newell, *Southern New Hampshire University*

This project examines data from a one semester course in calculus 1 that was graded using standards-based grading (SBG). In SBG, students are given multiple opportunities throughout the semester to demonstrate their proficiency on the course learning objectives. At the end of the semester, their final grade depends on how many objectives they have mastered. The dataset discussed in this presentation includes data from 25 students, including information on when students achieved proficiency on course objectives, homework completion, students' attendance in office hours for the purpose of objective reassessments, and students' final grades in the course. This study explores relationships between students' progress throughout the semester and their final overall grade. We will also discuss potential avenues for future research.

A Novel Analytical Approach to the Third Extended Fifth-Order Nonlinear Equation

Md Nurul Raihen, *Fontbonne University*

This article investigates traveling wave solutions for the third extended fifth-order nonlinear equation using the sine-Gordon expansion technique. Similar to the Korteweg-de Vries (KdV) equation, this nonlinear equation models the propagation of internal waves in deep fluid layers. By applying this analytical method, we derived several traveling wave solutions, including those characterized by hyperbolic functions. These solutions were graphically analyzed to reveal their physical properties, such as wave speed and amplitude. Our findings show that the sine-Gordon expansion technique is a powerful and efficient tool for solving strongly nonlinear partial differential equations. The analytical solutions provide valuable insights into the behavior of complex wave structures, with potential applications in fields such as mathematical physics, fluid dynamics, and ocean engineering.

Coupling RBF-FD with the Parareal Framework to Solve Time-Dependent PDEs

Jacob Blazejewski, *Appalachian State University*
Nadun Kulasekera Mudiyanselage, *Mt. St. Mary's University*
Benjamin Ong, *Michigan Technological University*

Cécile Piret, *Michigan Technological University*
The meshless Radial Basis Functions-Finite Difference (RBF-FD) method discretizes differential operators in both ODEs and PDEs. It is commonly used to discretize the spatial operator of a time-dependent PDE to convert the problem to a system of ODEs via the Method of Lines (MOL) approach. The resulting system of ODEs is solved by selecting an appropriate numerical technique that is traditionally viewed as a sequential process. Alternative ODE solvers include the Parallel in Time (PinT) integrators, such as the Parareal Framework. As their name implies, PinT integrators operate along segments of the time domain in parallel rather than sequentially. In this expository poster, we summarize options from our preliminary paper on how to couple the RBF-FD method with the Paraeal Framework. Additionally, we will demonstrate the coupling's potential for mitigating the impact of spurious eigenvalues present in the spectrum of certain RBF-FD differentiation matrices.

Bifurcation results for Elliptic problems with subcritical nonlinearity on the boundary
Shalmali Bandyopadhyay, *The University of Tennessee at Martin*
We consider an Elliptic equation coupled with a nonlinear boundary condition on a bounded domain. We discuss the existence of positive solutions with respect to a bifurcation parameter when the nonlinearity is superlinear and subcritical.

Initial Condition Reconstruction with Dynamical Sampling
Hiruni Pallage, *Central Michigan University*
Dr. Yeonhyang Kim, *Central Michigan University*
Roza Aceska, *Central Michigan University*
In practical applications, obtaining complete information about initial conditions for initial value problems (IVPs) is often challenging due to limited sensor networks. We utilize dynamical sampling - later time measurements taken at a strategically chosen location- to recover the unknown initial conditions. Criteria are established for attaining the target reconstruction accuracy by assuming that the initial condition function belongs to a specific function class. We control the errors in the recovered coefficients of the estimated initial condition function to follow a linear growth pattern. This approach improves the efficiency of the approximation procedure relative to prior reconstruction techniques. Moreover, our research involves various partial differential equations governing IVPs.

Multiplier Weak-Type Inequalities for the Maximal Operator and Singular Integrals
Brandon Sweeting, *Washington University in St. Louis*
David Cruz-Uribe, *The University of Alabama*
Brandon Sweeting, *Washington University in St. Louis*
We discuss a kind of weak-type inequality for the Hardy-Littlewood maximal operator and singular integrals that was first introduced by Muckenhoupt and Wheeden. This formulation treats the weight for the image space as a multiplier, rather than a measure, leading to fundamentally different behavior; in particular, as shown by Muckenhoupt and Wheeden, the class of weights characterizing such inequalities is strictly larger than A_p. This presentation concerns best constants for such inequalities, as well as recent work on the full characterization of those weights for which these inequalities hold for the Hardy-Littlewood maximal operator in dimension one.

