2023 MAA Missouri Section Meeting

Missouri State University, Springfield, MO

March 31 - April 1, 2023

Invited Talks

Lisa Marano **West Chester University**

Mathematics and Community Engagement: A story about finding mathematical problems in the community and bringing mathematics into the community

First-year seminars, learning communities, service-learning courses, undergraduate research projects, and capstone experiences are among a list of high-impact educational practices compiled by George Kuh (2008), which measurably influence students success in areas such as student engagement and retention. It is recommended that all college students participate in at least two of these HIPs to deepen their approaches to learning, as well as to increase the transference of knowledge (Gonyea, Kinzie, Kuh, & Laird, 2008). In Mathematics, if a student participates in service-learning, it is typically in the form of tutoring, in conjunction with a school or with an after-school program, or modeling work or statistical analysis for non-profits. Today, I will discuss a number of service-learning projects developed for mathematics courses, which do not involve these traditional opportunities. I will also describe my current research project which has potential impact on my community and yours.

Amy Ackerberg-Hastings **MAA Convergence**

Translating the History of Mathematics Education into Using History to Teach Mathematics

Although I co-edit one of the journals of the Mathematical Association of America, my PhD is in the history of technology and science, not mathematics. In this talk, I will briefly describe my path to professional research into the teaching of geometry in Scottish and American colleges during the 18th and 19th centuries. I will then share some themes from my work on John Farrar (17791853), who was the Hollis Professor of Mathematics and Natural Philosophy at Harvard College from 1807 to 1836. In particular, Farrar is most famous for translating a series of textbooks in mathematics and the physical sciences; I will explain how I found out that the story of these translations is more complicated than the summary statement suggests. Finally, I will discuss how my talks and publications on the history of mathematics education led to advocacy for history in mathematics education. Specifically, I have served 9 years and counting on the editorial board for Convergence, the MAAs free online journal that supports the use of history to teach mathematics, especially those subjects studied at the secondary and undergraduate levels: algebra, combinatorics, synthetic and analytic geometry, trigonometry, probability and statistics, elementary functions, calculus, differential equations, and linear algebra. Material you can use to teach or learn mathematics is surely among the thousands of pages of Convergence content.

Contributed Talks

Kevin Anderson **Missouri Western State University**
Happy Birthday!

In this talk we will explore the "Birthday Problem" and other interesting/fun mathematical results as time permits.

Colin Barker* & Jones M Mutua **Drury University**
Modeling the Role of Socioeconomic Status and Treatment Programs on Typhoid Fever Epidemics

Typhoid fever remains a consistent disease threat in developing and tropical countries. Socioeconomic delineations within populations contribute greatly to the control and the spread of Typhoid fever as well as the impact and effectiveness of vaccination initiatives. In this study we further develop a mathematical model describing socioeconomic status to include water treatment and ongoing antibiotic treatment. We examine the model predictions to analyze the transmission dynamics of Typhoid epidemics in a socioeconomically diverse population with vaccination, bacteria treatment, and antibiotic treatment. We describe both the local and global dynamics of the model via the basic reproduction number, $\mathfrak{R}_0$, and compare the impacts of antibiotic treatment to water treatment as disease control strategies. From numerical results we demonstrate that each single-control strategies on disease transmission has a similar effect. Utilizing both non-vaccination control methods is more effective, but not enough to eradicate Typhoid fever. Finally we conclude that without vaccination, our model predictions fail to control disease transmission.

Owen Bennion **Missouri State University**
Bounds on point configurations determined by distance and dot products for some imperfect trees

A study on a variant of Erdos' Unit distance problem, concerning distances and dot products between pairs of points chosen from a large finite point set. Specifically, given a large set of n points E, we look for bounds on how many subsets of k points satisfy a set of relationships between point pairs based on distances or dot products.

Jarrin Brown **Missouri State University**
Building the 15° - $\frac{\pi}{12}$ *radian Unit Circle*

The 15° - $\pi/12$ radian Unit Circle will be constructed.

