ISMAA 2024 Abstracts
Bradley University
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Pre-conference Workshop

Edray Goins, Pomona College , *Addressing Anti-Black Racism in Our Departments*
In April 2021, the PBS Newshour ran a story with the headline "Even as colleges pledge to improve, share of engineering graduates who are Black declines". Indeed, there is a dearth of Black students in our mathematics classrooms. A 2018 study by the Pew Research Center found that Black students earned just 7 percent of STEM bachelor's degrees. Unfortunately, this is an issue for our faculty as well. A 2017 report in Inside Higher Ed states that there has been an increase over time in the diversity of senior and junior faculty members in the STEM fields — except black faculty. A New York Times article, titled "For a Black Mathematician, What It's Like to Be the 'Only One'", quoted that there are just a dozen black mathematicians among nearly 2,000 tenured faculty members in the nation's top 50 math departments.

What can we as faculty members do to make our mathematics departments more welcoming and diverse for Black students and faculty alike? These are daunting problems, and many with an interest in presenting solutions do not even have tenure! In this interactive presentation, we present some practices that even tenure-track faculty can engage in to showcase how #BlackLivesMatter — from increasing the number of pathways for majors, to building community by conducting research with students, and having hard conversations within hiring committees.

Plenary Talks

Meghan Goldfarb, State Farm Insurance, *Do You Know Where Your Data Comes From?*
Models and AI are increasingly being used across the business world for automation and decision making as well as within our personal lives. Two critical components of these models include the statistical model and the data the model was built using. Improper assumptions about data can result in models that don't deliver the intended outcome, or models that aren't implementable. Understanding your data architecture — or how the data you use for analytics is captured, managed within the system, and transformed — is critical to properly using that data for analytics and predictive models. This interactive session will introduce some common statistical models and AI used in the insurance industry, and discuss the impact data architecture and technology has on these models. Next time you build or use a statistical model or AI — it will leave you asking — do I know where my data comes from?.

Edray Goins, Pomona College, *A Dream Deferred: 50 Years of Blacks in Mathematics*
In 1934, Walter Richard Talbot earned his Ph.D. from the University of Pittsburgh; he was the fourth African American to earn a doctorate in mathematics. His dissertation research was in the field of geometric group theory, where he was interested in computing fundamental domains of action by the symmetric group on certain complex vector spaces. Unfortunately, opportunities for African Americans during that time to continue their research were severely limited. "When I entered the college teaching scene, it was 1934," Talbot is quoted as saying. "It was 35 years later before I had a chance to start existing in the national activities of the mathematical bodies." Concerned with the exclusion of African Americans at various national meetings, Talbot helped to found the National Association of Mathematicians (NAM) in 1969.
In this talk, we take a tour of the mathematics done by African and African Americans over the past 50 years since the founding of NAM, weaving in personal stories and questions for reflection for the next 50 years.

Michael Malternfort, Northwestern University, *Multiple Definitions of the Generalized Stirling Numbers*
There is not always one best definition of a mathematical object. For example, an ellipse can be defined as a conic section or by specifying the sum of the distances from given foci. Both definitions are useful, and in this spirit, we will look at definitions of a single combinatorial object, the generalized Stirling numbers. We will discuss two new definitions, published in 2020, and see the interplay between the definitions. Time permitting, we will discuss both the original 1998 definition by Hsu and Shiue and also some related in-progress work. No prior knowledge is required, and this talk should be accessible to all.

Candice Price, Smith College, *Using Mathematics to Unlock Biological Mysteries*
Mathematical modeling is an effective resource for biologists — it provides ways to simplify, study and understand the complex systems common in biology and biochemistry. Many mathematical tools can be applied to biological problems, some traditional and some more novel, all innovative. This presentation will review some of the mathematical tools that I use to study biological questions including knot theory applied to DNA-protein interactions and using social networks to study evolutionary success.

Contributed Talks—Friday

Wilfredo Urbina-Romero and Loren Wszolek**,** Roosevelt University, *A non-centered asymmetric Cantor-like Set*
The ternary Cantor set C, constructed by George Cantor in 1883, is probably the best known example of a perfect nowhere-dense set in the real line, but as we will see later, it is not the only one. The present article will delve into the richness and the peculiarities of C through exploration of several variants and generalizations, and will provide an example of a non-centered asymmetric Cantor-like set.