Reflexive Thinking in College Algebra
Shelletta Baker, *University of North Florida*
Reflective thinking is purposeful consideration of actions, knowledge and thinking. And, according to the National Council of Teachers of Mathematics (2024), reflection improves instruction and student understanding. Reflexive thinking is exercised in several ways: reflection on learning; reflection on actions, reflection on experiences (Florida Department of Education; National Council of Teachers of Math; Stains & Machost , 2023). The current study examined the impact of reflection on college students'

midterm exam scores. One-hundred sixty-one students enrolled in college algebra participated in this study. Eighty participants were in the treatment group and completed reflection activities focused on their actions. The reflection activities included one-minute papers and questionnaires. Results revealed that the treatment group (M=67.3, SD=19.34) compared to the control group (M=57.9,SD=19.58) demonstrated significantly higher scores on their midterm exams, t(159)=1.96,p<0.01.

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Equivariance in Approximation by Compact Sets

Alison Rosenblum, *Wabash College*
Saugata Basu, *Purdue University*

This project adapts a construction of Gabrielov and Vorobjov for use in the symmetric case. Gabrielov and Vorobjov had developed a means for approximating an arbitrary subset S of R^n (definable in some o-minimal expansion of the real numbers) by a compact set T. If S is described using e.g. polynomial equations and inequalities, then T can be described using closely related functions, and chosen such that isomorphisms exist between as many homotopy and homology groups of S and T as the user desires.
Here, we consider sets S symmetric under the action of some finite reflection group G. The original construction preserves the symmetry of the defining functions, but we show here that there is an equivariant map from T to S inducing the aforementioned isomorphisms on the levels of homotopy and homology. We use this result to strengthen theorems of Basu and Riener concerning the cohomology spaces of sets defined by polynomials symmetric relative to the symmetric group S_n.

Classifying Ideals Based on Multiplicative Structures: An Experimental Approach

Alexis Hardesty, *Texas Woman's University*
Lars W. Christensen, *Texas Tech University*
Orin Gotchey, *Texas Tech University*

Ideals in the algebra of power series in three variables can be classified based on the multiplicative structure on their Tor algebras. The classification is incomplete in that it remains open which structures actually occur; this realizability question was formally raised by Avramov in 2012. We discuss the outcomes of an experiment performed to shed light on Avramov's question: Using the computer algebra system Macaulay2, we classify a billion randomly generated ideals and build a database with examples of ideals of all classes realized in the experiment.

$B^A(G)$ of Units!

Jennifer Guerrero, *University of California, Santa Cruz*

A common theme in mathematics is to package objects into algebraic structures, for example, a ring. From there, to learn more about the ring, mathematicians study the group of units. We will explore the A-Fibered Burnside Ring of a finite group G and an Abelian group A, $B^{A}(G)$, a ring that is constructed to encode information about the group G, such as its subgroups, homomorphisms into A, and

more. The goal of this poster will be to give a gentle introduction to what the A-Fibered Burnside Ring of a finite group is and to explore properties of its group of units.

Active, Collaborative Learning with Technology in the Calculus II Classroom
Christal Schoen, *Stephen F. Austin State University*
Douglas A. Lapp, *Central Michigan University*
Much research has been conducted on active learning, collaborative group work, and teaching with technology in the mathematics classroom. However, further study is needed to fully understand how these approaches work together to influence learning.
This study occurred at an R2 university in the USA. Subjects took a Calculus II course taught by an expert in active learning and technology use in mathematics education. The classroom was a technology-rich space designed for collaboration. Students used the TI-Nspire CX CAS as a learning tool, and the instructor used the TI-Navigator System to facilitate discussion. Data were collected through observations, interviews, and student work. Findings suggest combining such teaching strategies improves perseverance and fosters conceptual understanding. Students reported that a key result of instructional practices is that they felt compelled to learn during class, whereas they took notes and learned outside class for lecture-based courses.

Assessments in an Inquiry-Based Introduction to Proof Course
Praneel Samanta, *University of Kentucky*
In this presentation, I will discuss my experience in developing an inquiry-based elementary number theory course at the University of Kentucky. This introduction to proof course aims to actively involve students in the learning process. Students are encouraged to work in groups and learn by formulating questions and exploring answers on their own. The teacher serves as a facilitator, leveraging students' strengths and learning needs to guide the course and enhance the effectiveness and efficiency of the process. Providing students with multiple ways to demonstrate their content understanding enriches their learning experience and offers the instructor more insights into the students' thinking and learning needs. In this presentation, we will examine evidence-based concepts for alternative assessments of students' success and how to align them with the curriculum expectations.