Samuel Chamberlin* & Caleb Fernelius **Park University**
Structure Constants for the Universal Enveloping Algebras of the Lie Algebras of Types A_1 *and* A_2

Recently, Gourley and Kennedy gave a recursive formula for the structure constants for the universal enveloping algebra of the Lie algebra $\mathfrak{sl}_2$. Using Kostant's formula we give a closed formula for these structure constants and discuss our progress toward extending this to the universal enveloping algebra of the Lie algebra $\mathfrak{sl}_3$.

David Garth **Truman State University**
Playing Moneyball in Golf

There is a saying in golf that "you drive for show and you putt for dough." This view is widely held by many in the golf world, and it seems reasonable enough. After all, a typical golfer uses the driver 10 to 14 times per round, while taking about 32 to 40 putts per round, so there seems like more room for improvement in the putting game. Recently some people, such as Mark Broadie in his 2014 book, "Every Shot Counts," have used mathematical tools like dynamic programming to question this conventional wisdom. In this presentation we discuss a simple mathematical model that allows us to directly compare a golfer's driving and putting. The model relies mostly on simple probability and linear algebra, and requires a less computational power than some of the existing techniques. Our goal is to use this model to determine, with all other aspects of the game being equal, which results in a greater reduction in a golfer's score, improvements in driving or improvements in putting.

Dorsa Ghoreishi* & Daniel Freeman **Saint Louis University**
Phase Retrieval in Frame Theory

Frames, like orthonormal bases, give a continuous, linear, and stable reconstruction formula for vectors in a Hilbert space. However, frames allow for redundancy, and this makes frames much more adaptable for theory and applications. Phase retrieval is an application of frame theory which is prominently used in X-ray crystallography and coherent diffraction imaging where only the intensity of each linear measurement of a signal is available and the phase information is lost. The goal of phase retrieval is to recover these lost phases up to some global factor. Notably, phase retrieval requires the redundancy of a frame, and is not possible with a basis. We will introduce some of the mathematical foundations for phase retrieval, and discuss some projects concerning the stability of phase retrieval with respect to errors in measurements.

Taylor Harrison **Northwest Missouri State University**
AP Statistics: Who Teachers it and What do They Emphasize?

Results will be shared from a survey administered to 445 AP Statistics Teachers. The survey asked respondents about their professional learning, their beliefs, and their practices. Survey topics include backgrounds of the teachers, what their classrooms look like, technology use, and which aspects of statistics are emphasized in their instruction. Follow-up interviews were conducted with 18 respondents.

Blaise Heider* & Gary Birkenmeier **University of Central Missouri**
Right cP-Baer rings and their extensions

In this talk I will introduce right cP-Baer rings. Then we will discuss if the cP-Baer condition transfers to polynomial rings. That is, if R is a right cP-Baer ring, then will R[x] and R[[x]] also be a right cP-Baer rings? If there is time, then we will also discuss the cP-Baer condition transferring to matrix rings.

Joscalyn Hulderson* & Emily Lauer **Northwest Missouri State University**
Monotonicity of Sequences Generated by Powers of the kth-order Fibonacci Recurrence Relation

Starting from the theorems proposed by "Sequences Generated by powers of the k^{th}-order Fibonacci recurrence relation" by Chris D. Lynd and James W. Sharpe, and "Monotonicity of Sequences Generated by Powers of the k^{th}-order Fibonacci Recurrence Relation" by Jawad Sadek, we will provide a different proof for the case where $k = 3$.

Brody Johnson* & Tova Brown **Saint Louis University**
Pull-Back Cars: Vehicles for a First Modeling Experience in Differential Equations

The goal of this presentation is to describe a hands-on modeling activity for students in a first course on differential equations. Students conduct experiments with toy pull-back cars and extract position and velocity data from cellphone videos, which is then used to estimate unknown parameters in the model. This talk is based on a SIMIODE modeling scenario written by the authors and will also include general information about SIMIODE and its resources.