Jasmine Gillis (+), Roosevelt University, *Euclid's 5th Postulate*
This presentation delves into the enduring legacy of Euclid, the Father of Geometry, and his renowned work "Elements," which became the fundamental textbook for mathematics for over two millennia. It explores Euclid's systematic and rigorous approach to proving mathematical theorems, his impact on geometry and mathematics, and his influence beyond mathematics, shaping the scientific community's methodology and problem-solving approach for centuries. Additionally, the presentation delves into the significant contributions of Giovanni Saccheri, particularly in non-Euclidean geometry, and his efforts to challenge Euclid's parallel postulate. It also discusses Playfair's Axiom as an alternative to Euclid's fifth postulate and its influence on mathematical thought. Furthermore, the presentation provides a mathematical proof of Playfair's Axiom from Euclid's 5th Postulate and a proof using Playfair's Axiom to prove Euclid's 5th Postulate. Lastly, it fact-checks Euclid's Axioms in the context of the sphere, shedding light on their applicability and limitations.

Jont Allen, University of Illinois, Urbana, *Derivation of $E=mc^2$ starting from Maxwell's Equations*
In 1904 Einstein published five papers that changed science overnight. One of the papers resulted in his being awarded the Nobel Prize in Physics. Another resulted in the atomic bomb first demonstrated on July 16, 1945, when members of America's Manhattan Project held their first successful test of the atom bomb in Alamogordo, New Mexico. The basis for this bomb was his equation E=m c^2. Einstein tried for more than 20 years to prove his result, but was never successful. In my presentation I will derive his most famous equation in a few lines, proving for the first time that, as is well known, it is correct. The speed of light squared is a very large number (c^2=0.9 x 10^17). As a result, the conversion of a small mass gives a large amount of energy. It is somewhat amazing that this formula has never been derived. In this presentation we summary the history and derive the equation starting from Maxwell's equally famous equations.

Ricela Feliciano-Semidei, Northern Illinois University, *Caminatas Comunitarias for Teaching Math in Colombian Secondary Rural Schools*
In this talk I present a book that compiles the experience lived by mathematics teachers and researchers who participated in the Fulbright project: Rural Community-Based Pedagogies for Teaching Mathematics in the Colombian Caribbean region. In this book, the authors share their experience with the purpose of inspiring other educators to replicate their strategy of conducting caminatas comunitarias. In the talk we will discuss educational theories, educational policies, reflections and examples aligned with the current Colombian curriculum. We will also discuss how this may inform secondary and higher mathematics education in the US.

Rachel Rupnow, Northern Illinois University, *Definitions: Why Do We Care about Them and What Do We Teach Our Students?*
Definitions are fundamental tools for doing mathematics, as they stipulate objects of study and provide a basis for logical derivation in research and teaching. Moreover, they provide a lens for understanding what mathematicians do and find important for their work. However, these values

and expectations of practice are not always communicated to students. Thus in this session, we will discuss (1) ways definitions are viewed by the mathematical community; (2) some ways instructors support students in understanding definitions and communicate their values and norms of practice; (3) some ways you could incorporate such discussions in your classes; and (4) ways that math educators could engage more meaningfully with you, the mathematical community, to help improve communication between math teachers and students.

Elizabeth DeWitt, Trinity Christian College, *Whiteboards Big and Small in Thinking Classrooms*
Based on the research and guidance in Peter Liljedahl's book Building Thinking Classrooms in Mathematics, Grades K-12: 14 Teaching Practices for Enhancing Learning, my colleague and I this year increased the time in each class period dedicated to group work on vertical whiteboards. Last year the department purchased a class set of individual hand-held whiteboards that we have used for voting and other activities. I will share how we have used these big and small whiteboards, reflections of instructors and feedback from students when possible, and existing research supporting these techniques.

Keven Hansen, Southwestern Illinois College, *ISMAA, IMACC, The Articulation Guide, and IAI: Guiding Curriculum in Illinois*
Designing courses in the undergraduate curriculum can be difficult, and sometimes it is hard to know what students transferring in from other institutions have already seen or done in their math courses. This talk will help faculty understand the basics of the Illinois Articulation Initiative (IAI) as well as the leading role ISMAA plays (together with the Illinois Mathematics Association of Community Colleges, IMACC) in helping faculty build transferable courses in Illinois.