Units of Change: Integrating Units Coordination and Covarational Reasoning
Sarah Kerrigan, *Geroge Fox University*
Many have investigated the cognitive structures involved with students' reasoning on relationships between varying quantities. This poster presents revisions to Carlson et. al. (2002) covariational reasoning framework based on empirical evidence from a series of interviews with a middle grade student, Daniel. I developed a theoretical framework integrating theory from arithmetic reasoning, Units Coordination, and covariational reasoning to identify mental actions and structures involved in covariational reasoning. One major revision was the different types of mental actions and units Daniel used depended on his perception of the quantity as a gross or non-gross quantity. Within these two types of quantity classification, several new mental actions were identified within the existing framework that leveraged the student's Units Coordinating structures. This poster provides empirical evidence for the proposed revisions to the framework and future directions for further refinement.

Root Multiplicities of Certain Hyperbolic Kac-Moody Algebras
Michael Baker, *University of Kentucky*
Over 50 years ago, Victor Kac and Robert Moody introduced Kac-Moody algebras as a natural extension of the already classified semisimple Lie algebras. There are three types of Kac-Moody algebras: finite, affine, and indefinite. Both finite and affine have had all root multiplicities calculated. Some partial results have been obtained in the indefinite case, but the root multiplicities are not completely known. Using the combinatorial Kang's multiplicity formula, the root multiplicities to level -7 in the case of

hyperbolic E7 and level -9 in the case of hyperbolic E8 are computed. Additionally, a counterexample to Frenkel's conjecture for hyperbolic E8 found by Kac, Moody, and Wakimoto by computing the relevant root multiplicity is verified and a root whose multiplicity is a counterexample to Frenkel's conjecture for hyperbolic E7 is found. This shows that Frenkel's conjecture does not hold for hyperbolic E7. Additionally, several patterns are found in the roots of these algebras.

MAA Outreach Poster Session

Thursday, August 8, 9:00 am - 10:30 am

Join us for an engaging and interactive Outreach Poster Session at the MAA MathFest 2024, where math professionals, students and math enthusiasts all meet. This session serves as a vibrant forum for outreach community members to showcase their latest math education programs and foster connections within the math community.

Organizers:

Candice Price, *Smith College*
Rachelle DeCoste, *Wheaton College*
Zsuzsanna Szaniszlo, *University of Chicago*

DEEP-MATH (Discover Enjoy Explore and Practice Mathematics)
Viktoria Savatorova, *Central Connecticut State University*
Leah Scharfenberger, *Central Connecticut State University*
Colm Duffin, *New Britain High School*
The DEEP-Math program, funded by the MAA Tensor SUMMA grant, invites a cohort of 30 local high school students to connect with Central Connecticut State University faculty and students throughout the year by participating in academic hands-on activities and events. The goal is to create a positive and supportive environment where students will feel included in a community of learners and practitioners of mathematics. Each activity is designed to enrich students' knowledge and encourage the pursuit and enjoyment of mathematics. Saturday events, led by faculty assisted by student volunteers, spotlight our programs in mathematics, statistics, and mathematics education, introducing participants to educational and job opportunities in mathematics and mathematically intensive disciplines. In 2023-2024, students engaged in a data-driven activities, learned the mathematics behind games of strategy and chance, and explored the geometry of string art. The program will continue in 2024-2025.

Mathstravaganza for Maryland STEM Festival
Benjamin Wilson, *Stevenson University*
The Maryland STEM Festival is a month-long celebration of science, technology, engineering and mathematics that takes place every Fall. It includes hundreds of events focused on fun, interactive STEM learning opportunities around Maryland. As part of Maryland STEM Festival, math faculty and students at Stevenson University host the Mathstravaganza which is a celebration of mathematics that includes interactive exhibits and games open to the community with activities for all ages and math backgrounds. Some of the activities include a prisoner's dilemma simulation, a giant Tower of Hanoi puzzle, the Monty Hall problem probability game, a station to create minimal surfaces with soap bubbles, a Chaos Game simulation, and more!

The Math Movement

Axel Brandt, *The Math Movement*
Dionissi Aliprantis, *The Math Movement*
Recognizing the reality of separate and unequal educational opportunity within the Ohio K-12 education system, The Math Movement (TMM) seeks to expand educational opportunity to Cleveland-area students by means of community building. TMM invites students to discover beauty in the world with mathematics being a primary example. During their free four-week summer program, middle and high school students explore mathematical ideas while building relationships with role models in a multi-tiered mentorship structure.