William Klasinski* & Keith Brandt **Rockhurst University**
Domino Tilings on a Variety of Boards

My project examined the number of ways you can place dominos on chess boards of different dimensions. Using recursion, we placed horizontal (1 row X 2 column) and vertical (2 row X 1 column) dominos on the board until we have filled the entire board. Then we examined different boards and determined if two boards were the same after flips and rotations. After the completion of a few boards, we determined that our process worked correctly by checking the Online Encyclopedia of Integer Sequences. This presentation will go into detail about the setup, nuances, and conclusions drawn from the program and its outcomes.

Jae Hyeong Lee **Saint Louis University**
A Study of Bi-Lipschitz Embeddability into Euclidean Spaces

We define a function f from a metric space (X, d_X) into another metric space (Y, d_Y) to be bi-Lipschitz if for all $x, x' \in X$, $\frac{1}{C} d(x, x') \leq d(f(x), f(x')) \leq C d(x, x')$ where $C > 0$. We want to classify what types of metric spaces have a bi-Lipschitz embedding into Euclidean spaces. Assouad's Embedding Theorem gives the strong condition of if (X, d) is a doubling metric space and the metric is taken to the power of $0 < p < 1$, then it has a bi-Lipschitz embedding into some Euclidean space. In this paper, we find an example of a doubling metric space that does not admit a bi-Lipschitz embedding into any Euclidean space and also the image of the bi-Lipschitz embeddings of Assouad's Embedding Theorem.

Rachel Lee & Yashasvi Moon **Missouri State University**

Used in various applications such as coding theory and cryptography, Latin squares are a combinatorial concept that have been studied for a long time. A Latin square of order n is an $n \times n$ array filled with n symbols such that every row and every column contains every symbol exactly once. In other words, every row and every column is a permutation of $\{1, 2, \ldots, n\}$. Two Latin squares are said to be orthogonal if when superimposed, each ordered pair only appears exactly once. In 1782, Euler conjectured that if $n = 2 \pmod 4$, then a pair of orthogonal Latin squares of order n cannot exist. For $n = 6$, this was proved by Tarry in 1901. Recently, Musto and Vicary proposed the idea of generalizing Latin squares to quantum Latin squares by replacing the classical entries with quantum entries. This is analogous to passing from a classical computer that deals with bits (0 and 1) to a quantum computer that deals with qubits (superimposed states of 0s and 1s). The concept of orthogonality can also be extended to quantum Latin squares. Unlike the classical case, two orthogonal $6x6$ quantum Latin squares do exist. We hope to investigate other cases in which classically unsolvable problems can be solved by passing to quantum versions of them.

Angela Lopez **Northwest Missouri State University**
The Whiz of ENIAC: the Woman Behind the Curtain

Betty Jean Jennings Bartik changed the world through her work in the fields of mathematics and computer science. Despite the odds being stacked against her, she went from the daughter of a poor farmer to the world's first electronic computer programmer by the age of 21. Her work to accurately calculate missile trajectories, both by hand and later through her computer program, make her a classic American hero in the eyes of mathematicians, computer scientists, and the American military.

David McCune **William Jewell College**
Ranked Choice Bedlam in a 2022 Oakland School Director Election

The 2022 ranked choice election for the District 4 School Director in Oakland, CA was totally nuts. This talk presents some of the election's strange features, which include but are not limited to: a Condorcet paradox, a downward monotonicity paradox, and an upward monotonicity paradox.

Katarzyna Meyers **Northwest Missouri State University**
Woman Lost in History

Emmy Noether, an originator of modern algebra, despite facing many challenges, made landmark discoveries in the fields of physics and mathematics. In this talk we will consider the Noether Theorem and the Noetherian ring.

R. Lauren Miller **Saint Louis University**
Teaching through Play: a new approach to Corequisite College Algebra

Corequisite College Algebra covers all the topics in College Algebra and Intermediate Algebra. This is also referred to as just in time remediation. This course is for students who test into intermediate algebra and need to take precalculus for their major. This 3-credit hour course has 5 hours of seat time. Class is divided into lecture, group work, and games. This lecture will introduce how to incorporate play into your classroom to improve student learning outcomes. There may be an opportunity to play some games as well!