Sunil Karn (+) Southern Illinois University, Carbondale, *Behaviorally Correct Language Identification*
Behaviorally correct language identification is a pivotal challenge in the realm of machine learning and logic. In this study, we explore the intricate interplay between linguistic behaviors and algorithmic techniques for the accurate identification of languages. Language identification holds significant importance across various domains, including natural language processing, sentiment analysis, and machine translation. Through the lens of machine learning and logical frameworks, this research investigates methodologies to discern and classify languages based on behavioral patterns embedded within textual data. We delve into the development of robust models that effectively capture linguistic nuances and contextual cues to enhance language identification accuracy. By integrating principles from machine learning and logic, this study aims to contribute novel insights and methodologies toward advancing the field of behaviorally correct language identification.

Edmonde Olongo*, Dominican University, *Mathematically Modeling the Interactions of Community- and Hospital-Acquired C. difficile Infections*

Clostridioides difficile (*C. difficile*) is an infection-causing bacterium commonly contracted by patients in medical institutions in the United States. *C. difficile* creates endospores which can survive in harsh conditions for long periods. These bacteria can be spread either through contact from person to person or with surfaces hosting the endospores. Patients who are currently on or have recently taken an antibiotic are susceptible to contracting *C. difficile* as certain bacteria in the stomach become weaker, creating an ideal environment for *C. difficile* to grow as its spores spread faster without competition. This study quantifies the spread of the *C. difficile,* differentiating between community- and hospital-acquired infections. Using a system of ordinary differential equations distinguishing between individuals in the local community and hospital as well as varying environmental surfaces, results can be used by local communities to predict and limit potential outbreaks of *C. difficile*.

Lizbeth Leon*, Dominican University and Harold Arriaga*, Lewis University, *Modeling Disease Transmission and Control in Long-Term Care Facilities*

This research project focuses on studying the transmission of Clostridioides difficile (C. difficile) within long-term care facilities. By employing systems of ordinary differential equations (ODEs) to identify strategies for mitigating the spread of this bacterium. C. difficile is a healthcare-acquired infection frequently encountered in long-term care facilities, and its transmission can occur through direct contact with infected individuals or exposure to C. difficile endospores on contaminated surfaces. Mathematical models offer a unique opportunity to analyze complex dynamics and interactions that are challenging to study directly in real-world settings. By developing ODE models specific to long-term care facilities, this project aims to understand the primary routes of C. difficile transmission and find effective control strategies to reduce C. difficile within long term facilities.

Christopher Denq* and Liang Kong**,** University of Illinois Springfield, *A Meshfree Deep Learning Approach for Numerical Solution of Differential Equations*

This study explores the application of Deep Learning in the realms of classical mechanics and fluid dynamics, particularly focusing on the harmonic oscillator model and the Burgers' equation. We demonstrate new neural network models that can be trained to perform supervised learning tasks while adhering to physical laws represented by general nonlinear partial differential equations. These physics-informed neural networks (PINNs) incorporate physical constraints directly into the loss function used for training. Additionally, we show how PINNs integrate physical laws into machine learning to enhance model accuracy and reliability, especially in cases with limited data. Through code implementation of case studies and the use of Residual-based Adaptive Refinement (RAR), the project showcases PINNs' capability to optimize computational resources and capture complex physical phenomena with high precision. PINNs show promise in solving differential equations, offering a significant advancement in computational science over traditional machine learning methods.

Jessica Cotturone*, Augustana College, *Counting Subgroups of Finite Abelian Groups*
In this talk we discuss the problem of counting subgroups of a specific family of Abelian Groups, namely the direct product of $Z_2 \times Z_4 \times \ldots \times Z_{2^n}$. We will discuss a conjectured "super" recurrence relation for counting the number of subgroups of particular orders. Special attention is given to demonstrate how the number of cyclic subgroups is related to the number of elements of a certain order.

Career Panel-Saturday

Career Panel for Undergraduate Students: Preparation for Careers in Mathematical Sciences

Amanda Liaromatis got her Bachelor's degree from Bradley University. She has been teaching for more than ten years. She is currently a math teacher and chair of the math department at a public high school in the city of Peoria.

Nathan Pauli, earned Bachelor's degrees in Math and Physics. He has been working in Industry for more than twenty years. Nathan currently works on vibration and signal processing at Caterpillar in Peoria.