West Virginia Math Games
Vicki Sealey, *West Virginia University*
Erin Goodykoontz, *West Virginia University*
Cody Hood, *West Virginia University*
Funded by the MAA and the Neff Outreach Fund, WV Math Games is a project that provides math board games to middle school students in rural West Virginia schools. Through our project, we host game nights for middle schoolers and their families, and students leave with their own copies of the games. Our team aims to bridge the gap between home and school by fostering enthusiasm and proficiency in mathematics, making math an accessible and enjoyable subject. By leveraging games as educational tools, WV Math Games seeks to supplement classroom learning, particularly in regions with limited enrichment opportunities. Overall, WV Math Games is a promising avenue for enhancing math education, fostering community collaboration, and addressing the educational needs of under-served populations in the region. During this session, we will share strategies that have worked well for us for recruitment and implementation of these events and solicit feedback on ways to improve and grow our initiative.

The AMC 8 @ ASMSA: Increasing Mathematics Interest in Arkansas Middle School Students
Ashley Hicks, *Arkansas School for Mathematics, Sciences, and the Arts*
As part of a Neff Outreach Grant, the Arkansas School for Mathematics, Sciences, and the Arts hosted the AMC 8 exam for 67 Arkansas students from several school districts. The competition also allowed for a brief educator development opportunity and community building activities within the student cohort. This poster outlines the reasoning for shifting from Math Olympiad to AMC as a competitive event on our campus, presents an overview of student engagement and learning outcomes experienced through the AMC 8 competition event, and reports the impact on mathematics interest for the sample. Plans for future events based on feedback from the 2024 event will be presented, and we welcome additional feedback on our program from other AMC 8 hosts.

Culturally Responsive STEM Enrichment Activities for Middle School Students
Yardley Dominguez Lopez, *Towson University*
Mary K. Stapleton, *Towson University*
Diana Cheng, *Towson University*
R. Michael Krach, *Towson University*
This Dolciani Mathematics Enrichment Grant funded project provides culturally responsive STEM enrichment experiences for middle and high school students throughout greater Baltimore, Maryland. These enrichment experiences are designed and delivered by undergraduate preservice teachers in partnership with university faculty. Through this project, students at various academic levels will develop an awareness of authentic STEM applications and thus raise awareness of career opportunities in STEM. This poster presents two middle school level STEM lessons focused on climate change and living wage, implemented in May 2024.

A Tapestry of Trails: Cultivating Collaborative Mathematical Journeys to Expand Bob and Ellen Kaplan's Thirty-Year Legacy

Taylor Yeracaris, *The Global Math Circle*
Avital Oliver, *The Global Math Circle*
The Global Math Circle was founded over 30 years ago by Bob and Ellen Kaplan, authors of "Out of the Labyrinth: Setting Mathematics Free" and ""Art of the Infinite: The Pleasures of Mathematics". Our goal is to bring an authentic experience of doing mathematics to as many young people as possible, where kids own the entire process of doing math: making conjectures, making mistakes, solving problems, and asking new questions.
Our motto is "Tell me and I forget. Ask me and I discover." Kids in our circles learn to think mathematically: to engage with open-ended questions, to approach problems critically, to discuss collegially with others, and to have confidence in their own thinking abilities.
Our growing program offers online circles to children around the world, as well as a 10-week training institute for math circle leaders. Our poster also describes the Nexus, a new project that aims to create an ever-growing map of mathematics, in order to better support math circle leaders.

Everyday Math: Exploring Mathematical Modeling in Daily Life
Md Nurul Raihen, *Fontbonne University*
"Everyday Math" engages high school students with the practical applications of mathematical modeling in daily life. Workshops teach students to create models for real-world problems, such as budgeting, travel planning, and environmental impact analysis. Interactive activities include predicting population growth, analyzing sports statistics, and designing efficient layouts. The program demonstrates the use of mathematical modeling in professions like finance, healthcare, and urban planning. Collaborating with local schools and community organizations, "Everyday Math" aims to inspire students from diverse backgrounds to appreciate mathematics and pursue STEM studies and careers.

Summer Math Research Experience for Lowcountry High School Students and Teachers at The Citadel
Mei-Qin Chen, *The Citadel*
Rigoberto Florez, *The Citadel*
Antara Mukherjee, *The Citadel*
Breeanne Swart, *The Citadel*
The Math Research Experience for Lowcountry High School Students and Teachers is a week-long non-residential camp held at The Citadel. During this week, students learn about the research process from finding an open math problem to solving the problem and submitting a solution. Students explore problems outside the typical high school curriculum and write their solutions using LaTeX. The students are presenting their progress daily and giving culminating presentations to family, friends, and teachers at the end of the camp. Teachers learn about mentoring this type of student research which they can transfer to their high schools during the school year. After the camp, students are invited to write a paper to submit to the SC Junior Academy of Science (SCJAS) and to present their findings at the SCJAS annual meeting in the spring while teachers are invited to attend and help preparations. The camp are partially supported by the Dolciani Mathematics Enrichment Grant for 2023 and 2024.