R. Lauren Miller **Saint Louis University**
A Pathway for Expanding Math Education in Prison

Lauren Miller has been working in prison education for over three years. She developed a pathway to calculus for incarcerated men at Pacific State Prison. This talk will cover her experiences, the expansion of college programs in Missouri Prisons with the reinstatement of Pell grants for incarcerated persons, and how you can get involved. This talk is appropriate for undergraduates, graduate students, and faculty.

Collin Moore **Missouri State University**
Covering Groups with Proper Subgroups

A group is said to be "covered" by proper subgroups if it is equal to the set-wise union of these subgroups. We use the term "covering number" to denote the fewest number of proper subgroups needed to cover a given group. Some immediate questions are: Which groups can be covered? What is the covering number for a given group? Are there any covering numbers that aren't possible?

Gavin Moore **Missouri State University**
Proof of the addition/subtraction formulas for sine and cosine

The formulas $\sin(\alpha \pm \beta) = \sin(\alpha)\cos(\beta) \pm \cos(\alpha)\sin(\beta)$ and $\cos(\alpha \pm \beta) = \cos(\alpha)\cos(\beta) \mp \sin(\alpha)\sin(\beta)$ will be proved.

Emmanuel Nsiah **Southeast Missouri State University**
A Comparison of Variant Methods in Random Forest with Multicollinearity Data for Classification Prediction Modeling

Random forest is a popular machine learning model aggregating decision trees to make predictions. Different from standard decision trees, the random forest model uses a random sample of predictors to build a group of decisions. Speiser et al., [35] analyzed 311 classification datasets to compare many variant random forests such as the standard Random Forest (RF) [7], random forest based on a permutation test, Boruta [29], Regularized Random Forest (RRF) [9], the Random Forests for Survival, Regression, and Classification (RF-SRC) [22], and Variable Importance Testing Approaches (VITA) [23]. They concluded that the RRF method had high computation times and low out-of-bag (OOB) error rates. The Boruta method had fairly low out-of-bag (OOB) error rates and computation times. However, all these are tested using datasets with at most 1000 observations. Motivated by Speisers [35] study, the aim of the thesis is to examine the classification performance among the above popular variant RF methods using a large dataset with collinear predictors.

Emmanuel Ocran **Southeast Missouri State University**
A Nonparametric Random Forest Multiple Imputation Method for Missing Categorical Data

Researchers would love to have accurate, clean and complete data but in real life it is virtually impossible due to several factors. Dealing with missing values can become a real dilemma. Some researchers decide to eliminate observations with any missing data. The National Cancer Institute and most states maintain a database for cancer to be used by researchers and policy makers to make better healthcare decisions. This data can have missing observations for one or more variables. In order for health professionals and other stakeholders to make better informed decisions with regards to cancer diagnostics and treatment, models they rely on should be built with adequate data with missing data properly replaced. While there have been several methods proposed to impute missing values of quantitative variables, very few research has been done to impute missing values for categorical variables. Van Buuren (2011) proposed Multiple Imputation with Chained Equations (MICE) with polytomous logistic regression to impute categorical data. Stekhoven et al. (2012) developed a random forest based missing data imputation algorithm called missForest. Their method outperformed established imputation methods. Zhou et al. (2017) has proposed a nonparametric multiple imputation method using the nearest-neighbor approach. Their method uses distance function calculated by a predictive score, which is derived from two working models: one fits a multinomial logistic regression for predicting the missing categorical outcome (the outcome model) and the other fits a logistic regression for predicting missingness probabilities (the missingness model). This study proposes a modification of the method proposed by Zhou et al. by calculating the predictive score of the distance function using Random Forest method. Lung adenocarcinoma is the most common primary lung cancer seen in the United States (Myers, 2022). The study will use the lung adenocarcinoma data from the National Cancer Institute to generate missingness and perform imputation. A Monte Carlo study will be done to compare the proposed modified multiple imputation method to Zhous, MICE and missForest methods.