Contributed Talks—Saturday

Elaina Khasawneh, Chicago State University, *Revolutionizing Education: Unleashing the Power of OpenAI's ChatGPT for Dynamic Learning Experiences in Mathematics Education*
Unlocking the potential of OpenAI's ChatGPT in educational contexts holds the promise of revolutionizing learning experiences, especially within the realm of mathematics education. This summary explores the numerous applications, benefits, and considerations associated with incorporating ChatGPT into educational environments, specifically emphasizing its impact on mathematics education. Utilizing the GPT architecture, ChatGPT demonstrates exceptional proficiency in understanding and generating human-like text, paving the way for a wide range of educational applications.
In the educational sphere, ChatGPT functions as an intelligent virtual assistant, offering instantaneous responses to student queries, aiding in homework support, and providing personalized tutoring experiences in mathematics. Exploiting its natural language processing capabilities, ChatGPT establishes an interactive and engaging learning atmosphere, nurturing student curiosity and facilitating dynamic discussions on mathematical concepts. Additionally, educators can harness ChatGPT for content creation, generating educational materials, and even assisting in the development of tailor-made lesson plans designed for the intricacies of mathematics education.

A K M Raquibul Bashar, Augustana College, *Building Classification Models for Early Detection of Asthma in Children for USA Population based on the Behavioral Risk Factor Surveillance System (BRFSS)*

Asthma is the most prominent chronic disease in children and one of the most challenging ailments to diagnose in infants and preschoolers. In this study, we have developed classification and prediction models for early detection of Asthma in Children of the USA population based on the Behavioral Risk Factor Surveillance System (BRFSS) collected and maintained by the Center for Disease Control and Prevention (CDC), USA. This prediction model can be utilized through the APP built through a web page domain-ed in an Academic website or from a personal web page that can be established through web development. In this study, we have built several machine-learned and statistically learned models based on the data collected from CDC. We have studied several algorithms to develop an algorithm with the highest accuracy. The result shows that "Visiting Doctors", "Duration of Symptoms in the last 30 Days", and several other variables of this nature play a significant role in the building process of the model. In our study, we found the "XgBoost" algorithm provides the highest accuracy when it comes to predicting Asthma based on the behavioral data that were collected by the CDC. Since our model algorithm predicted the outcome based on the available data only. So, in the case of the issue of improving the model prediction accuracy, it is inferred that if we had access to the bigger data resources and data collection process then the accuracy of the model algorithm will be improved significantly.

Maral Tajova (+) and Dinesh Ekanayake, Western Illinois University, *Higher order root finding algorithm with controllable rate of convergence.*

Householder methods provide higher order numerical algorithms to solve f(x)=0. However, an increase in order necessitates the evaluation of derivatives of increased order. Subsequently, these methods are not widely utilized due to the increased number of function evaluations with the increased order. Generally, Hayleys method (order 2 Householder method) is considered the optimal. In this presentation, we discuss a third order method with a parameter that can be utilized to increase the rate of convergence. Using finding roots of a number as an example, we compare the proposed method with the first three Householder methods.

Harsha Iduruwage (+) and Dinesh Ekanayake, Western Illinois University, *Estimating transmission parameters and the reproduction number: COVID-19 in Sri Lanka as a case study.*

The study of the dynamics of an infectious disease is fundamental to understanding its community spread. These include obtaining estimates for transmission rates, recovery rates, and the average number of secondary cases per infectious case. Due to many factors, these parameters can be time dependent. Data on the prevalence of COVID-19 provides an excellent source for case studies to analyze such time-dependent parameters. Using Sri Lankan COVID-19 data, we demonstrate how one could utilize Itô stochastic differential equations with a gamma distribution correction to estimate disease transmission parameters as function of time.

Kevin Palencia Infante, Northern Illinois University, *Rehumanizing the teaching of calculus*
Student-faculty connections are positively associated with students' sense of belonging, academic achievement, and engagement. In this talk, we present students' perspectives on their ideal classroom to teach and learn calculus. We analyzed data from interviews completed by a group of students enrolled in calculus I, II, or III at a midwestern research university. Students expressed a desire to humanize mathematics by strengthening faculty-student relationships and caring about their success. Discussions of this presentation include faculty practices that promote positive relationships with students and how it helps mitigate the high percentage of grades of D or F or of students withdrawing from the course entirely mid-semester (DFW) in calculus classes, as well as student retention issues in science, technology, engineering, and mathematics (STEM) programs

Angela Antonou and Christina Jamroz , University of St. Francis, *Research Training Seminar Series - Training Undergraduate Students for Math Research*
This presentation will include an overview of the research training seminar series being 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.