The Texas A&M Mathematics & Statistics Fair: The Thrill of Discovery for K-12 Students
John Weeks, *Texas A&M University*
Patricia Alonso Ruiz, *Texas A&M University*
Scott Crawford, *Texas A&M University*
Sinjini Sengupta, *Texas A&M University*
Philip Yasskin, *Texas A&M University*
The Texas A&M Mathematics Department hosts a community outreach day each year. Over 250 participants, predominantly K-12 students, get the chance to become hooked on the feeling of mathematical discovery. We have four booths which illustrate the beauty of our subject. Arts & Crafts

uses crafting items like balloons and origami to show the geometric principles like symmetry and tessellations. The Problem Solving competition entices students to think critically to win prizes at the end of the Fair. Puzzles & Games illuminates math strategies coming from Julia Robinson Math Festival activities and puzzles. Statistics teaches our youth the value of data science to make decisions in the face of uncertainty. The success of this event is made possible by our undergraduate and graduate student population as well as our mathematics and statistics faculty. We discuss the impact of each booth in engaging our young audience and how our design promotes mathematical exploration beyond the classroom.

Yupanas and Fibonacci Numbers
Amanda Serenevy, *Riverbend Community Math Center*
Yupanas are a type of abacus that was used in the Inca Empire to perform calculations. The historical documentation about what they looked like and how they were used is incomplete, and so researchers have proposed various theories to fill in the gaps. Some have noticed that several Fibonacci numbers are featured in the system and have suggested that this makes the calculation system more efficient than it otherwise would be. In this Math Circle, we explore some of the theories about how this calculation system worked and examine the efficiency claim proposed by these researchers.

Research in Motion (Undergraduate Student Poster Session)

Friday, August 9, 9:00 am - 12:00 pm

- *Posters setup: 8:00 am - 9:00 am*
- *Students and Judges only: 9:00 am - 10:00 am*

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

Organizers:
Amber Russell, *Butler University*
Thomas Langley, *Rose-Hulman Institute of Technology*
Peri Shereen, *California State University*

Sponsor:
Committee on Undergraduate Student Programming (CUSP)

WEBSIGMAA Showcase of Web-Based Teaching Resources

Thursday, August 8, 4:15 pm - 5:45 pm

Technology is increasingly available and used in and out of the classroom to support learning of mathematics. From visualization of relations between variables, exploring patterns to motivate conjectures, and online practice of answering practice exercises to development and distribution of interactive online texts and embedding editable computer algorithms that can be executed in

the browser, web-based technology provides many resources that instructors can use to engage their students in learning, exploring, and constructing mathematical knowledge. This session will showcase new and innovative uses for online resources including visualization tools, applets, and interactive computing tools. In addition to the traditional poster format, presenters will provide demonstrations and opportunities for trying out the technology in action.

Organizers:
D. Brian Walton, *James Madison University*
Shanda Hood, *University of Arkansas*
Bernd Sing, *University of the West Indies (Cave Hill Campus, Barbados)*
Joe Fields, *Southern Connecticut State University*

Sponsor:
SIGMAA on Mathematics Instruction Using the Web (SIGMAA WEB)

MERLOT (Multimedia Education Resource for Learning and Online Teaching)
Shanda Hood, *University of Arkansas*
MERLOT (Multimedia Education Resource for Learning and Online Teaching) is a referatory of high-quality online learning resources for a wide variety of disciplines, including mathematics and statistics. Geared toward higher education, resources shared in MERLOT are freely available to educators and learners at all levels and are peer-reviewed by educators and subject matter experts. This expansive collection of online resources is a valuable source of OER materials for anyone looking for additional materials or helpful tools to share with students as well as individuals who are interested in more self-directed study. MERLOT also includes free content builder tools to allow users to build accessible and shareable resources.

Using AI to Decrease Anxiety
Shanda Hood, *University of Arkansas*
Nama Namakshi, *University of Arkansas*
For a chosen topic, students in a Survey of Calculus class were asked to create a video presentation using ChatGPT. Students in this course are non-STEM majors with a fair amount of self-reported math anxiety. Using mathematical terminology correctly can be difficult. Using ChatGPT to create a script will reduce this anxiety, allowing students to engage with course material in a less stressful way. Using AI tools will increase comfort with terminology, allowing students to use discipline-specific terms more naturally. We will present our preliminary findings based on data collected from participants about their experience and perception when creating a video presentation using AI.