Josh Putty **Missouri State University**
Building the 18° - $\frac{\pi}{10}$ *radian Unit Circle*

The 18° - $\frac{\pi}{10}$ radian Unit Circle will be constructed.

Lane Rogers **Missouri State University**
The Theory of Calculus on Banach Spaces

The following presentation will explore the use of the Contraction Mapping Fixed Point Principle to build up the Implicit Function Theorem and the Inverse Function Theorem in the context of Calculus on Banach spaces, and subsequently connect the theorems to topics such as the theory of constrained optimization. It will then conclude with a discussion of the application of these concepts to the well-known theory of the Calculus of Variations – in particular, optimization problems with an imposed constraint.

Mark Rogers **Missouri State University**
Knot Theory, Modular Arithmetic, and Linear Algebra

In this talk we will discuss the tricolorability of a knot, a generalization using modular arithmetic and linear algebra, and the determinant of a knot.

Ridwan Sakidja **Missouri State University**
Use of applied mathematics in artificial neural networks (ANN) to model advanced and complex materials

Predicting interatomic forces in muti-component systems has been one of the "Holy Grails" in the field of materials physics. While quantum mechanics (QM) in general can be used to address this issue, such an ab-initio method is very time-consuming and moreover, it has a very limiting cube-scaling dependency with respect to # of atoms modeled. More recently, Artificial Neural Networks (ANN) instead are being used to replace QM to perform a similar job more efficiently. The key, first, is their inherently linear scaling, allowing us now to significantly scale up the simulation models. Another key is their capability in applying fundamental math concepts of invariant & equivariant transformations to represent the atomic configurations & subsequently utilize them to formulate the essential descriptors of the ANN. This approach can be used to help model a wide range of advanced and complex materials with potentially significant technological implications. Such use of AI-driven & applied math-based modeling is one of the research areas actively pursued at the Materials Science Graduate Program in the PAMS dept. at Missouri State.

Steven Senger*, Alex Iosevich, Thang Pham, Mike Tait, & Nguyen Thu-Huyen **Missouri State University**
Pseudorandom graphs, VC dimension, and incidence theory

We discuss recent applications in pseudorandom graphs that lead to advances in VC dimension and incidence theory.

Mary Silverglate **Saint Louis University**
Cheeger's Inequality: Theory and Applications

Cheeger's inequality is a well-known result from graph theory that states that the conductance of a graph can be bounded from below by the second-smallest eigenvalue of the graph's Laplacian matrix. This master's thesis is a survey paper that presents a comprehensive analysis and proof of Cheeger's inequality in the undirected case and compares various methods for finding analogous inequalities in the directed case. In the first part, we prove Cheeger's inequality for an undirected graph. In the second part, we compare and contrast analogous inequalities for a directed graph using GEANT computing network data. In the last part, we explore applications of Cheeger's inequality in various fields, including Markov chains, image segmentation, and computing networks. This thesis aims to be a useful resource for researchers and students interested in graph theory, spectral theory, and their applications in science.

Charlie Smith **Park University**
The Silver Sequence

The great majority of mathematicians are familiar with the Fibonacci sequence $F_n = \frac{\phi^n - \tilde{\phi^n}}{\sqrt{5}}$, where $\phi = \frac{1+\sqrt{5}}{2}$ is the golden ratio and $\tilde{\phi} = \frac{1-\sqrt{5}}{2}$ is its conjugate radical. The Fibonacci has a companion, namely the Lucas sequence $L_n = \phi^n + \tilde{\phi}^n$. Similarly, one can manufacture a sequence beginning with any number of the form $\frac{a+b\sqrt{c}}{d}$, where $a, b, c, d \in \mathbb{Z}, d \neq 0$, and $\sqrt{c}$ is irrational. The simplest such number is $\alpha = 1 + \sqrt{2}$, which is coincidentally known as the silver ratio. Let $\tilde{\alpha} = 1 - \sqrt{2}$. Then $A_n = \frac{\alpha^n - \tilde{\alpha}^n}{\sqrt{2}}$ shall be called the Silver sequence, and its companion $B_n = \alpha^n + \tilde{\alpha}^n$ shall be called the Scout sequence. This talk will investigate properties of A_n and B_n, and present numerous summation formulas involving them.