Jasmine Gillis (+), Phillipa Asare-Ababio (+), and Eric Damerow*, Roosevelt University, *Python-Powered Peak Discovery: Unveiling Moss's Pollution-Sensing Potential*
The project aims to develop a faster and more accessible method for identifying elemental peaks from an XRF machine, with a focus on leveraging GPS coordinates to gather additional information about the moss placement locations. This is crucial as moss walls are effective in identifying air pollution, and understanding the distribution of pollutants can significantly aid in combating their effects and fostering interdisciplinary collaboration across scientific fields. The project involves examining previous work on peak identification in spectrum data, transforming raw data into images for easier peak identification, and creating a peak range file for all elements to facilitate the development of peak-finding code. The findings indicate that elemental peaks, especially for lower atomic numbers, are more readily identifiable using Python, and the project anticipates creating an alternative method for reading spectrometry data from the XRF. These findings are important as they can expedite data processing for scientists, improve data accuracy, and ultimately contribute to a better understanding of air pollutant distribution and aid in the development of effective mitigation strategies.

Catherine Crawford and Jon L. Johnson, Elmhurst University, *Gibbs Phenomenon for a Weighted Piecewise Linear Approximation*
Gibbs phenomenon occurs when a function with a jump discontinuity is approximated by a finite Fourier series where both an overshoot and an undershoot occur at the discontinuity. However, it is not restricted to just Fourier series, but occurs in other classical series expansions as well. It even occurs when using splines to approximate a function with a jump discontinuity. We

examine piecewise-linear functions (splines of degree one) by introducing a weight function in the inner product used to define orthogonality. We show that the choice of the weight function can greatly reduce the size of the observed Gibbs phenomenon.

Cara Sulyok, Lewis University, *A Mathematical Framework to Augment the Q-MARSH Score in the Diagnosis of Celiac Disease*
Celiac disease is a hereditary autoimmune disease that affects approximately one in 133 Americans. It is caused by a reaction to the protein gluten found in wheat, rye, and barley. After ingesting gluten, a patient with celiac disease may experience a range of unpleasant symptoms while small intestinal villi, essential to nutrient absorption, are destroyed in an immune-mediated process. The only known treatment for this disease is a lifelong gluten-free diet and there is currently no drug treatment.

This work provides a mathematical model to better understand the effects of immune activation on gut health using a system of ordinary differential equations. The system tracks changes in small intestinal cell densities and relates them to the Q-MARSH score, a criterion used in the diagnosis of celiac disease. The model can be used to investigate and analyze the immune response and various theories behind the progression of this disease by focusing on understanding the dynamics of the small intestine in situations mirroring healthy function and celiac disease. By doing so, we can assist in further quantifying and augmenting diagnostic measures and investigate potential therapies to mitigate the negative effects of celiac disease.

Matthew Senese*, Austin Kind*, Cara Sulyok, and Brittany Stephenson, Lewis University, *Stochastic Simulations of Nosocomial Clostridioides difficile Infections and Transmission*
Clostridiodes difficile (C.difficile) infection has been a prominent issue in healthcare settings for over a decade with healthcare workers (HCWs) and fomites, surfaces likely to carry infections, being recognized as the main vectors of transmission. We have developed an agent-based model to stochastically simulate how C.difficile endospores spread through hospital wards and infect patients. Our simulated hospital consists of six wards where factors like antibiotic prescription rates, a patient's length of stay, HCW interactions, and other parameters are varied. We monitor how patients progress through different disease statuses, including a potential C.difficile infection, and the main vector of transmission to cause this progression. These results can be used by hospital administrations and HCWs to mitigate the transmission of C.difficile.

Ngoc Le*, Augustana College, *Deriving the Black-Scholes Equation*
In this talk, I explore the journey from Ito's Lemma to the Black-Scholes equation for valuing call and put options. I will break down how Ito's Lemma transitions stochastic calculus into partial differential equations, emphasizing its crucial role in option pricing and risk management. Additionally, I will show how to convert the PDE into a heat equation and provide a solution method.

Boga Mzila-Ndlovu*, Northern Illinois University, *Population Models with Non-local Dispersal and Stage-structure*
Population models have been employed by mathematical biologists and epidemiologists to describe the dynamic changes in species' populations over time for applications to species-specific scenarios like resource allocation or disease control. In this talk, we will present our study of some population models with stage structure and non-local dispersal strategy. We shall discuss some recent results on such models and present some research prospects.

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