Using Manim for Pedagogical Animations
Joe Fields, *Southern Connecticut State University*
Manim (Mathematical ANIMations) was created by Grant Sanderson of the "3 blue 1 brown" YouTube channel. Sanderson released the software as an open source project - a friendly fork, which is supported by a large community of users and developers is known as the "community edition." We will illustrate the use of manimCE to make pedagogically useful animations. The full scope of the process, from setting up a development environment, to gaining basic familiarity, to exploring the extensive help documents, to advanced topics like 3-d and moving cameras will be presented. A cursory knowledge of python would be helpful but not required. There will be lots of pretty example!

A CRAFTY-Compliant Business Calculus Online Text

Mike May, *Saint Louis Univesity*
This poster presents on an open-source textbook that is available online. The project was to make a textbook for a one semester course in calculus for business students following the MAA recommendations for courses for partner disciplines. (CRAFTY CFP reports.) The text is available online and is written using the PreTeXt format. This allows easy production of a LaTeX print version. The online format allows east inclusion downloadable Excel files to follow examples of screencast videos to explain to bring students up to speed on software usage.

Authoring randomized math exercises for multiple target platforms
D. Brian Walton, *James Madison University*
Different platforms for web-based math exercises often allow for user-defined problems. Each platform implements its own language defining problems. The PreTeXt publishing system has implemented an XML-standard for defining documents, particularly those that are STEM related and include mathematical content. This interactive poster demonstrates an XML-standard for defining math exercises that can be embedded within PreTeXt documents in order to generate stand-alone as well as homework platform problem definitions that can be integrated within the the text. A prototype blockly visual interface for the definition will also be demonstrated.

Math Circles in Motion: A Dynamic Activity and Poster Session

Friday, August 9, 4:00 pm - 7:00 pm
Join us for an engaging opportunity to immerse yourself in the world of Math Circles! Math Circles vary widely in format and frequency, but they share a common theme of bringing groups of students and/or teachers together with mathematicians to collaboratively investigate and discover mathematics. Bring an interactive, hands-on math circle activity with manipulatives and provide a poster or a set of printed slides or a printout that can be displayed on a cork board to describe your activity. Together with poster boards, tables will be available where attendees can try out your activity. Direct engagement with these problems and puzzles will allow participants to experience the joy of mathematical exploration and inspire them to incorporate these activities into their own Math Circles or K-16 classrooms. There will be multiple presentations going on in the room, so attendees can sample a variety of different types of Math Circle activities. Math Circle activities are an ideal way to incorporate active and inquiry-based learning in the math classroom, leveling the playing field for diverse learners and promoting collaborative problem solving.

Organizers:
Lauren Rose, *Bard College*
Peter Petto, *Greater Cleveland Council of Teachers of Mathematics*
A. Gwinn Royal, *Ivy Tech Community College*
Jeffrey Musyt, *Slippery Rock University*
Tom Stojsavljevic, *Beloit College*
Nick Rauh, *Seattle Universal Math Museum*
Ed Keppelman, *University of Nevada, Reno*

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

Big Math Circle Demonstration
Dave Auckly, *Kansas State University*
Dani Alvarez-Gavela, *Brandeis*
Damien Hunter-Ben, *DZIŁ DITŁ'OOÍ School of Empowerment Actions & Perseverance*
Dawnlei Hunter-Ben, *DZIŁ DITŁ'OOÍ School of Empowerment Actions & Perseverance*
Bruce Bayly, *University of Arizona*
Kaybah Hoycott, *Navajo Math Circles*
Henry Fowler, *Navajo Technical University*
Matthias Kawski, *Arizona State University*
Kim Klinger-Logan, *Kansas State University*
Shay Logan, *Kansas State University*
We will bring and demonstrate some "BIG MATH" objects including polyhedral compounds, surfaces, and puzzles.

The Odyssey of a Classroom Task
Peter Petto, *Greater Cleveland Council of Teachers of Mathematics*
This poster chronicles the transformative journey of a classroom task in which students construct Voronoi diagrams as part of a high school Consumer Math course. Over several years, this learning activity underwent numerous enhancements inspired by the presenter's experiences with Math Circles. The evolving iterations highlight the inclusion of practical applications, engaging enhancements, and game-like elements, all aimed at increasing student interest. Additionally, it includes a few examples of the increasing emphasis on student explanation and collaborative sharing over the years. This demonstrates the principle that lessons evolve, and hopefully continuously improve.