Josh Stanek **Missouri State University**
The $\frac{1}{2}$-angle formulas for sine and cosine

The $\frac{1}{2}$-angle formulas for sine and cosine will be proved. These formulas will be used to build the $22.5°$-$\frac{\pi}{8}$ radian Unit Circle.

Scott Thatcher **Truman State University**
Calculating Lyapunov Exponents for Human Movement using Motion Capture Data

The Lyapunov exponent measures the degree to which state space trajectories diverge, and is one measure of the presence of chaotic dynamics in a dynamical system. In human movement analysis, the Lyapunov exponent can be used as a measure of non-linear variability, which might help differentiate between movements performed in different circumstances or by different groups of people. In this context, the Lyapunov exponent is often calculated from a single time series measurement through "reconstruction of the state space." However, when multiple measures of the same system are available from a motion capture system, it may also be possible to estimate the Lyapunov exponent by using those multiple measurements and bypassing the "reconstruction" stage. In this talk, I'll present a comparison of those two approaches applied to a study of college runners.

Emily Twardy **Saint Louis University**
Supercharacter Theories for Dihedral Groups

In Representation Theory, we use character tables to encode information about a group in a compact way, using the irreducible representations of a group and their values for conjugacy classes in that group. However, for some groups, the character table can be quite large and unmanageable, which motivates the introduction of Supercharacter Theories, as first described by Diaconis and Issacs in "Supercharacters and Superclasses for Algebra Groups." Using Supercharacter Theory, we can condense character tables by adding characters to combine rows, and unioning conjugacy classes to combine columns, while still maintaining information about the group. This talk explores possible supercharacter theories for Dihedral groups.

Lianwen Wang **University of Central Missouri**
Extrema of Multivariable Functions

It is well-known that both the first derivative test and the second derivative test can be used to determine extrema of single variable functions. However, for multivariable functions we have only the second derivative test which is introduced in most calculus books. In this talk we establish a first derivative test for the extrema of multivariable functions. The extrema of some examples from Larson's Calculus book can be determined by the first derivative test even though the second derivative test is failed.

Matt Wright*, Shelby Kilmer, & Xingping Sun **Missouri State University**
Interpolation using Polynomials with Restricted Exponents

Let $(x_0, y_0), \ldots, (x_{n-1}, y_{n-1})$ be points in the plane with distinct x coordinates. It is well known that there exists a polynomial of degree at most n whose graph passes through all n points. This talk considers the question of which sets $K \subseteq \mathbb{N} \cup \{0\}$ of possible exponents have the property that for any n points with distinct x coordinates, there always exists a function of the form $f(x) = \sum_{k \in K} c_k x^k$ whose graph passes through all n points. We will also highlight connections between such interpolating polynomials and strictly positive definite functions.

Kwame Yeboah **Southeast Missouri State University**
Bundling Your Insurance: A Comparative Study of Some Classification Methods

Risks are part of our daily activities, including personal, property, and liability. These risks are typically managed by employing a risk management tool. The primary and most widely used risk management tool is insurance. Combining all your risk policies with one insurer can be more cost-effective than having a variety of carriers. Also, when one insurer handles all your insurance policies, you spend less time sorting through and paying each policy. Factors such as home ownership, marital status, education, and occupation determine one uptake of an auto insurance and the premium to be paid. However, there is no consensus on which other variables may be key determinants of uptake of an auto insurance policy. Therefore, the present study aims to identify key predictors of an uptake of an auto insurance policy by comparing three classification methods: Logistic Regression, LASSO Logistic Regression, Elastic net Regression and Random Forests. Data from an insurer who has provided health insurance to its policyholders already but now wants to know if the existing policyholders will also be interested in vehicle insurance will be used for the study. The study further aims at proposing a parsimonious predictive model for an uptake of an auto insurance policy.