Prime Climb - Introduction to Problem Solving
Brandy Wiegers, *College of Idaho*
Math For Love has an amazing game called Prime Climb (https://mathforlove.com/games/prime-climb/). There is secret code in the colors that are displayed and before we even play the game I ask all Math Circle participants to notice and wonder. What do you see in the first twenty numbers? Is there a pattern that you can guess will continue with the next forty numbers? After we've collected our observations and thoughts, we expand to see if the game board meets what we had guessed. From there we can talk about properties of numbers and remind ourselves of all those factor words that we might not have used in a while. Having established a shared set of language we are ready to take off and explore the full game. This poster is sure to be full of ideas for problem solving and fun!

The Game of Take Away
Rachel Lynn, *Schreiner University*
The game Take Away, which is a variation on the combinatorial game Nim, can be used in a variety of settings to introduce students to mathematical reasoning and explanatory mathematical writing in a more comfortable setting. In the game, two competitors take turns removing tokens until one of the competitors wins the game by taking the last token. I personally have used this activity in a Discrete Math/Introduction to Proofs course after stumbling across it in MAA Notes #74. In this session, I will introduce participants to the game of Take Away, have them experiment with winning strategies, and discuss how my students engaged with the activity. I also hope to have fruitful discussion with Math Circle veterans on how to adapt this game to different settings and age groups.

Pentomino Puzzlers
Asmita Sodhi, *University of Victoria*

A pentomino is shape made by joining five equal squares edge to edge (think TETRIS pieces, but with five squares instead of four). As a set of geometric manipulatives that lead to many interesting spatial activities, pentominoes are an excellent tool to use in Math Circles across a range of ages and abilities – there's something fun for everyone! In this poster, I'll present three different activities (among many!) that can be explored using pentominoes: making 4x5 rectangles, building fences, and an accessible proof that there are exactly 12 distinct pentomino pieces up to reflection and rotation.

Floor-to-Ceiling Adventures with Rubik's Cubes
A.Gwinn Royal, *Ivy Tech Community College*
Lauren Rose, *Bard College*
Daniel Rose-Levine, *Bard College*
In honor of the 50th anniversary of the Rubik's cube, we present a variety of cube-related explorations. In addition to standard cubes, we will provide modified cubes for beginners. Our goals for this session include guiding participants toward an understanding of the algorithms involved in solving a cube and showcasing the cube as a gateway to mathematical discovery.

Use Sampling to Draw Inferences about Populations
Mariana Ortiz, *Central Jersey College Prep Charter School*
Tarhan Ivanna Teli, *Central Jersey College Prep Charter School*
Chidiebere Chiduto, *Central Jersey College Prep Charter School*
Our group plans to teach IEP students (students with learning struggles) in 6th grade how to use sampling to draw inferences about populations. We plan to teach the students in the form of an interactive illustrated story in which we will ask questions throughout the story to make the students stop and think and make sure that they understand and can properly follow along with the story.
On our poster we will make sure to include background information first like the definition of population and the definition of sample. (Stating some types of samples such as a random sample, representative sample) What it means to make an inference using data and how data can be collected. The story will provide a real-life situation so that the students can understand more clearly about the topic and how they themselves can apply them to the real-world.

Eulerian Embroidery
Jane Butterfield, *University of Victoria*
In this activity, participants get hands-on with a form of embroidery that was popular in 16th century Europe, has become popular again in the 21st century, and has a meaningful connection to graph theory. Starting from simple patterns, participants gradually demonstrate that every connected pattern they can think of can - theoretically - be embroidered in this special way! This activity scales marvellously; you will experiment with child-safe manipulates suitable for ages 10 and up, and activity notes will help you add mathematical depth to the activity suitable for undergraduate students. Mathematical connections to counting, parity, algorithms, mathematical induction, and graph theory.

Dihedral Groups, Paper Snowflakes, and Vyshyvanka Embroidery
Maria Droujkova, *Natural Math*
Math Makers 5 is a participatory research project making all the subject areas of mathematics accessible to everyone. Our benchmark for accessibility is 5-year-old children. This session provides examples of embodied, artistic activities for elementary student or teacher math circles, community fairs, and outreach programs. Participants can join at any level of artistic skill (stick figure to pro artist) and mathematical prowess (counting to 10 to researcher).
Most people know paper snowflakes but not their mathematical structure, which also appears in vyshyvanka embroidery from Ukraine. The young and the young at heart can hide secret messages in their snowflake and vyshyvanka creations. With these accessible, adorable puzzles of their own making,

participants will model dihedral groups and other topics related to spatial symmetry. The activity is festive enough for holidays such as the international Vyshyvanka Day in May or winter festivals with extra mathy snowflake decorations.

Volume and Surface Area of 3D objects
Anushka Jadhav, *Central Jersey College Prep Charter School*
Ertugrul Tarhan, *Central Jersey College Prep Charter School*
Trishona Chinala, *Central Jersey College Prep Charter School*
Bhavini Sharma, *Central Jersey College Prep Charter School*
Our topic was Surface Area and Volume of 3d shapes. Our content was teaching these topic to IEP students. In our Poster board we gave examples of 2 shapes that you can find the volume of them and then gave "Try It!'s" for both shapes to see if you understand how to find the volume. We gave examples of 2 shapes that you can find the surface area of and gave a "Try It!" for both shapes to see if you understood it too. The answers for the "Try It!"s were hidden in a pull out card that showed the answer and how to find it.

Teaching Trigonometry to IEP Students
Saashi Jain, *Central Jersey College Prep Charter School*
Ertugrul Tarhan, *Central Jersey College Prep Charter School*
Arisha Ghori, *Central Jersey College Prep Charter School*
Akshara Srinivasan, *Central Jersey College Prep Charter School*
We will teach IEP students about trigonometry, who invented it, and its different theories. Trigonometry is a fundamental topic so we are teaching them. The formulas will be on the side of the posters, and we will show examples to the students. We will understandably teach them. We will also add funny jokes.

Understanding and Overcoming Math Anxiety: Strategies and Insights
Lu Wang, *Christel House Indianapolis DORS*
Math anxiety is a pervasive issue that affects students' ability to perform and engage with mathematical concepts. This session aims to explore the roots of math anxiety, its impact on learning, and effective strategies to mitigate its effects. Through interactive activities and discussions, participants will gain insights into identifying signs of math anxiety and implementing techniques to build confidence and resilience in students. The poster session will showcase research findings, case studies, and innovative approaches to fostering a positive math learning environment.

Deborah and Franklin Tepper Haimo Awards

Saturday, August 10, 3:00 pm – 4:00 pm

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

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

Long Story Short
Candice Price, *Smith College*

As I reflect on my time as a teacher of Mathematics, I see many pivot points in my career. I hope to share those with you all.

Bridging Theory and Practice: A Journey in Applied Mathematics
Malena Español, *Arizona State University*

As an applied mathematician, my career has been driven by a deep passion for not only solving complex real-world problems but also for translating these experiences into impactful teaching and mentorship. In this talk, I will reflect on how my work in applied mathematics has shaped my approach to education, fostering a dynamic and engaging learning environment. I will share insights from my experiences guiding students through the intricacies of mathematical concepts, promoting equity and inclusion within the classroom, and contributing to the broader mathematics community through my involvement in various educational programs. Join me as I discuss the synergy between applied mathematics and pedagogy and how this interplay enhances both the learning experience and the advancement of the field.

Alder Award Session

Friday, August 9, 5:00 pm – 6:20 pm

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

Enhancing Multivariable Calculus: Integrating 3D-Visualization and Tactile Activities to Support Spatial Concepts
Shelby Stanhope, US Air Force Academy

When students enter multivariable calculus, a unique transition occurs. Up to this point, students have spent their mathematical careers becoming experts in the two-dimensional xy-plane. Adding another dimension allows us to explore this 3D world we live in, but the transition to three-dimensional mathematical thinking does not come easily to many students. To better support students' spatial understanding of concepts in the course, we should provide interactive computer visualizations, tactile manipulatives, and experiential learning opportunities. In this presentation, I will discuss several classroom activities using 3D printed surfaces. Additionally, the free web applet CalcPlot3D can be used to provide insightful through computer visualizations. The program requires no coding and is extremely accessible to students. I will present demonstrations that instructors can use to illuminate concepts and visualizations that students can easily create themselves.

Making Meaningful Moments
Axel Brandt, John Carroll University

With a preschooler at home, the saying about it "taking a village" has become increasingly internalized for me over the past few years. As a result, I have started recognizing the inherent message about community and shared responsibility in more places. As educators, we can quickly cite examples of both people in the village that helped shape us into who we are, and also the shared moments that motivate why we do what we do.

In this talk, I'll reflect on some of the memorable moments from my "academic upbringing" and how they have shaped my professional practice.

Shared Joy, Time, and Attention: Apprenticeship in Undergraduate Math Education
Haydee Lindo, Harvey Mudd College

I offer my thoughts on the interactions between undergraduate teaching and undergraduate research in the context of my evolving understanding of my role as a math educator. Connecting with my own math journey, I'll share some insights gathered while preparing myself, my students, and my classroom communities for fulfilling long-form and mini research experiences.